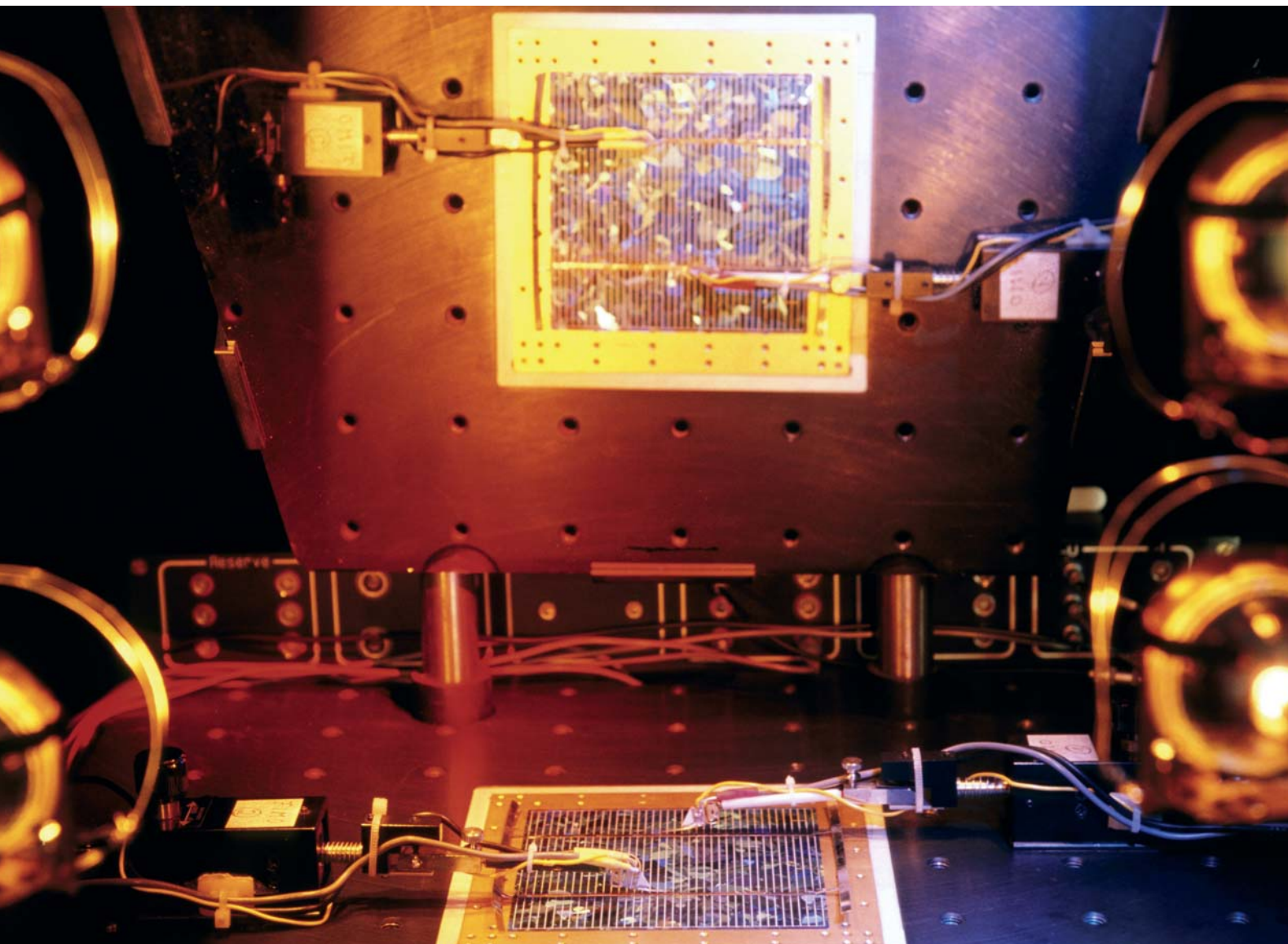




Federal Ministry
of Education
and Research

Basic Energy Research 2020+

The Funding of Energy Research by the
Federal Ministry of Education and Research



RESEARCH

Igniting ideas!

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**The Funding of Energy Research by the
Federal Ministry of Education and Research**



Global economic growth and the rise in demand for energy are factors substantially contributing to the emission of harmful gases and to climate change. To reduce emissions of greenhouse gases by almost half over the next few decades, the federal government launched a strategy in August 2007 for increasing energy efficiency and the further development

of renewable energies. This aims to ensure security of supply, cost-effectiveness and environmental compatibility.

To achieve this we must step up our energy research, because effective technologies for better energy efficiency and for the competitive use of renewable energies are vital here. A high level of basic research is essential.

This funding concept aims to promote, in close cooperation with research institutions funded by the federal government, developments that focus on products and services for the markets of tomorrow and beyond. It will bring together basic research and practical approaches, and further promote networking between science and business.

This brochure presents the project funding of the Federal Ministry of Education and Research and how it fits within existing and planned activities in the institutionally funded research facilities. Today is when we must act, for our both own futures and for those of generations to come.

A handwritten signature in black ink, which reads "Annette Schavan". The signature is written in a cursive, flowing style.

