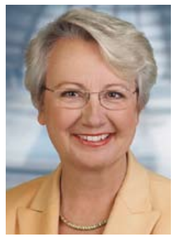
Driven by curiosity

Initiated by the German Federal Ministry of Education and Research

Science Year 2010

The Future of Energy

Dear readers,



Growing global energy needs, limited resources and profound climate change are challenging humanity and imposing responsibility. If we truly wish to safeguard resources and living conditions for future generations, we need to act today to promote energy sustainability and new technological developments for our energy sector. Throughout an enormous range of fields and disciplines, scientists are working on new methods and technologies that can enhance resources development, renewable energy efficiency and energy transport and use.

Viable, forward-looking solutions can be implemented only if everyone gets on board. What sort of workplaces do we want to have in the future? What sort of mobility do we want? And how do we want to be living? We all need to work together to shape the future. And research and development will give us the tools we need for our efforts.

In Science Year 2010 – *The Future of Energy*, we want to give our citizens a look at the latest findings and strategies in energy research, developments that cover a wide spectrum, from bioenergy to wind and solar power and to new lighting concepts.

During this year, we again want especially to inspire and encourage children and young people to learn about the world of research. Scientists from throughout the country will be opening their research institutions and laboratories for visitors – and visiting young future scientists in their classrooms.

We need to act now. Resources issues concern all of us. Scientists and researchers have found some great ways to meet our future energy needs, and we cordially invite you to visit the laboratories and institutes that are focussing on these key issues. And we urge you to learn, ask questions and join the ongoing discussion.

I cordially invite you to take part in the Science Year 2010!

Dr. Annette Schavan, Member of the German Bundestag
Federal Minister of Education and Research

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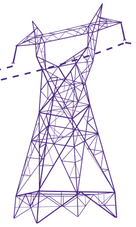


Science Year 2010 – The Future of Energy

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 using energy – is a key to meeting such challenges.

Science Year 2010 – *The Future of Energy* focuses on precisely this key issue. This year, the Federal Ministry of Education and Research (BMBF), in co-operation with German science and industry, is showcasing scientists' creativity in tackling the challenge of building a safe, cost-effective and climate-friendly energy sector.

Many experts are working together to find environmentally friendly, efficient ways of using available resources. In the process, they are developing new ways of storing energy and more intelligent systems for transporting it. These efforts are concentrating especially on the energy areas of electricity and heat. Another crucially important scientific focus is the search for additional renewable energies and alternative energy sources. Wherever possible, the new technologies involved should not impose new economic burdens. That is a realistic constraint, since the new technologies promise to provide new jobs and new markets.

THE FOUR TOPIC AREAS OF SCIENCE YEAR 2010 – THE FUTURE OF ENERGY

Energy research can succeed only through teamwork – close teamwork involving a range of different scientific disciplines. Development of high-performance storage media, such as batteries that can increase the ranges of electric cars, thereby making them a more attractive option, can succeed only through co-operation between chemists, physicists, engineers and materials scientists. Research into completely new forms of energy is similarly interdisciplinary. And non-technological issues – such as public acceptance of new technologies – also play an important role in many areas.

Any energy technology that is used on a large scale will have a public impact. Scientists and researchers need to understand that it is up to them to enter public forums and offer people the information and arguments they need in order to weigh the opportunities and risks. In connection with large-scale technology systems, both new and established – such as nuclear power, wind farms and carbon capture and storage (CCS) – supporting research is needed that addresses legitimate safety concerns and helps society to adjust.

Science Year 2010 has four thematic focuses:

→ Improved protection for the climate and the environment: Environmentally friendly, responsible ways of using fossil fuels – coal, oil and natural gas.

→ Energy efficiency: Intelligent use of energy resources is one of the keys to reducing global energy consumption. In this area, research teams are working on such advances as energy-saving LED lamps and powerful, efficient microchips. More efficient energy use is also a key to protecting our climate and environment.

→ Renewable energies: How can solar energy, wind power, hydroelectric power, geothermal energy and biomass systems be improved and made more cost-effective? What can we learn from nature in this area? What climate-friendly energy mix will we be using in the future? Experts are working to answer these questions. Renewable energies have enormous potential. If at all possible, renewable energies should be meeting all of our electricity and heat requirements by the end of this century.

→ International co-operation: International co-operation needs to focus on making safe, clean and climate-friendly energy available to all the world's people.

THE SCIENCE YEARS – NOW WITH A NEW APPROACH

Past Science Years have focussed on individual scientific disciplines, subject areas or great scientists. This Science Year, the 11th to date, is concentrating on a challenge of vital importance for our society and for coming generations: the challenge of the Future of Energy.

The Science Years are initiated by the BMBF, in co-operation with *Wissenschaft im Dialog* (Science in Dialogue). In addition, this Science Year is also being supported by the Helmholtz Association of German Research Centres (HGF) – along with additional partners from the areas of research, science, industry and the arts. For ten years now, Science Years have been presenting the world of research to all of Germany's people. They have been a great success. In children and young people, they spark interest in things new and unknown. Many a boy and girl has been inspired by Science Year encounters to aim for a scientific career.

A RESEARCH EXCHANGE FOR YOUNG SCIENTISTS AND RESEARCHERS

Once again this year, children and young people can gain a close-up look at the world of research. Via an online research exchange, school classes and teachers have the opportunity to invite energy researchers to their classrooms – and to set up laboratory visits and watch scientists in action. A wide range of additional events, and fascinating Internet experiences, round out the range of programmes and offerings in Science Year 2010 – *The Future of Energy*. For young and old, the Science Year can explain the seemingly unexplainable and simplify the thorniest problems. A world of discovery awaits!

Energy – a challenge for policy, science and industry

How can we meet the world's growing energy needs and still protect the climate? Day in and day out, a great many teams of scientists and researchers are working hard to answer this question. It is clear that it will be some time before renewable energies can meet the world's growing demand for electricity and heat. Therefore, we urgently need more efficient technologies for extracting useful energy from gas, oil and coal. Such technologies will help conserve fossil resources, thereby reducing greenhouse-gas emissions. Experts remind us that as we seek to progress in these areas we can't afford to confine our focus to energy production – we also have to improve energy use.

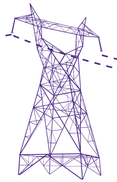
The world's population is growing by leaps and bounds: By the year 2050, the earth will have some nine billion people – instead of the some 6.5 billion it has today. Energy demand in booming threshold countries such as China and India is forecast to double over the next two decades. And this will have a serious impact on the climate. Most of our electricity and heat still comes from combustion of fossil fuels – coal, oil and natural gas. The carbon dioxide released in such combustion intensifies the earth's natural „greenhouse effect" – thereby warming the earth's atmosphere. How can we slow and stop climate change? By immediately shutting down all of our coal-fired power stations? By relying on nuclear power? By using only renewable energies, such as solar and wind power? With hydroelectric power? Geothermal energy? Biomass?

There is no single magic answer to the problem of developing an adequate, climate-friendly energy supply. The energy issues involved are simply too complex. Scientific and political experts are working together to find a range of solutions – all the while, taking account of the many interrelationships that energy and climate research has revealed. The central issue is that of creating a safe, affordable and clean global energy supply.

RENEWABLE ENERGIES OR FOSSIL FUELS?

Needless to say, it would be ideal if renewable energies could supply all of our electricity needs. But a glance at current electricity use quickly shows how far we still are from such a vision. In 2008, Germans relied primarily on fossil fuels for their electricity and heating needs: oil, natural gas and coal (including lignite and hard coal) together accounted for over 80 percent of the country's „primary energy consumption".

Nuclear power accounted for nearly 12 percent, while renewable energies accounted for a share – a growing share – of seven percent. According to current forecasts, renewable energies' share of total electricity production will triple by 2030 – but still be less than ten percent.



In the long term – and this is something the experts agree on – solar, wind and hydroelectric power will play the key role in the world's energy supply. As we move toward that goal, however, electricity and heat have to remain affordable. In Germany, one kilowatt-hour of electricity from coal is still considerably cheaper than one kilowatt-hour of electricity from wind or solar systems. In short, even though our fossil reserves have a limited time horizon, they will remain indispensable over the coming decades. And this is especially true for lignite and hard coal.