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

Content

Executive Summary	6
Strategic objectives	8
Opening position	10
Funding concept – core areas	12
Next generation solar energy application) .	14
Photovoltaics	14
Biomimetic hydrogen production	16
Bioenergy conversion	17
Efficient conversion and use of energy	19
Sustainable CO ₂ storage and use	24
Nuclear fusion	26
Nuclear safety and disposal research	28
Funding resources	30
International co-operation	32
Instruments for implementation of the concept	34
Annex	36
Guidelines for project funding	36
List of funding notices already published ..	37
List of contacts (project management agencies)	38
Photograph Credits	39
List of abbreviations	40

Executive Summary

Energy Basic Research – an important contribution to climate protection

3% of gross national product on research

Broader interdisciplinary approach in research work for greater energy efficiency

Expanding the share of renewable energies

CO₂-storage as an important element in the future utilisation of coal

The federal government has set climate protection as one of its key objectives for the next few years. It has set ambitious targets at national and international level (CO₂ emission reduction by up to 40%, doubling of energy productivity between 1990 and 2020). This funding concept focuses on areas of energy research in which completely new technological options are to be developed, requiring fundamental and extended research effort to bring the technology into real-world application.

This funding concept aims to further promote integration between science and industry in research. The funding is intended to bring together energy-related basic research with application-oriented work. Strategic alliances between business, science and the public sector also play a useful role in this respect. By boosting its expenditure on energy research the BMBF intends to induce reinforcement of the deployment of industry resources.

The funding concept gives special priority to research work relevant to the high-efficiency generation, conversion, storage, consumption and low-loss transmission of energy. This includes major development work in the area of key technologies, such as in materials research, optical technologies and state-of-the-art information and communication technologies. As well as technological work, research will include system analyses and studies into consumer behaviour.

The part played by renewable energies in our energy supply has to be increased. This requires developments in next generation technologies, particularly in photovoltaic solar power generation – thin-film photovoltaics and organic photovoltaics – and bioenergy conversion, but also in alternative solar and biomimetic hydrogen production. The aim is to achieve decisive breakthroughs in increasing the efficiency of energy conversion and the reduction of costs and production effort.

As coal will continue to play an important role in maintaining the flexibility and diversity of our energy supply for decades to come, the development of technologies for the capture and subsequent storage of CO₂ from coal-fired power plants is of strategic significance. Funding will therefore be given to research work into underground CO₂ storage.

Fusion research as a long-term option for a secure power

In addition to climate protection, ensuring security of supply is one of the federal government's energy policy goals. To ensure secure supply in the long term, every technological option must be investigated, developed and advanced. Against this background, fusion research is also to be funded. Beyond 2050 nuclear fusion offers possibilities for ensuring a secure CO₂-free power supply.

Securing nuclear expertise for the structured exit from nuclear energy

Germany is to undertake a structured phasing-out of power generation from nuclear energy. Until the last nuclear power plant is shut down, safety must be guaranteed in line with the very latest developments in science and technology. Expertise in nuclear technology is also required for the dismantling of the facilities and safe disposal of radioactive material.

Bringing together institutional and project funding

To date, the BMBF has primarily funded energy research at an institutional level in the research centres of the Helmholtz Association. The Helmholtz centres work on extremely complex topics, involving long development times and high risks, and have the necessary technical lab facilities, infrastructure and personnel resources for this. To better utilise these capabilities, the present funding concept will more closely combine and integrate institutional funding with BMBF project funding.

System-oriented approach to research

To achieve a sustainable energy supply requires not only individual technology developments, but also new organisational approaches for energy systems as a whole. The funding concept therefore attaches particular importance to system-oriented research approaches, which includes the conducting of energy-related socioeconomic studies and the elaboration of comprehensive optimisation concepts. Key factors in this respect are the transfer of the results of research into business and society, the acceptance of new technologies, and consumer behaviour.

Funding new blood – a key tool in the success of energy research

Special attention is to be paid within this concept to the funding of young scientists. In addition to doctorate posts in research projects, special funding instruments are to be offered to promote the next generation of scientists, for example postgraduate programmes on clearly defined topics and the development of working groups led by postgraduates.

Strategic objectives

The objective of the German government's energy policy is to achieve sustainable energy supply, taking into consideration the criteria of security of supply, cost-effectiveness, and climate and environmental compatibility.

The EU Commission has set ambitious targets for global climate protection, to be met across Europe by 2020. These are: Reduction of greenhouse gases by 20%, increasing the share of renewables in energy supply to 20% (10% share of biofuels in traffic) and 20% reduction of primary energy consumption. The federal government has set itself even more ambitious targets: With key points for an "integrated energy and climate programme", an action plan has been approved under which by 2020 greenhouse gas emissions are to be reduced by up to 40% compared with 1990 levels.

The 5th federal government energy research programme sets out the framework for various federal government

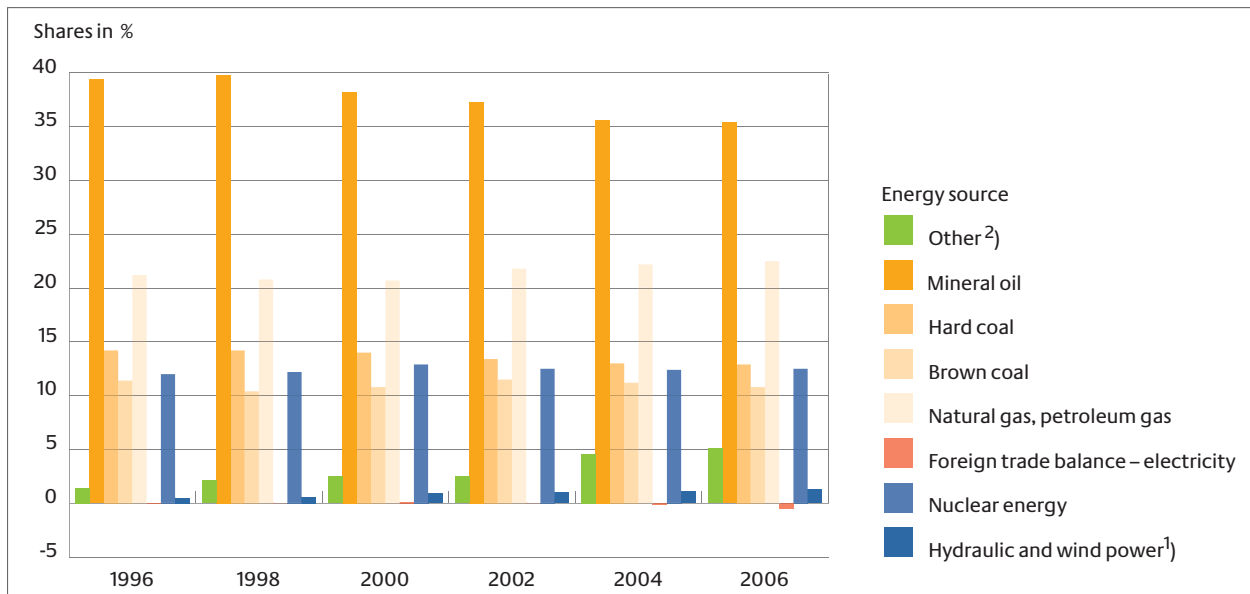
funded key energy research areas. Above all the aim is to fund the development of technologies that

- Can contribute to meeting the targets set out by the federal government in its energy and climate policy,
- Extend technological options to bring about greater flexibility in energy supply,
- Generally increase Germany's technological capability.

With its "Basic Energy Research 2020+" funding concept, the Federal Ministry of Education and Research intends to initiate research that contributes to a doubling of energy productivity between 1990 and 2020, which the federal government has set itself as a target. The funding concept therefore focuses on areas of energy research in which new technological options will be developed on the basis of fundamental, long-term research work. Application of the latest theoretical knowledge in the area of mathematical modelling, as well as basic physical and chemical research to overcome the technological problems in energy technology, will also be required.

Apart from maize (photo), biogas plants also include rye, fodder beets and grasses





Primary energy consumption by energy source in Germany

¹⁾ incl. photovoltaics, ²⁾ firewood, peat, sewage sludge, waste, other gases, etc.

A further aspect covered by the funding concept is the development of technologies that lead to a reduction in gases harmful to the climate. This includes research and development work on next generation solar energy utilisation together with use of biomass for energy and biomimetic hydrogen production

By integrating its research activities in the area of key technologies, the BMBF intends to provide a boost to innovation in energy efficiency. Materials research and development work in optical technologies and knowledge of state-of-the-art information and communication technologies are to be focused on the high efficiency generation, conversion, and storage of energy. These key technologies may contribute significantly to low-loss energy transmission.

To achieve sustainable energy supply it is insufficient to keep developing individual technologies; rather, it is necessary to look at energy systems or functional chains as a whole. There is thus a particular need for system-oriented approaches to research. This also includes the conduct of socioeconomic studies and elaboration of comprehensive optimisation concepts.

A further goal of the funding concept is to extend integration of science and industry, so that new knowledge

from the world of science can more quickly be harnessed for energy research and technology. Strategic alliances between science, industry and the public sector also play a useful role here. The BMBF firmly believes that by increasing expenditure on energy research it will jumpstart more resource from business.

Ensuring a sustainable energy supply means taking into consideration all future options for supply of that energy. By providing specific project funding the BMBF therefore will help to not just maintain the leading position of German research institutes in fusion research in Europe, but also to further build upon it.

Overall, it will be possible to achieve stronger connections not only between the worlds of science and business, but also between institutional energy research funding and BMBF project funding.

Opening position

In the 5th federal government energy research programme, BMBF involvement is via institutional funding for the “energy” research area to be carried out by the Helmholtz Association (Helmholtz Gemeinschaft, HGF), and the funding initiative “Networks – basic research into renewable energies and rational energy use”. Overall responsibility for energy policy and for the 5th federal government energy research programme is assumed by the Federal Ministry of Economics and Technology (BMWi).

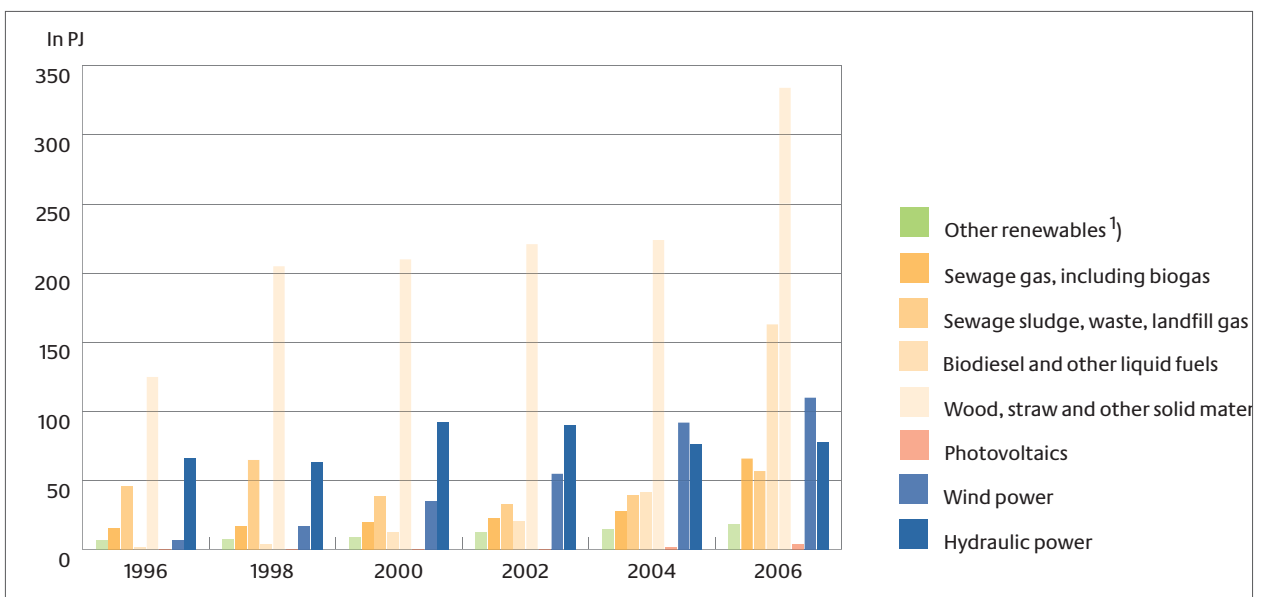
In Germany, energy research is carried out in many institutions – both public and private – as well as in business. Institutionally funded energy research and energy

technology development are concentrated in the research centres of the Helmholtz Association.