WHAT WE NEED: CLEAN, EFFICIENT TECHNOLOGIES

As long as we still lack an adequate, affordable supply of alternative energy sources, energy researchers face an enormous challenge. They urgently need to find the best, most environmentally friendly technologies for extracting electricity and heat from fossil fuels. And this must include reducing CO_2 emissions to an absolute minimum.

One focus of such efforts is on improving the conversion efficiency of power stations, which is a measure of how efficiently a system converts a fuel's energy into useful energy, i.e. electricity and heat. The average efficiency level for today's fossil-fired power stations in Germany is 38 percent. That is also about the average for power stations in Europe. In general, the higher a power station's combustion temperature is, the higher its energy conversion efficiency will be. State-of-the-art, coal-fired systems with components that are more heat-resistant can already achieve efficiency levels of over 40 percent. According to estimates of the Intergovernmental Panel on Climate Change (IPCC), China is bringing carbon-fired power stations with efficiencies of over 44 percent on line at a rate of one per month. More power, at constant or even lower emissions levels – that is one of the aims for the coming years and decades.

REMOVING CO_2 WITH SCRUBBERS AND ALGAE FILTERS

Several major energy companies are already operating pilot CO_2-scrubbing systems. Such systems have the purpose of preventing CO_2, a harmful greenhouse gas, from escaping into the atmosphere when it is released via fossil-fuel combustion. One of these projects uses a liquid that can wash 90 percent of the CO_2 out of exhaust gases. At the system's current scale, that amounts to 300 kilograms per hour. One enormous advantage of such systems is that they can be retrofitted to existing power stations.

Biological CO_2 filters made of microalgae are an alternative to such scrubbers. While such algae absorb CO_2 via photosynthesis, like most plants do, they grow ten times as fast as „regular" plants do. The pilot systems pass cooled, pre-filtered flue gases through large, transparent water vessels containing such algae. One such pilot system, already in operation, can bind 12,000 kilograms of CO_2 per year. In the process, the carbon in the CO_2 is bound in 6,000 kilograms of algae biomass, while the oxygen produced in the photosynthesis is released into the atmosphere. The algae themselves can then be used as energy sources for fuel production or as construction materials.

STORING CARBON DIOXIDE – THE VIABILITY OF CCS

Separation systems using microalgae bring up the next question: What can we do with the separated CO_2? German scientists are playing a key role in the development of a process for CCS (experts also use the term sequestration to refer to such storage). In the process, separated CO_2 is compressed, transported via pipelines and then injected into deep, porous rock layers. The types of formations that are especially suited for this purpose include depleted oil and gas fields and „saline aquifers" – porous rock formations filled with salt water. Such formations occur in various areas, including Germany.

A globally unparalleled project is now underway in Ketzin, a small town in the German Federal State of Brandenburg. In this unique effort, 60,000 tonnes of separated CO_2 will be stored in sandstone formations at a depth of 800 meters. Institutions from a total of 18 different countries are co-operating in the project, which is being led by the Helmholtz Association of German Research Centres (HGF). Using state-of-the-art sensors, interdisciplinary teams of geologists, physicists and chemists are studying how the sequestered gas behaves and how it affects rocks at different depths. If such rock storage reservoirs prove suitable, and can be suitably monitored, for periods of centuries they could keep over 99 percent of human-produced CO_2 from entering the atmosphere.

On the other hand, some scientists are sceptical about the potential of CCS technology. They point to the enormous quantities of CO_2 that would have to be safely stored for indefinite periods of time.

IMPROVING EFFICIENCIES: HIGH-EFFICIENCY SYSTEMS AND POWER STATIONS

As part of efforts to find technologies that are both cleaner and more effective, ten European energy companies are currently developing a new generation of high-efficiency coal-fired power stations that operate at temperatures of up to 700 degrees Celsius – 100 degrees higher than the operating temperatures of today's best power stations. Thanks to such high temperatures, as well as to high live-steam pressures, such systems reach efficiencies of over 50 percent. Materials scientists are participating in development of the new high-temperature turbines such power stations require. Planning for a 500-megawatt demonstration system, fired with hard coal, is currently underway, and longer-term plans call for construction of a 1,000-megawatt system. If the first such system proves successful, a lignite-fired power station with similar output is to follow. Such new power stations emit about 25 percent less CO_2 per unit of power output than do conventional systems. They thus represent a decisive step.

Combined gas and steam turbine power stations are another major advance. They produce electricity and district heat simultaneously. With that combination, systems now in existence already achieve efficiencies of nearly 60 percent. They use their fuel – usually, natural gas – in an especially effective, environmentally friendly way. And a new, fuel-saving turbine generation is currently being developed in Germany.

Using energy intelligently – research and development for more energy efficiency

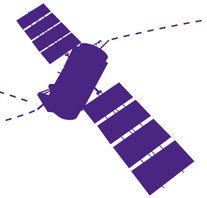
How can energy be used more intelligently and efficiently? Researchers are approaching this vitally important question from different perspectives. Some are looking for ways of converting and transporting electricity with no power losses. Others are studying new light sources that will illuminate the monitors of the future. The effort to reduce global energy consumption has already reached some key milestones. And many of these involve intelligent power electronics – organic light-emitting diodes (OLEDs) and electronic microchips.

The scientists' overarching aim is to maximise the output for a given energy input, i.e. to minimise energy input and save energy. Interdisciplinary research teams, for example, are working toward this aim in areas such as energy-optimised buildings, new-generation batteries, efficient power converters and more powerful, yet mass-producible, solar cells and fuel cells.

PASSIVE HOUSE, ZERO-ENERGY HOUSE, PLUS-ENERGY HOUSE

Houses offer enormous potential for saving energy. A total of ¾ of the energy that the average German household uses goes toward heating. Furnaces, burners and baths thus account for a significant share of private households' total contribution to Germany's total CO_2 emissions. Currently, that contribution amounts to about 14 percent. „Passive houses", „zero-energy houses" and „plus-energy houses" are already showcasing ways of reducing that emissions contribution. They increase efficiency via a number of ways, beginning with effective wall insulation and state-of-the-art triple-pane insulating windows. They also use advanced heating, ventilation and air-conditioning (HVAC) strategies. Such strategies prevent winter ventilation from squandering valuable indoor heat and summer ventilation from taking in unwanted outdoor heat.

HVAC plays an even more important role in the case of large buildings. Airport terminals, office high-rises and other large buildings are used by thousands of people each day. In such structures, computers, lighting systems and other types of equipment generate large quantities of waste heat. In addition, glass facades and roofs have powerful greenhouse effects. Conventional buildings thus have to rely on enormous air-conditioning systems to prevent heat overloads. But such systems are heavy energy users, and they often create unpleasant or even unhealthy indoor climates. Modern technology, drawing on important research work, can change this picture entirely. Bonn's 160-meter Post Tower, the world's first passively air-conditioned skyscraper, provides an excellent example. For its air conditioning, it relies primarily on two physical effects.



One is the chimney effect, in which warm air rises, thereby drawing in fresh, cooler air from below. Traditional Arab houses use this method of cooling. A second is the wind pressure that results from the chimney effect – it can be used to power ventilation systems. In the planning phase for the building, extensive and sophisticated computer simulations and experiments were carried out in wind tunnels in order to optimise the wind circulation and harness it effectively for air conditioning.

Today, buildings can produce more energy than they consume. Such „plus-energy houses" do that primarily with roof-mounted photovoltaic systems. Glass facades and roofs of large buildings can be covered with transparent solar modules. While allowing light to pass into buildings, such modules filter overly intense sunlight and produce electricity. They thus can turn protective roofs and facades into intelligent, climate-friendly power stations.