These centres cover the areas of:

- Thin-film photovoltaics,
- Solar and geothermal,
- Biomass processing,
- Power plant systems,
- Fuel cell technology,
- Fusion research,
- Nuclear safety and disposal research.

In accordance with their mission, the Helmholtz centres work on extremely complex topics involving long development times and high risks, and have the necessary test facilities, infrastructure and personnel resources for this.



Contribution of renewable energies to primary energy consumption - in PJ
¹⁾ solar thermal energy, geothermal, heat pumps



Sunlight is concentrated on the high efficiency III-V multiple solar cells

Basic research in the areas of maths, physics, chemistry and biology as well as developments in key technologies are a prerequisite for innovative energy system technologies, processes and services in the future. The “Basic Energy Research 2020+” funding concept will continue to fund research alliances, as was previously done by the BMBF under the “Networks – basic research into renewable energies and rational use of energy” initiative, and will extend funding to particularly innovative and forward-looking areas. Particular value will be attached to ensuring a close link between project funding and institutional funding for the “energy”

research area of the Helmholtz Association. These activities form part of the 5th federal government energy research programme. Institutional funding will take into consideration initial aspects of the new research policy requirements applicable as of 2010.

This also includes energy-related research activities in key technologies that are funded in other specialist programmes and do not form part of the energy research programme. Integrating research activities in the area of key technologies in this way is expected to provide a boost to innovation in energy efficiency.

Responsibility of relevant government departments for energy research

- The BMWi is responsible for the programme orientation of energy research policy (referred to as “programme responsibility”). It is also responsible for project funding in the areas of non-nuclear energy research (excluding renewable energies), rational energy conversion, nuclear safety and repositories.
- The Federal Ministry of Transport, Building and Urban Affairs (BMVBS) is responsible for project funding in the area of transportation and has partial responsibility for the area of building and housing. However, these funding activities do not form part of the federal government’s 5th energy research programme.
- The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) is responsible for project funding in the area of renewable energies (excluding bioenergy).
- The BMBF is responsible for institutional funding of energy research (in particular the HGF) as well as for basic and precautionary research. The BMBF’s responsibility therefore extends into all areas, but only activities focusing on basic research will normally receive funding. Particular importance is attached to integrating with other research areas such as materials research, nanotechnology, laser technology, microsystem technology and sustainability.
- The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) is responsible for project funding in the area of bioenergy.

Funding concept – core areas

By means of its “Basic Energy Research 2020+” funding concept, the BMBF aims to support research work into efficient energy generation and conversion, including energy storage, transmission and consumption, as well as the reduction of greenhouse gases.

In terms of the above strategic objectives, under the aspect of reduction of gases harmful to the environment the following topics are to be supported:

- Utilisation of next generation solar energy, in particular photovoltaics and biomimetic hydrogen production,.
- Bioenergy generation and conversion,
- Sustainable CO₂ storage and use.

Flexible silicon wafer with test solar cells



Contribution of core funding areas to energy policy objectives	
Objectives	Core areas
<p><i>Primary objectives:</i> Climate and environmental compatibility, security of supply, cost-effectiveness</p>	All core areas listed make a contribution
<p><i>Special objectives:</i> Increasing energy efficiency</p>	Further developments in power plant systems, fuel cell development, work on superconductivity, increasing energy efficiency in buildings including materials research, optical technologies, information and communication technologies, energy-efficient production technologies, system analyses, studies on consumer behaviour
Increased share of renewables in energy supply	Developments in the area of solar energy – including thin-film photovoltaics, organic photovoltaics, bioenergy conversion, biomimetic hydrogen production
New technological options, flexibility and diversity in energy supply	Sustainable CO ₂ storage and use, fusion research, maintenance of nuclear energy expertise in the area of safety and disposal of radioactive waste

R&D work into energy efficiency is performed in the following areas:

- Energy efficiency in final consumption sectors – buildings, industry, services, including system analyses.

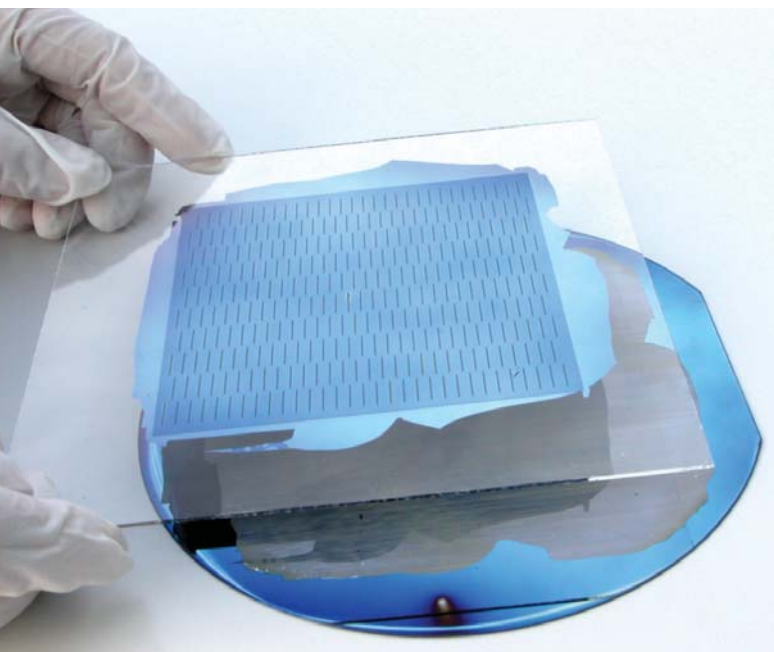
The aim of conserving and further expanding technological options is addressed by the following targeted research work:

- Fusion research, in particular measures to support ITER,
- Nuclear safety and disposal research, in particular to retain expertise.