FUEL CELLS: GENERATING ENERGY WITH „COLD COMBUSTION"

Fuel cells are also environmentally friendly. They function by means of a simple principle: Oxygen reacts with hydrogen, thereby producing water and releasing energy. Fuel cells convert such energy into electricity. Fuel cells that operate with pure hydrogen emit no CO_2, in contrast to engines and power stations that burn coal or oil. However, the hydrogen that powers fuel cells first has to be produced – for example, via electro-chemical separation of water molecules into oxygen and hydrogen. And that process consumes energy – for example, electrical energy supplied by power stations. If fuel cells are to become widely adopted, their energy balances must surpass those of other energy-conversion strategies. Scientists are thus working to optimise fuel-cell life cycles, seeking to make fuel-cell technology as efficient and cost-effective as possible.

ENERGY-EFFICIENT ELECTRONIC SYSTEMS

Increasing use of information and communications technologies – especially the Internet – has triggered and boosted rapid growth in the computer-centre sector. This, in turn, has greatly increased that sector's power consumption – in fact, computers are now responsible for two percent of the world's CO_2 emissions. „Cool Silicon", a BMBF-funded top cluster, is working to develop ways of significantly reducing energy consumption in this sector. Taken to extremes, the strategies being pursued could lead to systems that are completely energy-independent.

Other researchers are developing energy-efficient technologies and processes for production of computers, mobile communications systems and sensors. One joint research group with this focus, located in the Dresden region, brings together over 60 semiconductor companies, research institutes and universities. Energy-efficient electronic systems developed by that group are already yielding significant energy-consumption reductions in PCs and Internet servers.

SEMICONDUCTORS AS ENERGY-SAVING LIGHT SOURCES

Energy-efficient LEDs can now be found in a wide range of devices, including flash-lights and bicycle lights, traffic lights and electronic signs. LEDs, or „light-emitting diodes", are semiconductor components. LEDs produce much less waste heat per unit of light output than conventional light sources do. LEDs are still rather expensive, however, and they still lack the brightness that many lighting applications require. Research teams at universities and major research institutions, and in lighting producers' research departments, are working to improve LEDs.

OLEDs are another, even more recent scientific advance. OLEDs are organic light-emitting diodes. While they tend to have shorter lifetimes than their inorganic „relatives" do, OLEDs are superior in a number of other respects. OLED production requires less energy than LED production does, and OLEDs are especially powerful light sources that can produce brilliant colours. OLEDs will further improve efficiency in a number of areas – in computer and TV screens, for example. Conventional liquid-crystal display (LCD) monitors produce dark areas by simply covering their background illumination (i.e. with liquid crystals). OLEDs, by contrast, can be „turned off" completely. By only having to illuminate bright areas, they are thus able to produce high-contrast images with much less energy input than other technologies require.

NANOMATERIALS AND EFFICIENT STORAGE SYSTEMS

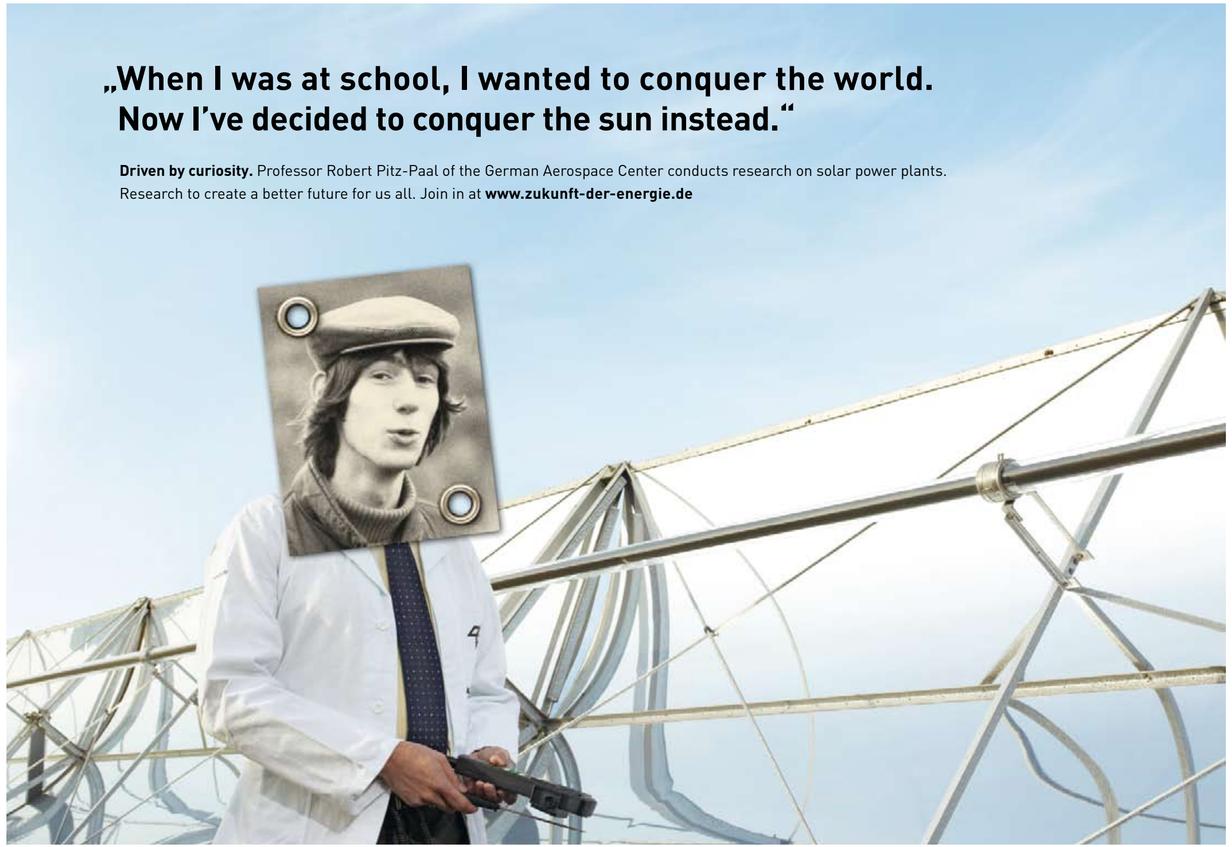
Optimised materials can also help save energy, in many different ways. In aircraft and automobiles, new types of light, strong materials can replace heavier, conventional materials, thereby reducing weight and, thus, fuel consumption. In an internationally renowned centre of excellence in Germany, such materials are being studied and developed by leading companies and research institutions. And nanotechnology has been providing important impetus for such work. Scientists have developed energy-saving recyclable nanofibres for fibre-reinforced plastics for strong, lightweight components.

Additional potential for saving energy is seen in the area of individual mobility. It is clear that the role of petrol and other fossil fuels is going to decline in the face of resources scarcities and the need to reduce CO_2 emissions. The Federal Government has thus been promoting development of electromobility. In fall 2009, the Federal Government approved a „national development plan" in this area. Under the plan, up to one million electric cars will be on Germany's roads by 2020, and Germany will become a lead market for electromobility. The CO_2 balance of individual mobility can be significantly improved via use of cars powered by electricity from renewable energies. Consequently, the BMBF has been supporting research into the development of electric cars. The important focuses of such work have included the development of long-lasting, cost-effective and safe batteries.

CONVERTING ENERGY MORE EFFICIENTLY

Numerous research centres, institutes, universities and companies in Germany are engaged in study and development of efficient energy conversion schemes and systems. One example of such efforts is the „Efficient Energy Conversion" programme of the Helmholtz Association of German Research Centres (HGF), in which scientific teams from throughout Germany are working interdisciplinarily in a range of relevant fields: New power station technologies, superconductivity, fuel-cell technology and nanotechnology.

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 optimisation 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" (Leistungselektronik zur Energieeffizienz-Steigerung, LES).



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.

Currently, Germany obtains considerably less than ten percent of its primary energy from renewable energy sources. Although it may not sound like much, that usage level is already having a noticeable beneficial environmental impact: In 2008, renewable energies cut Germany's CO_2 emissions by over 109 million tonnes.