Broadening of the funding topics is possible, such as in connection with the federal government’s national innovation programme for hydrogen and fuel cell technology or further innovative research approaches, e.g. CO₂-free heat and power generation.

BMBF provided funding should encompass topics intended for medium to long term application, which primarily involve fundamental aspects of research. The funding is provided in addition to and in close coordination with the application-oriented project funding of the BMWi, BMU and BMELV.

Next generation solar energy application ¹⁾



Removal of a wafer-thin solar module from its silicon substrate

With production capacities in the gigawatt area, the photovoltaic industry turns over some € 10 billion a year. Experts now see photovoltaics as a technology enabling CO₂-free power generation from sunlight that has almost unlimited future development potential. For instance, the European Photovoltaic Industry Association (EPIA) predicts that solar systems will meet approximately 10% of global electricity requirements by the year 2020. The prerequisite for this however is that technical development continues, to achieve far more efficient solar cells at significantly lower production costs. This can be achieved only with the help of significant basic research efforts. To this end, BMBF funding is provided in addition to, and in close coordination with, the application-oriented project funding provided by the BMU. ²⁾

Photovoltaics

In view of the various very promising developments in the field of crystalline and thin-film solar cells, it is too early at this stage to opt for a specific technology. As there remains considerable potential for development in the highly innovative areas of thin-film technology, including with respect to large-scale applications, particular priority is given to these in the BMBF funding.

Thin-film modules of all three inorganic semiconductor material classes are already in serial production. Although thin-film technologies occupy only a total of 5% of the global photovoltaics market, EPIA estimates that the share of thin-film cells will grow rapidly to 20% by 2010, assuming 30% annual global market growth of all photovoltaic technologies. The prerequisite for this is a significant improvement in technical and economic parameters.

Organic solar cells occupy a special place in the area of thin-film photovoltaics. Although organic solar cells do not currently meet requirements for use in energy supply in terms of efficiency and life, the further development of such cells is extremely important for the widescale use of solar energy, as, apart from silicon, organic semiconductors have the only almost inexhaustible raw materials for alternative photovoltaic thin-film technology. They also possess attractive benefits in view of their material properties, transparency and low production energy requirements.

Research in institutions funded by the BMBF

The research institutions institutionally funded by BMBF comprise the Hahn-Meitner Institute in Berlin (HMI) and the Jülich Research Centre (Forschungszentrum Jülich, FZJ) – both members of the Helmholtz Association – together with the Fraunhofer Institute for Solar Energy Systems (Fraunhofer Institut für Solare Energiesysteme, ISE). They focus on a wide range of issues relating to photovoltaic components and modules.

¹⁾ See also guidelines for funding in the area of “Organic photovoltaics” under funding programmes “Optical Technologies”, “Materials Innovations for Industry and Society (Werkstoffinnovationen für Industrie und Gesellschaft) - WING” and “Basic Research Energy 2020+” (due: October 14, 2007) and also guidelines for funding in the area of “Next Generation Solar Energy Systems” under funding programme “Basic Research Energy 2020+” (due: October 31, 2007) at www.bmbf.de

²⁾ Funding notices issued by the BMU can be found at www.erneuerbare-energien.de

³⁾ Amorphous / microcrystalline silicon, polycrystalline cadmium telluride (CdTe) and CIS materials (copper-containing chalcopyrite materials)

Under the Helmholtz programme on “Renewable Energies”, HMI’s work concentrates mainly on thin-film solar cells of polycrystalline compound semiconductors and on developing the potential of this material class. Research is also carried out to find new thin-film concepts based on silicon and silicon-based heterostructures. This includes new photovoltaic working hypotheses and solar cell concepts with nanostructured materials of inorganic and organic compounds and hybrid combinations. One of the key features of the HMI research portfolio is its highly specialised analytical procedures including the use of its large BER II and BESSY II research reactors.

The Institute's work schedule for photovoltaics in FZJ focuses on thin-film solar cells based on silicon and its amorphous and microcrystalline alloys. The goal is reasonably priced high efficiency photovoltaics modules.

The ISE carries out research into a wide range of photovoltaic materials and solar cell concepts. Wafer-based silicon solar cells form an important core area. The ISE also provides services relating to the characterisation of solar cells, materials for solar cells, together with modelling and the development of research instruments. In the area of photovoltaic modules, development and consultancy activities focus on performance measurement, aging and

BMBF project funding

BMBF project funding intends to specifically supplement the identified developments in a few areas. This includes reviewing current production methods in the area of thin-film cells, with the aim of reducing costs. With respect to efficiency, large-scale thin-film modules achieve values of less than 15% - not yet half the thermodynamically achievable limit value of simple solar cells.

The gap between organic solar cells and the established technology is significantly greater. As part of a strategic partnership with industry in the field of organic photovoltaics, BMBF supports this future technology so that it can more quickly be put into practical application. This funding initiative integrates the areas of basic research, application-oriented materials research and development, process technology and component-specific developments. Options are also to be explored for improving the price/performance ratio of OPV cells by increasing the efficiency, output, throughput and stability of the OPV components. Options for improving the price/performance ratio of thin-film cells can be created by improving efficiency, output, throughput and stability.