Use of renewable energies – especially wind energy – has been increasing, and renewable energies have become an economic success. The know-how leadership that German companies in the renewable energies sector have gained in recent years has been generating sales around the world – and creating jobs, now at the rate of about 80 new jobs per day. Overall, the sector now employs about 250,000 people in Germany. Solar energy, wind power, hydroelectric power and bioenergy are also favourable in terms of supply reliability – and of reducing Germany's dependence on the international energy market. The relationship is really very simple: As renewable energies' contribution to Germany's energy supply grows, Germany can reduce its fossil fuel imports. At the same time, it is already clear that use of energy sources that vary in accordance with the weather and with the seasons – as is the case for wind power and solar power – will create a need for new power-grid design and management strategies.

WIND – THE KEY ENERGY SOURCE

There are thus many reasons why we should be focusing on renewable energies. Wind energy has been paying off especially well in Germany: As of 2008, over 20,000 wind turbines were in place, and wind power met nearly seven percent of the country's electricity requirements. The installed capacity has surpassed the 25-gigawatt mark. The great advantage of wind turbines is that they are environmentally friendly. In operation, they neither release greenhouse gases nor pose a threat to groundwater.

Wind power will thus remain a valuable energy source. Even the smaller wind turbines in place today produce enough power to meet the needs of over 1,000 households. In 20 years of operation, they prevent the burning of some 90,000 tonnes of lignite. The largest wind turbines in place today produce three or four times that amount of power, with the result that one wind farm can suffice to meet a small city's electricity needs.

Numerous coastal regions already have wind farms in place, and wind turbines have also been installed on mountain ridges in inland areas. More and more systems are now being installed in offshore areas. The first German offshore wind farm, which resulted from a research initiative, was set up in 2009, some 45 kilometres off Borkum, a North Sea island. Each of its twelve wind turbines has a capacity of five megawatts – and thus the entire installation produces enough electricity for some 50,000 households. In general, the fluctuations that occur in wind-powered electricity generation have to be compensated for via intelligent grid-management systems. Such systems enable optimal use of wind energy and help to keep the overall power supply stable.

HYDROELECTRIC POWER WORLD-WIDE

Moving water also holds a great deal of energy: River currents can be harnessed to drive 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 Jülich 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 large solar-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.

Cost-effective operation of nuclear fusion thus amounts to an enormous scientific challenge. Currently, six of the world's leading industrialised countries are working on nuclear fusion in co-operation with the European Union. The group is now building a first fusion reactor, dubbed „ITER", in Cadarache in the south of France. The name „ITER" stands for „International Thermonuclear Experimental Reactor".

In addition, „Iter" is a Latin word that means „the way". With ITER, the partner countries involved in the project, Japan, Russia, India, China, South Korea, the USA and the EU, are taking a large step into the future. ITER is to be completed in 2019.

Its reactor, 30 meters tall, will consist of a ring-shaped vacuum vessel in which magnetic fields, among other sources, will heat the plasma to the required high temperatures. The thermal energy output from the fusion reaction could reach 500 megawatts. For comparison: A large coal-fired or nuclear power station has a thermal energy output of about 3,000 megawatts. From such an output, over 1,000 megawatts of electricity are generated. ITER is only a research reactor, however. If the experiments are successful, DEMO, a first demonstration power station, is to be built beginning in around 2020. Scientists estimate that DEMO would then be commissioned about 20 years later. German research institutes are intensively involved in the project, and the BMBF is supporting the involved German centres of competence in this unique international development and research programme.

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 gigawatt of geothermal energy output. The largest German geothermal power station is located in Unterhaching, near Munich. Currently, it has an electrical output of 3.4 megawatts. In its final configuration, it is expected to reach a thermal energy output of 70 megawatts.

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. This is why aviation-sector researchers are driving the development of this technology.

INTERNATIONAL BASIC RESEARCH: THE ENERGY 2020+ FUNDING PROGRAMME

With its „Basic Research Energy 2020+" (Grundlagenforschung Energie 2020+) funding concept, the BMBF is supporting the numerous research efforts in Germany aimed at efficient energy production and conversion, energy storage, energy transport and final energy use. The key focuses within this research framework include reduction of greenhouse-gas emissions, nuclear fusion and next-generation solar energy systems. Processes for sustainable geological storage of carbon dioxide are also being supported.

A FUTURE SCENARIO

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 like this: In the morning, the sun shines on solar panels mounted on the eastern section of our roof, thereby generating electricity to cook our eggs and make our coffee. In the afternoon, the wind picks up, and the wind farm located just outside the city produces the electricity for our kitchen radio and stove. In the evening, the heat for our hot shower comes from geothermal wells directly under our house. The interaction of all such components is reliably controlled by intelligent electricity-distribution and energy-storage systems that ensure that, in sum, enough energy is always produced and available – even when weather conditions preclude the operation of some energy-production technologies. Day in and day out, German researchers are working to improve renewable energy technologies so that this vision of a climate-friendly, safe and reliable energy mix can become a reality.

Energy research for global climate and energy policy

Climate change does not respect international boundaries. And a growing world population is competing more and more intensively for scarce resources, including energy. Many key energy resources are distributed very unevenly around the globe. As the global community becomes increasingly interconnected, human coexistence will flourish only if policy-makers tackle the complex international challenges facing us. Old-style policies of national isolation offer no way out or ahead.

This applies especially to climate policy – and, thus, to energy policy. After all, energy is the motor for human civilisation. Climate policy and energy policy are closely interrelated. Today, these two policy areas have to incorporate many different concerns: Climate protection, a safe and reliable energy supply, efficient energy use and development of sustainable energy sources – ideally, inexhaustible energy sources.

Without strong scientific support, from all areas of energy research, policy-makers will be unable to deal with such complex challenges. This principle was confirmed by the highly publicised Copenhagen climate conference, which highlighted the difficulty of harmonising the economic and political interests of all countries. At the same time, it is important to carry out international energy research projects that involve the largest possible numbers of countries. Since the 1970s, a number of countries have been working together on such projects in the framework of the International Energy Agency and in programmes of the European Union. Such co-operation is especially important when it comes to expensive major research projects aimed at developing new, reliable and sustainable energy sources for all of humanity. Nuclear fusion is one such project area, for example. At the same time, science and technology are just one side of the coin. The other side consists of research into the economic and social impacts, both actual and potential, of large-scale use of specific forms of energy.

A COMPLEX GLOBAL CHALLENGE

The recent debate about biofuels illustrates the complexities of international climate and energy policy. Several years ago, the European Union decided – with the best of intentions – to increase mixing quotas for biofuels, in order to reduce greenhouse-gas emissions from fuels. Studies carried out in the meantime, however, have pointed to a need for caution. This applies especially to a scenario in which industrialised countries massively promote cultivation of fast-growing energy plants – such as oil palms – in tropical countries. Such cultivation could have highly negative regional and global impacts. Firstly, energy plantations could displace local food cultivation, thereby creating hunger risks for local populations. Secondly, clearing of rain forest for such plantations would dramatically worsen the overall climate effects of so-produced biofuels.

Every new type of large-scale energy production can lead to such dramatic missteps. As scientists work interdisciplinarily to analyse complex interrelationships, from climate impacts to social consequences, they must seek to recognise such dangers

before they occur. That way, they can help ensure that the door to new resources does not close before it ever really opens. Biofuels, for example, can make an important contribution to the global energy supply. They need to be produced and used with care, however.

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, labelling 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.

NETWORKING CREATES SOLIDARITY AND SECURITY – AND PROTECTS THE CLIMATE

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.

Better networks, with tighter, more intelligent internal links, provide many advantages. That is why such networks must be a priority aim of European energy policy. The problem of uneven geographic distribution of resources is not confined to fossil fuels such as natural gas. Uneven distribution is also a factor in the area of renewable

resources, including wind power, hydroelectric power, solar power and biomass. It is especially pronounced in the area of energy from the sea, such as wave and tidal energy. The idea of connecting North African desert countries to the European network, as suppliers of solar electricity, is particularly appealing. The chances for such a vision to become a reality are good, since the industrial consortium behind the Desertec project, the effort oriented to that aim, is a powerful group of leading industry players. Ideally, the project will be a „win-win" effort for the North African Mediterranean countries and Europe. But, as experience shows, such major investments need to be carefully protected, legally, via international agreements. International energy policy will thus have to provide the decisive framework in this area as well.