Key approaches for this include for example the areas of:

- Finding more efficient inorganic and organic materials, as well as solar cell structures and hybrid structures,
- Devising new experimental and theoretical methods for the structural and functional analysis of materials and components
- The transfer of complex structures with material systems from other areas of materials research,
- The accompanying modelling and simulation of processes in photovoltaic materials structures.

The use in energy supply of thin-film solar cells of compound semiconductors and amorphous and microcrystalline silicon is to be increased. This can be done if the efficiency of the solar cells is significantly increased or their production costs are clearly reduced. Research work will therefore also be funded that serves to clarify crucial scientific questions with the known thin-film solar cell types or opens up approaches for completely new types of thin-film solar cells.

working life estimation for solar modules integrated into equipment.

In addition to the BMU's application-oriented project funding, BMBF project funding is targeted at:

- Systematic materials research, component and system development, for medium to long term technological application,
- Basic research looking beyond existing photovoltaic technologies or those already in development and investigates completely new potential photovoltaic materials and materials systems.

Biomimetic hydrogen production

Hydrogen is the main fuel for operating fuel cells. Production of this fuel by adopting the electrolytic or catalytic methods used to date makes economic sense in only exceptional cases. Biophotocatalytic processes or photocatalysts for power technology are at the early – albeit very promising – stages of development. Based on our knowledge of photosynthesis, which has been so perfected in nature, two variants of photosynthesis can be discerned: A more natural biochemical variant and a more artificial (bio)inorganic photosynthesis. The key process in both variants is the conversion of light energy into chemical energy, especially the production of hydrogen from light.

In natural photosynthesis, water in plants is primarily split into oxygen and protons. The protons are then converted into hydrogen enzymatically. Finding a way to technologically reproduce this natural biosynthesis process is one of the great hopes for future hydrogen production.

Special biochemical processes in plants can be mimicked by inorganic substances: By using semiconductors to be specially developed, hydrogen can be produced by splitting water using light.

The investigation of these and similar photobiochemical or (bio)inorganic processes for producing hydrogen is the subject of intensive research worldwide. Once photosynthetic splitting can be efficiently effected in one of the systems described, a renewable, carbon-dioxide-free energy source will become available.

BMBF pro Funding concept ject funding

BMBF project funding focuses on the practical application of photobiological hydrogen production within the scope of research projects with an interdisciplinary structure; in other words, on transferring the special processes of natural photosynthesis into an artificial photosynthesis that can efficiently produce the energy source hydrogen from light energy. The feasibility in principle of the basic concepts has already been demonstrated. All problems connected with transferring basic knowledge into technical knowledge to produce hydrogen are the objective of funding.

The aim is to achieve a close link with BMBF's ongoing research activities into biological systems, in order to obtain a better and more comprehensive understanding of photosynthetic processes (e.g. GoFORSYS).

Bioenergy conversion



Biomass is the most significant regenerative energy source in Germany. With a primary energy share of 3.3% (2005), it makes the biggest contribution among renewables and has potential for further development. For instance, were an additional 2 million hectares of land to be set aside for cultivation of energy plants, the share of biomass in final energy consumption could be increased to approximately 10%. In addition to agricultural cultivation techniques for higher terrestrial plants in open fields, the mass cultivation of microorganisms (algae) in closed process plants with low water and energy requirements presents completely new potential for efficient biomass production. This option is already of great interest not only due to the high energy efficiency for combined heat and power utilisation, but also in particular due to the favourable CO₂ balance. It also offers great flexibility due to the decentralised use of resources and the broad raw material base

Biomass generally offers two possibilities for energy recovery:

- Direct energy recovery through combustion and power plants with the aim of obtaining heat and power and so replacing fossil energy sources.

- Indirect energy recovery by biomass conversion into chemical energy sources such as fuels, biogas or hydrogen.

Biomass use is already widespread, but by focusing on specific research and development activities, the goal is to optimise existing processes, to combine techniques (cascade utilisation) and to develop new processes for utilising the limited quantities of biomass raw material as efficiently and sustainably as possible. Closed nutrient cycles, such as those sought in “zero waste” biorefinery concepts, require the integrated research and development of optimised production and conversion systems. Technological processes are combined with processes used in green and white biotechnology, contributing to enhancing value and protecting resources.

Research in BMBF funded institutions

Research into the use of biomass is carried out primarily at the FZK research centre. Pioneering work on energy recovery based on thermochemical processes was done here. The structure of entire process chains from plant to material and energy utilisation has been successfully demonstrated, with work now culminating in the construction of the BioLiq

facility which when completed will enable products to be obtained for fuels or chemical raw materials. In parallel to these activities work is continuing on direct energy recovery in either centralised or decentralised facilities.

The general aim of biomass utilisation research at FZK is the raising of output through increased efficiency while minimising any possible environmental impact. The UFZ also carries out research work in this area. Work here focuses primarily on the subject of competitive land utilisation.

In the near future the following topics are to be addressed in co-operation with both universities and industry:

- Basic molecular principles of biomass production,
- Biomass preparation,
- Biomass recovery using thermochemical and biotechnological methods,
- Environmental impact, system analysis and technology impact assessment.

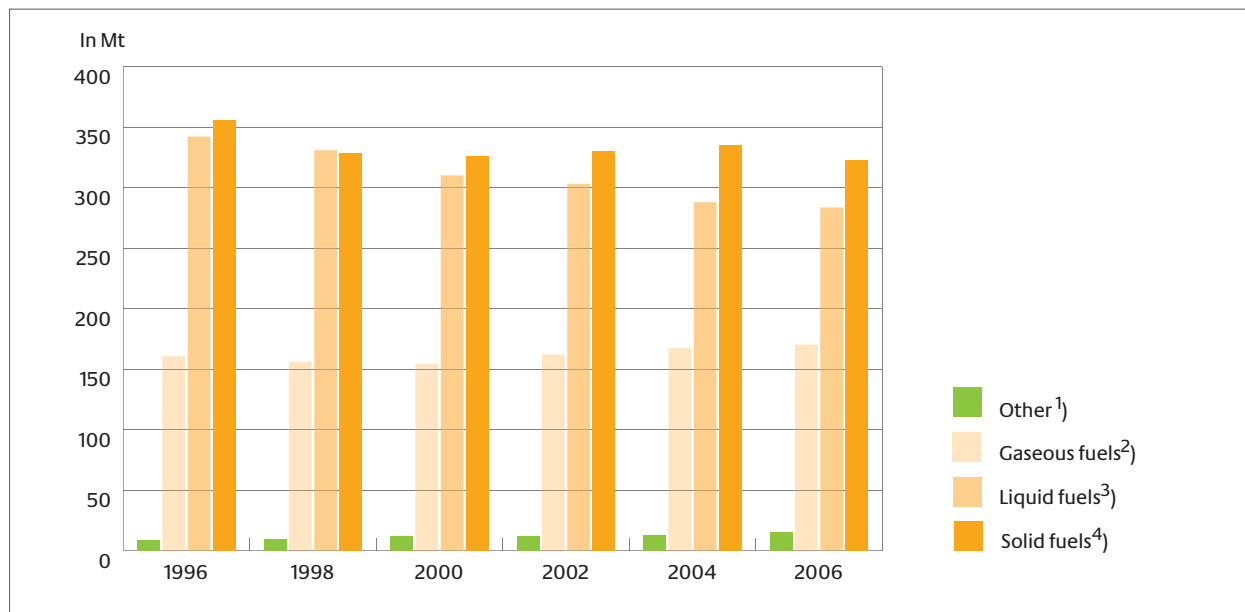
BMBF project funding

The generation of heat and power as well as that of biofuels is considered to be cutting-edge technology. Yet there is a need for research to which basic research is expected to make an important contribution. On the one hand, this involves molecular biological research and subsequent optimisation of plants for biomass production (GABI FUTURE). On the other, of central importance is basic research into the various conversion pathways for the utilisation of biomass. Conversion pathways are considered to be the gasification of solid biomass and the anaerobic fermentation of biomass via biogas to the combined generation of heat/power and/or power/fuel/heat. Other methods include extraction processes, e.g. to obtain vegetable oils.

The core areas cover the overall process of biomass production up to conversion into the desired final energy form, and serve to

- Increase energy source flexibility,
- generate synthetic gases and product gases as well as develop new types of biofuels (including cascade utilisation),
- Develop innovative gas separation, gas cleaning and/or gas conditioning processes,
- Develop the physical and process-technology fundamentals for new forms of electrical energy generation in biogas facilities, with waste heat utilisation,
- Model the entire material and energy conversion chain, including the removal of pollutants.

Efficient conversion and use of energy



Energy-related CO₂ emissions by energy source in Germany

¹⁾ including statistical differences. ²⁾ natural gas, petroleum gas and mine gas, ³⁾ including liquid and refinery gas; excluding aircraft fuel consumption for international air traffic (80% of all traffic fuel consumption in Germany is in air traffic), ⁴⁾ including coal, city and fuel gases, NB: Differences to values in other tables result from varying calculation methods and emission factors.

In terms of energy efficiency the standard of energy-technologies currently available is high. Thanks to developments and the high level of expertise of German scientists and engineers in the energy technologies sector, contributing to energy efficiency and the protection of resources in industrial processes, a flourishing economic sector has emerged that is active worldwide. However, leading studies conclude that merely continuing to develop and expand the energy technologies available today is not enough to meet the requirements set by international sustainability strategies, for example within the scope of the Kyoto Protocol, or further-reaching strategies to reduce CO₂ emissions and ensure climate protection. As a result, new and unconventional approaches will be required for the future, which based on the latest findings in science and technology will make it possible to leap ahead in terms of efficiency in the conversion and utilisation of energy.

In this respect, the BMBF intends to apply its funding and support in parallel to the following three areas of research activity into energy efficiency:

- Institutional funding to fundamental and long-term research into energy efficiency,
- Project funding to system-oriented research into energy efficiency,
- Research approaches for greater energy efficiency in existing programmes within the research areas of “Key technologies” and “Sustainability”.

Institutional research funding for energy efficiency

The Helmholtz “Rational energy conversion” programme involves primarily the three HGF centres: DLR, FZK and FZJ.

Individual programme areas are:

- Power plant technology (efficient and environmentally friendly power generation),

- Fuel cells (decentralised and environmentally friendly power generation),
- Superconductivity (the reduction of electrical transmission losses in the grid)

These areas are aimed at the development of new technologies for power generation and electrical energy transmission.

Future research in these areas is to be extended. This will involve adopting new research approaches that open up new opportunities for renewable and fossil energy sources (a smart link between the form and utilisation of energy, fundamental work on thermochemical processes); equipping and upgrading existing power plants to incorporate CO₂ capture facilities; and intensifying research work into energy storage.

BMBF project funding for system-oriented research into greater energy efficiency.