A similar need applies in connection with the plan to capture carbon dioxide from conventional power stations and store it underground. CCS technology could contribute significantly to climate protection, since any phasing-out of fossil fuels in the near future is an unrealistic goal. According to the latest scientific findings, suitable reservoirs are available. Such reservoirs could include large depleted natural gas fields, for example. The gas we extract now has been held securely in such fields for many millions of years. On the other hand, such fields are not always located in close proximity to relevant power stations. One solution to this problem would be to build a European network of gas pipelines for pumping captured CO_2 to the reservoirs.

Clearly enough, a lot more research is needed before such ideas can be put into practice. The efforts required include development of pertinent new technologies, geological studies of reservoirs and research into the societal issues that this major technology could bring up. Regarding the last of these points: Although surveys highlight public support for climate protection, public acceptance levels for the required additional pipelines and storage areas are not particularly high. This would thus be an important area for supporting research in social and cultural sciences.

FROM NATIONAL INSIGNIFICANCE TO COMMON BENEFIT

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 greenhouse-gas 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.

Energy professions in Germany

In recent years, few sectors have attracted the sort of attention that the energy sector has received. Issues such as climate change and scarcities of fossil resources have been widely and hotly discussed. The German energy market has developed continually in the 13 years since it was liberalised. Today, the sector contains well over one thousand companies and, according to estimates, it will be employing over half a million people by 2020. What is more, it is going to keep on requiring a great deal of fresh young talent.

German technology and German specialists and experts are in demand around the world. The range of available education and training in Germany has been growing in step with the employment market's demand for energy experts: Universities, universities of applied science, chambers of crafts, training institutes for specific occupations, regional training centres and chambers of industry and commerce are all working continually on the development of new opportunities for training and studies.

The energy sector has a broad spectrum of occupations. Technical specialists are in particularly strong demand, as are engineers in various fields, including electrical engineering, systems and power engineering, mechatronics and environmental protection. Experts in areas related to resources development – such as geophysicists, chemists and geologists – are also needed. In addition, the energy trading sector has been changing, and thereby increasing its demand for well-trained personnel. The European Energy Exchange (EEX), established in 2000, offers attractive opportunities for specialists in business administration and economics. In 2009, it was chosen as the forum for European trading in emissions allowances – it thus is a forum for trading in CO_2 certificates, coal and natural gas.

PATHWAYS INTO THE ENERGY SECTOR

Four different pathways lead into the energy sector: Training programmes, study programmes, training and combined studies programmes, and in-service training programmes. Places for in-company training are normally awarded by the involved companies themselves. The many different formally established occupations requiring training include service technician, electronic services specialist, and building services specialist.

Programmes of studies are offered by both universities and universities of applied science. At least a dozen German higher education institutions offer bachelor's degree programmes in the areas of energy systems and energy management. Bachelor's degree students in energy technology can choose from among a number of different emphases, throughout a spectrum that includes energy conversion via biological, physical or chemical processes, energy transport and energy storage.

Numerous German universities also offer master's degrees in the energy field. The Bremen University of Applied Sciences provides a good example: It offers a programme in „sustainable energy systems".

The Hamburg University of Technology (TUHH) offers a programme in „energy and environmental engineering". The TU Berlin has a programme in „renewable energy systems". The degrees offered in such programmes equip students with specialisation in scientific and engineering research in areas such as photovoltaics, biomass and wind energy systems. Young people can earn master's degrees in „energy" at many other higher education institutions as well.

DUAL UNIVERSITY PROGRAMMES AND CONTINUING-EDUCATION OPPORTUNITIES

Another pathway into the energy sector consists of dual university programmes. Such programmes differ from non-dual programmes in that they have a more practical orientation, via pertinent co-operation arrangements between universities and industry. As interns in companies, students can directly apply what they learn in their seminars and lectures. And they are able to gain real-life work experience during their studies.

In-service training programmes also provide good opportunities for entry into the sector. The Renewable Energy Training Centre (BZEE), located in Husum, provides one example. The BZEE was quick to respond to the growing demand for energy-sector specialists. Since 2000, it has been successfully training service technicians in the area of wind power. Like other institutions, the Centre develops its training programmes in close co-operation with educational institutions, chambers of industry and commerce and chambers' member companies and institutes.

NUMEROUS WORK OPPORTUNITIES

Industry, engineering offices, energy companies, research institutions and government authorities are all looking for specialists in energy sciences. The energy sector offers a highly diverse range of fascinating fields of work. Energy companies, for example, require specialists in the areas of energy-supply planning and energy trading. Research institutes, needless to say, require staff able to carry out relevant scientific research. Engineering offices focus intensively on development of new procedures and processes for energy production and energy-efficiency enhancement, as well as on design of all types of power stations.

The demand for energy specialists continues to grow – and thus the employment opportunities in the energy field continue to grow as well. The energy sector, including all the people who work in it, or will work in it someday, can look ahead to an exciting future.

ENERGY EXPERTS OF SCIENCE YEAR 2010

Prof. Dr. Carola Griehl (page 8)

Director of biochemistry / algae-biotechnology research at the Anhalt University of Applied Sciences

Main field of work: Development of biotechnological processes for production of CO_2-neutral energy sources.

The photo shows Professor Griehl in front of a bubble-column reactor, for cultivation of microalgae cell cultures, at the university's Centre of Life Sciences.

Prof. Dr. Günther Hasinger (page 22)

Scientific Director of the Max Planck Institute for Plasma Physics in Garching

Main field of work: Nuclear fusion research

The photo shows Professor Hasinger in front of the Wendelstein 7-X fusion reactor, which is currently under construction, at the Max Planck Institute for Plasma Physics in Greifswald.

Prof. Dr.-Ing. Robert Pitz-Paal (page 16)

Head of the solar-research department at the German Aerospace Center (DLR), Institute of Technical Thermodynamics

Main field of work: Solar research.

The photo shows Professor Pitz-Paal in front of the solar system in the outdoor area of the DLR's Institute of Technical Thermodynamics, Cologne-Porz.

Dr. Regina Palkovits (page 12)

Group Director at the Max Planck Institute of Coal Research

Main field of work: Production of fuels and chemicals via reactions with renewable resources.

The photo shows Dr. Palkovits at her work centre in the research laboratory of the Max Planck Institute of Coal Research, located in Mülheim.

Energy on the Internet: www.zukunft-der-energie.de

The website www.zukunft-der-energie.de is the central point of contact for Science Year 2010. The website offers visitors event information, an online research exchange, the „E-Zoom" tool and much more.

RESEARCH EXCHANGE

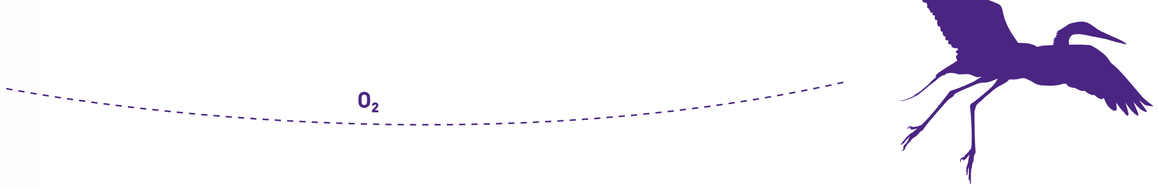
Via the research exchange, Science Year 2010 puts children and young people in contact with researchers. Teachers and school classes can use the online research exchange to invite experts into their classrooms – or to set up appointments to visit them at their places of work. Also: Energy researchers introduce themselves and their work. Along with brief portraits of themselves, they present descriptions of their career stations and everyday work. A calendar shows when they are available for visits to nearby schools. All persons involved in energy research are cordially invited, throughout the entire year, to register and take part in such knowledge transfer. The website of Science Year 2010 presents complete information about how to participate.

A SPECIAL TOOL: E-ZOOM

The website offers yet another attraction: The „E-Zoom". Visitors can use the E-Zoom to move through eight different levels that show important areas of energy research. The levels cover a spectrum from the smallest sub-atomic particles to biological cells and people: from nature to houses and cities and out into the universe. Numerous „hotspots" describe areas in which energy is a key research and development focus. For those desiring still more information, the E-Zoom includes links to additional relevant content at websites of the Science Year's approved partner institutions, all of which are reliable authorities.

OTHER RESOURCES AVAILABLE IN THE NETWORK

As always, the website offers visitors a complete calendar of Science Year events. The calendar lists all events in thematic and geographic categories. Please note that the number of listed events normally grows in the course of the Science Year's first few months. Under the heading „Energy in brief" (Energie in Kürze), a range of facts, figures and dates is presented – with entries ranging from short definitions to comprehensive dossiers. Here as well, persons of all ages will find suitable recommendations regarding further information and materials of Science Year partners, presented in co-operation with the Schools Online initiative. The area „Energy to get involved" (Energie zum Mitmachen) presents a quiz, competitions and a „Stream of ideas" (IdeenStrom). In the Stream, anyone who has a good idea or a request for information can send out a Twitter message. For Twitter pros: The hashtag for the Science Year 2010 is „WJ2010". Twitter delivers a constant stream of short messages that you can read and comment on right away. For those new to Twitter, the website presents a guide to the service.



A first look at events, projects and competitions during Science Year 2010 – The Future of Energy

As a theme year, Science Year 2010 is open to a broad spectrum of scientific fields. Its central focus is on the complex issues surrounding the future of energy. Such issues are much broader and larger than the scientific and technical problems involved: They also concern ecological, social and economic aspects. Researchers are looking for viable, sustainable solutions, and, ultimately, such solutions can be found only via dialogue between science and society. This is a common theme of the following activities, which are listed by way of example. And it is a common theme of Science Year 2010.

JANUARY

Kick-off event on 26 January, at the Energieforum Berlin
Prof. Dr. Annette Schavan, Federal Minister of Education and Research, opens the Science Year 2010 – *The Future of Energy*. Prof. Dr. Ottmar Edenhofer, Deputy Director of the Potsdam Institute for Climate Impact Research (PIK), holds a special opening speech on the significance of energy research with regard to climate protection.

Project Presentation
A first project exchange connects Science Year stakeholders and provides a forum for exchanges of opinion and experience.

Online research exchange
Launch of the online research exchange at the website of Science Year 2010 – *The Future of Energy*. The exchange provides a forum for direct contacts between energy sector researchers and schools.

Online energy quiz
The Helmholtz Association of German Research Centres (HGF) launches an exciting energy quiz in which research teams present a stream of increasingly difficult questions. Quiz winners will receive attractive prizes.

Energy for ideas
This year, the BMBF's competition for students is devoted to energy research. Students of all universities are invited to develop original ideas, experiments and solutions with respect to the energy mix of the future and to the presentation of scientific topics. The 15 best proposals for events and other measures will each receive EUR 10,000 for their implementation. The deadline for applications is 23 April 2010.

Climate workshop
The „get involved" exhibition of the Deutsche Bundesstiftung Umwelt (DBU), devoted to the topic of climate and energy, starts at the end of January in Osnabrück.

FEBRUARY

Energy Route of the Museums
In 2010, the research museums of the Gottfried Wilhelm Leibniz Science Association (WGL), in co-operation with other partners, will organise an Energy Route, leading through the great diversity of energy topics in German museums. The German Mining Museum in Bochum presents the history of hard-coal mining, while the Deutsches Museum in Munich offers an exciting range of special displays. In a special presentation at the Berlin Museum of Natural History, a large meteor strikes the earth, thereby triggering an energy drama. Other participating museums will also present energy-charged features, including special tours and workshops – and aimed especially at school classes.

Events at the Deutsches Museum in Munich
On 10 February 2010, the event series „Women guide Women" begins, presenting energy-research topics at the Deutsches Museum in Munich. The series begins with mobility and drive concepts („mobile with no CO2") – and continues on a monthly basis with focuses on the history of energy use, energy conversion and electricity distribution, and people and climate.

Forums for school pupils
In Essen, Magdeburg, Stuttgart and Karlsruhe, upper-level grammar-school pupils will spend three days looking at the „energy mix of the future". In the process, the pupils will trade ideas with scientific institutes. The ideas that emerge from the effort will then be presented at a closing public event. Time period: between January and October.

Presentations by the Energy Experts of Science Year 2010
The presentations begin on 18 February 2010, with Prof. Dr. Günther Hasinger, Scientific Director of the Max Planck Institute for Plasma Physics in Garching, at the facilities of Urania Berlin e.V.. The event is being held in co-operation with the Helmholtz Association of German Research Centres (HGF).

Debate on energy and climate change
On 24 February 2010, and at the Deutsches Museum in Munich, research groups from five countries, and teams from eight German schools, universities and research institutions, will develop and test fictive scenarios for a city's electricity sector.

MARCH

SchulKinoWochen
Start of the SchulKinoWochen (movie festival for schools): This year's event presents three documentaries on the topic of energy. The aim of the event is to initiate a broad-based debate at participating schools.

CeBIT
Presentation of „Invent a Chip", a nation-wide competition for pupils sponsored by the Association for Electrical, Electronic & Information Technologies (VDE), and supported by the BMBF. In the competition, pupils have the opportunity to design an energy-saving microchip. The winning circuit will then be produced as a real silicon chip.

APRIL

ScienceStation
On 12 April 2010, ScienceStation, a mobile, interactive exhibit on the topic of energy, opens at Munich's central railway station. The exhibit will be presented at a total of nine railway stations in Germany – including those of Stuttgart, Mannheim, Mainz, Frankfurt am Main, Wiesbaden, Halle (Saale), Braunschweig and Berlin (Ostbahnhof).

Girls' Day bets on energy
Girls' Day takes place on 22 April 2010. Over 200 partners from the areas of energy research and energy companies will participate in the „energy" theme area and offer girls a special programme on the world of energy research and energy applications. As part of the event, interesting energy sector careers will be featured.

MAY

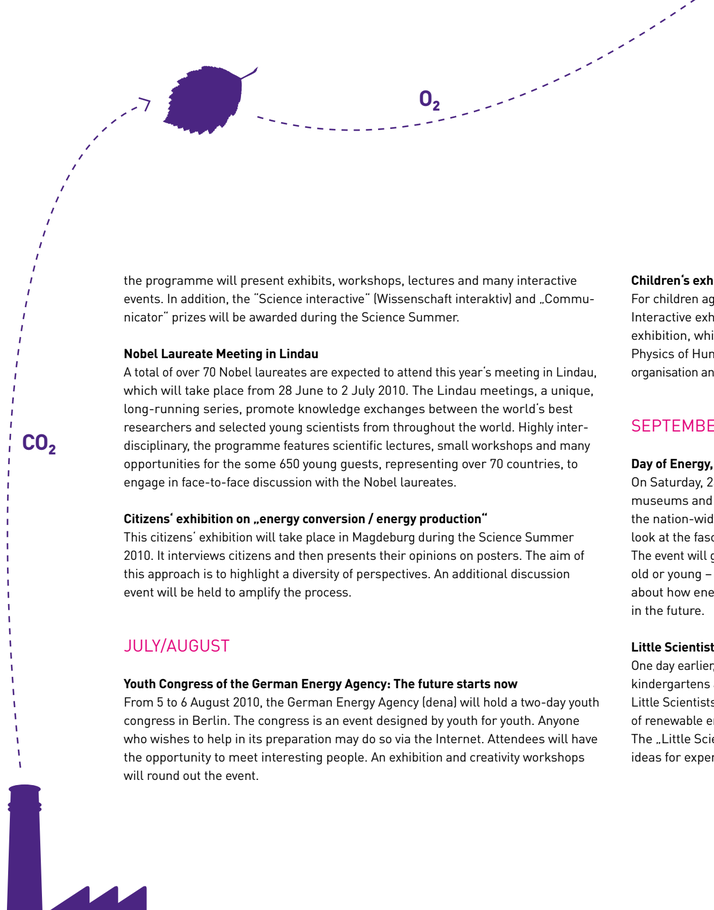
The „Year 2050" simulation game: An energy scenario
Where will our energy come from in the year 2050? This is the question that will concern young people in the online simulation game of Science Year 2010 – *The Future of Energy*. Game participants will seek to develop viable solutions, taking account of ecological, economic and social parameters. The task: To create energy scenarios for the future. The path is uncharted, and the topic is complex. Who will come up with the most convincing solution? The resulting solutions will be publicly discussed and honoured.

The MS Wissenschaft 2010 exhibition ship
The MS Wissenschaft, a floating Science Centre, offers pure energy in 2010, with a comprehensive range of information about the latest energy research. From mid-May to early October, the „energy ship" will travel to some 30 cities in Germany – and make a short side tour to Austria. In its „Dialogue on Deck" discussion forum, a new addition to the programme, visitors can participate in an open discussion about energy issues. Below deck, visitors can take a journey to „Planet Energy". There, an interactive, hands-on programme presents all kinds of instructive, fascinating details about energy.

The „Discoveries" exhibition of the Foundation Lindau Nobel Prizewinners Meetings at Lake Constance
On 22 May 2010, an exhibition on energy opens on the Isle of Mainau. Until the end of August 2010, it will show „Discoveries", a presentation of scientific strategies for meeting the challenge of resource scarcities. It includes attractive presentations on new processes for production, storage and transport of renewable energies. Another topic is energy-saving. A children's programme, supported by the „Little Scientists' House" (Haus der kleinen Forscher), rounds out the event.

JUNE

Science Summer 2010 in Magdeburg
From 5 to 11 June 2010, the Science Summer visits Magdeburg. In co-operation with research institutes, *Wissenschaft im Dialog* will organise a fun, variety-filled programme at that location for children, young people and adults. All aspects of the programme have to do with energy. A „long science night" open-house event will offer fascinating tours of institutes, workshops and laboratories. For an entire week,



the programme will present exhibits, workshops, lectures and many interactive events. In addition, the "Science interactive" (Wissenschaft interaktiv) and „Communicator" prizes will be awarded during the Science Summer.

Nobel Laureate Meeting in Lindau
A total of over 70 Nobel laureates are expected to attend this year's meeting in Lindau, which will take place from 28 June to 2 July 2010. The Lindau meetings, a unique, long-running series, promote knowledge exchanges between the world's best researchers and selected young scientists from throughout the world. Highly interdisciplinary, the programme features scientific lectures, small workshops and many opportunities for the some 650 young guests, representing over 70 countries, to engage in face-to-face discussion with the Nobel laureates.

Citizens' exhibition on „energy conversion / energy production"
This citizens' exhibition will take place in Magdeburg during the Science Summer 2010. It interviews citizens and then presents their opinions on posters. The aim of this approach is to highlight a diversity of perspectives. An additional discussion event will be held to amplify the process.

JULY/AUGUST

Youth Congress of the German Energy Agency: The future starts now
From 5 to 6 August 2010, the German Energy Agency (dena) will hold a two-day youth congress in Berlin. The congress is an event designed by youth for youth. Anyone who wishes to help in its preparation may do so via the Internet. Attendees will have the opportunity to meet interesting people. An exhibition and creativity workshops will round out the event.

Children's exhibition: Here comes the sun
For children age eight and older, along with their families, friends and school classes. Interactive exhibits will take the children on a trip to the sun and its energy. The exhibition, which is supported by the BMBF and presented by the Department of Physics of Humboldt-Universität zu Berlin, along with the „Neues Universum" organisation and other partners, opens in July in Dortmund. Later, it will move to Berlin.

SEPTEMBER

Day of Energy, on 25 September 2010
On Saturday, 25 September 2010, research institutions, universities, companies, museums and many other organisations around the country will open their doors for the nation-wide Day of Energy (Tag der Energie). In the process, they will offer a look at the fascinating world of energy research, energy use and energy applications. The event will give children, families, adults – in short: people with curiosity, whether old or young – a chance to conduct experiments. In the process, they will learn about how energy is now produced and used and how it will be produced and used in the future.

Little Scientists' Festival
One day earlier, on 24 September 2010, all the little ones in children's day-care centres, kindergartens and elementary schools are cordially invited to get involved in the Little Scientists' day, which offers opportunities to explore and experiment in the areas of renewable energies, renewable resources, climate and environmental protection. The „Little Scientists' House Foundation" (Haus der kleinen Forscher) will develop ideas for experiments that youngsters can also carry out at home.

Highlights of Physics
The annual one-week festival „Highlights of Physics" will take place again this year. This year's festival is devoted to the topic of energy. The „Highlights" festivals are co-operatively sponsored by the Deutsche Physikalische Gesellschaft (German Physical Society) and the BMBF. This year's week-long festival, with programmes for pre-schoolers, hands-on experiments and entertaining science shows for children and young people, and evening presentations, offers a uniquely broad programme for all age groups. The science festival will also include an exciting physics competition for pupils in the middle and upper levels of grammar school.

Citizens' conference
For an entire week, some 200 citizens from throughout the entire country will focus on the topic of energy use. Participants in the citizens' conference, which is organised by *Wissenschaft im Dialog*, will interview experts and then formulate joint recommendations for decision-makers and scientists. The recommendations will then be published. The conference will take place in Berlin.

OCTOBER

Energy in the art museum
An exhibition of the Brandenburg Gate Foundation, held at the Max Liebermann House, will illuminate the topic of energy and research from artistic and historical perspectives. It will offer a comprehensive look at the topic of „the future of energy".

„Energy – basis for life and driver for the future"
The 10th „Munich Science Days" (Münchner Wissenschaftstage) will take place from 23 to 26 October 2010. In this framework, universities, scientific institutions and researching companies will offer tours, lectures, workshops and open houses focussing on energy.

NOVEMBER/DECEMBER

Junior Science Café
Within the course of a school year, school working groups will plan and organise three meetings with scientists, for discussion of central energy research issues. As time goes by, so the expectations, participating pupils, representing grade levels nine through twelve, will be able to organise more and more of this small event series under their own responsibility. The participating working groups will concern themselves with energy research, and its societal relevance, throughout the entire year.

Experimentation course: Energy – always and everywhere
At the Exploratorium Potsdam hands-on science museum, children of all ages will have the opportunity to experiment with lemon batteries and solar updraft towers, working under the motto „Energy production made easy!"

Exhibition on climate, energy and sustainability
With an exciting exhibition on the topics of climate, energy and sustainability, suitable for all ages, the Senckenberg Natural History Museum, located in Frankfurt am Main, will present state-of-the-art science in an interactive framework.

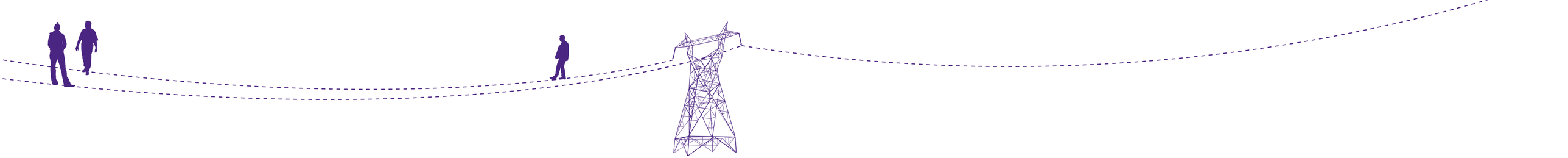
Sponsors and partners of Science Year 2010 – The Future of Energy

The Science Years are the result of an initiative of the Federal Ministry of Education and Research (BMBF) and Wissenschaft im Dialog. The sponsors of Science Year 2010 also include the Helmholtz Association of German Research Centres (HGF). Other partners with a role in 2010 include various associations, institutions, research establishments, companies, and federal and Länder ministries. All of these partners are highly committed and are offering their own programmes and projects.

Federal Ministry of Education and Research
The BMBF has been organising the Science Years since 2000. The purposes of the Science Years are to make science accessible for all people, to foster public interest in science and research and to awaken young people's interest in scientific subjects and encourage them to participate in the overall effort. Each of the first ten Science Years focussed on a particular field or famous scientist. Now, in an unprecedented approach, Science Year 2010 – *The Future of Energy* is covering an interdisciplinary topic of decisive importance for the future of our society.

Wissenschaft im Dialog
Ten years ago *Wissenschaft im Dialog* was established by leading German science organisations. It is the result of a proposal, supported by the BMBF, of the Donors' Association for the Promotion of Sciences and Humanities in Germany. Since its inception, *Wissenschaft im Dialog* has been promoting exchanges between scientists and the public, via exhibitions, workshops and other interactive science events throughout Germany. The areas of Science Year 2010 – *The Future of Energy* in which *Wissenschaft im Dialog* is involved include the floating science centre „MS Wissenschaft" (an exhibition ship) and the „Science Summer" in Magdeburg.

Helmholtz Association of German Research Centres (HGF)
The Helmholtz Association is a group of 16 research centres, with focuses on science, technology, the life sciences and medicine. The Association's aim is to address pressing scientific, societal and industrial challenges. The Association carries out interdisciplinary research in six different research areas: Energy, earth and environment, health, key technologies, the structure of matter and aeronautics, space and transport. The Helmholtz Association institutes carry out Germany's most extensive range of energy research.



PARTNERS IN SCIENCE YEAR 2010 – THE FUTURE OF ENERGY

A high-ranking co-ordination committee, under the direction of Cornelia Quennet-Thielen, State Secretary of the BMBF, develops the concept for Science Year 2010 – *The Future of Energy* and co-ordinates the contributions and formats of all of its key stakeholders and participants. The co-ordination committee is supported in its efforts by a steering committee. The following experts are involved in shaping this process, under commission to, and as representatives of, their associations, institutions and companies:

Prof. Dr. Frank Behrendt – Director at TU Berlin's Institut für Energietechnik (Institute for Energy Technology)

Dr. Fritz Brickwedde – Secretary General of Deutsche Bundesstiftung Umwelt (DBU)

Detlef Dauke – Department Head in the Federal Ministry of Economics and Technology (BMWi)

Willi Fuchs – Director of the Association of German Engineers (VDI)

Dr. Oliver Geden – Researcher at the German Institute for International and Security Affairs (SWP)

Prof. Dr. Ute Harms – Director of the Leibniz Institute for Science and Mathematics Education (IPN), Kiel

Dr. Thomas Kathöfer – Secretary General of the German Rectors' Conference (HRK)

Prof. Dr. Claudia Kemfert – Department Head at the German Institute for Economic Research (DIW)

Prof. Dr. Wolfram Koch – Managing Director of the German Chemical Society (GDCh)

Stephan Kohler – Chief Executive of the German Energy Agency (dena)

Dr. Joachim Lang – Head of the Berlin Office of E.ON AG

Prof. Dr. Martha Lux-Steiner – Department Head at the Helmholtz-Zentrum Berlin für Materialien und Energie (Helmholtz Center for Materials and Energy)

Dr. Volker Meyer-Guckel – Deputy Secretary General of the Donors' Association for the Promotion of Sciences and Humanities in Germany (Stifterverband für die Deutsche Wissenschaft e.V.)

Hildegard Müller – Chairwoman of the Central Management Board of the Bundesverband der Energie- und Wasserwirtschaft e. V. (Federal Association of the German Energy and Water Industry (BDEW))

Dr. Herbert Münder (consulting) – Managing Director of *Wissenschaft im Dialog*

Dr. Bernhard Nunner – Managing Director of the Deutsche Physikalische Gesellschaft (German Physical Society)

Prof. Dr. Ortwin Renn – Department Head at the University of Stuttgart's Institut für Sozialwissenschaften (Social Sciences Institute)

Andreas Renner – Head of the Berlin Office of Energie Baden-Württemberg AG

Dr. Gerd Romanowski – Managing Director of the Association of the German Chemical Industry

Dr. Bernhard Schleich – Director at Evonik Degussa GmbH

Dr. Susanna Schmidt – Department Head in the Federal Ministry of Education and Research (BMBF)

Dr.-Ing. Joachim Schneider – President of the Association for Electrical, Electronic & Information Technologies (VDE)

Prof. Dr. Matthias Steinmetz – Spokesman of the Gottfried Wilhelm Leibniz Science Association (WGL)

Prof. Dr. Ferdi Schüth – Director of the Max Planck Institute of Coal Research

Prof. Dr. Eberhard Umbach – President of the Karlsruhe Institute of Technology and Vice-President of the Energy Research Area of the Helmholtz Association of German Research Centres (HGF)

Prof. Dr. Gerold Wefer – Chairman of the Steering Committee of *Wissenschaft im Dialog*

Prof. Dr. Eicke Weber – Head of the Fraunhofer Institute for Solar Energy Systems

Dr.-Ing. Karl-Friedrich Ziegahn (consulting) – Programme Director at the Karlsruhe Institute of Technology

The many different Science Year activities and events are co-ordinated and linked by the Science Year 2010 Task Force:

Helga Ebeling – Head of the Task Force within the Federal Ministry of Education and Research (BMBF)

RD Dipl.-Ing. Matthias Nagel – Deputy Director of the Task Force within the Federal Ministry of Education and Research (BMBF)

In addition to the aforementioned institutions, organisations and associations, the following organisations are also involved:

Agentur für Erneuerbare Energien (Renewable Energies Agency)

Berlin-Brandenburgische Akademie der Wissenschaften (Berlin-Brandenburg Academy of Sciences and Humanities)

German Academy of Natural Scientists Leopoldina – National Academy of Sciences

Dialogik, non-profit institute for communication and cooperation research

Europäisches Informations-Zentrum Thüringen (European Information Centre, Thuringia)

ForschungsVerbund Erneuerbare Energien (Renewable Energy Research Association)

Stiftung "Haus der kleinen Forscher" (Little Scientists' House Foundation)

Kompetenzzentrum Technik-Diversity-Chancengleichheit e.V. (Competence Center Technology-Diversity-Equal Chances)

Münchner Wissenschaftstage e. V.

Neues Universum Berlin e. V.

Otto von Guericke University of Magdeburg

Staatliche Hochschule für Gestaltung Karlsruhe

Schulen ans Netz e.V. (the Schools Online Initiative)

Stiftung Brandenburger Tor

Stiftung Lesen

Stiftung Lindauer Nobelpreisträgertreffen (Foundation Lindau Nobel Prizewinners Meetings at Lake Constance)

Technische Jugendfreizeit- und Bildungsgesellschaft gGmbH

Urania Berlin e. V.

Vision Kino gGmbH

Welt der Physik

BECOME A SCIENCE YEAR PARTNER

Science Year 2010 – *The Future of Energy* brings together a broad range of disciplines and topics. In addition to presenting scientific findings and interrelationships from the perspectives of science, technology and the humanities and social sciences, Science Year 2010 focuses on issues of training and education – on requirements pertaining to specific occupations, on career opportunities in science and industry and on relevant start-ups. What is more, Science Year 2010 is designed to promote broad-based discussion, by all stakeholders, regarding the future of energy: What decisions and measures need to be taken? What directions is research moving in? What can each of us do?

The Science Year seeks to reach all citizens, especially younger generations – from children in kindergarten to people starting out on their careers.

In the interest of showing young people the latest energy-sector developments in practical, interesting and vivid ways, additional institutions and companies are invited to provide their support – for projects, events, competitions, exhibits or discussions having to do with energy research.

Researchers and energy experts are invited to use the research exchange at the Science Year's website to announce their willingness to visit schools and to participate in events. Ideally, such visits include presentations of new developments and descriptions of career perspectives.

Throughout the entire year, the doors of participating institutes and companies should stay open for children, young people and all interested persons. All Science Year partners are urged to pursue such a policy especially on 25 September 2010, the nation-wide Day of Energy. To its partners, the Science Year 2010 announces its readiness to include events and campaigns in its public relations efforts, to list public events in its website events calendar, to present selected events, current programmes and news in its monthly programme preview and newsletter, and to permit use of the official logo of the Science Year 2010 in public communications.

Please direct any questions regarding the Science Year and partners' status to:

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