In addition to the application-oriented project funding of the BMWi, BMBF project funding intends to specifically support research into raising energy efficiency especially with respect to the use of energy in buildings, industrial production and services. Basic research is to make an important contribution to the use of innovative components, processes or design strategies aimed at increasing energy efficiency. The approach adopted will therefore be based on both problem resolution and basic principles. Thus, known technical problems that currently impede adoption of a technology to increase energy efficiency will be eliminated through new approaches to basic research (technical pull). Furthermore, the possibility will also be created for the testing and further development of new fundamental knowledge for application in energy technology within a framework of interdisciplinary cooperation between science and energy technology (science push).

In the building sector application of the latest basic findings should lead to progress in the increasing of energy efficiency in the following areas::

- New materials and components for construction techniques,
- Energy-efficient components in building equipment for heating, ventilation and lighting purposes,

- Modelling and simulation for the development of better building designs and systems that use energy more efficiently, as well as the energy optimisation of the design and layout of entire communities.

There are plans to fund system-oriented projects, such as activities to create energy-efficient cities or smart grids, as well as projects with comprehensive system analysis studies into energy efficiency. Research will be carried out in particular into the systemic aspects of the generation, storage, transmission and efficient consumption of energy. This will involve consideration of the aspects of resource protection, cost-effectiveness, competitiveness, the environment and sustainability.

Funding is also to be given to areas that contribute to increasing the energy efficiency of industrial processes, including the service sector:

- Development of new processes and process management strategies,
- Significant improvement of the efficiency of materials and resources,
- Development of substitution strategies,
- Innovative energy-efficient machines and facility concepts.

Research work into superconductivity and the development of new materials for power plant technology are also important aspects for increasing energy efficiency. Efficiency in industrial production should also be increased through the intelligent design and construction of technical products.

Priority goals in fuel cell research are increasing the life, robustness and performance of the cells, reducing costs and developing new methods for analysis of the aging mechanisms and for quality assurance.

Project funding in the areas of key technologies and sustainability for greater energy efficiency

In the ongoing and planned core funding areas, the BMBF supports a wide range of research activities that may lead to energy savings. In future, these are to be dovetailed with the activities of the institutionally funded research and the new system-oriented research approach. This mainly concerns the following areas of direct and indirect energy savings through the application of modern technologies:

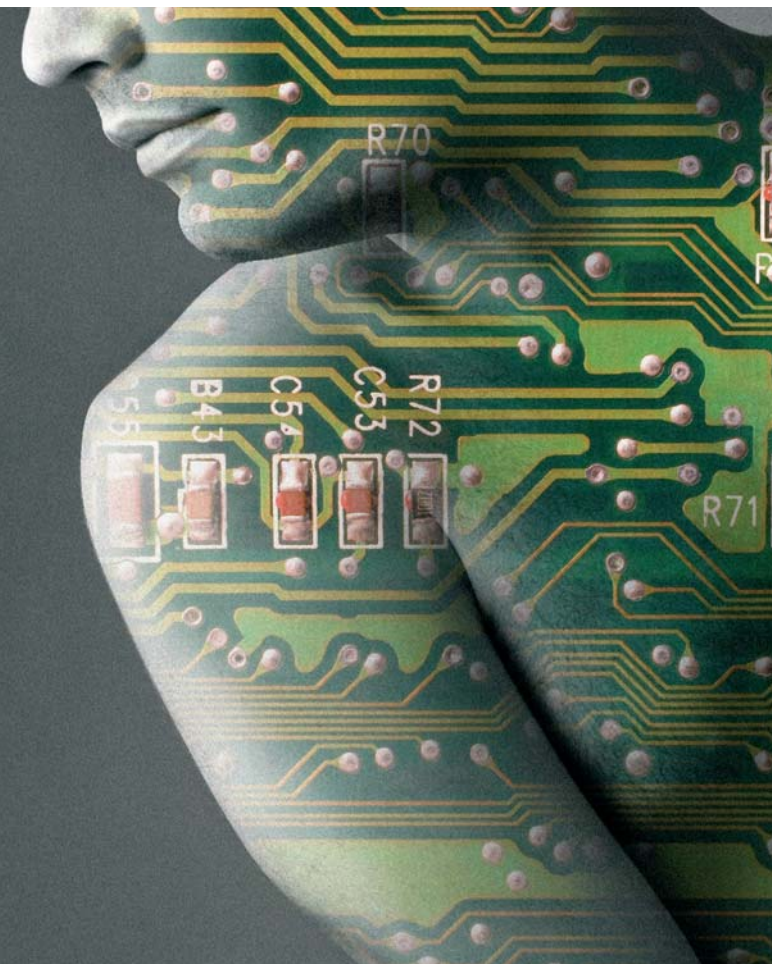
- **Materials research for products and processes with high resource efficiency**
The use of resource-efficient materials in technical systems can significantly contribute to savings in energy, materials and production time. Technologies should therefore be tested that on the one hand protect natural resources and that on the other, for companies and consumers, contribute to increased productivity and/or reduced costs, particularly with respect to material costs.
- **High performance materials for greater energy efficiency and CO₂ savings**
The focus is on developments for new or clearly improved materials that on the basis of extended limit load (thermal, mechanical, corrosive and/or chemical) make it possible to increase power densities and efficiencies of energy and engine conversion processes. Such developments should also contribute to clearly increasing the reliability, safety and life of critical components, particularly in energy and vehicle technology, mechanical engineering and aviation. This objective also incorporates significant reduction of harmful emissions in energy and traffic technology.



Organic light emitting diode on flexible substrate

- **Nanotechnology for the building sector**
The main aim is the application of nanotechnology in building to improve energy efficiency. The use of nanotechnology in building frontages, windows and roofs can contribute to energy efficiency. Nanomaterials can also contribute to energy savings in the production of building materials.

- Research projects into the use of light
Use of light from semiconductors (LED + OLED) and plasmas should help reduce energy consumption for lighting in Germany by 20% over the next 10 years.



- Development of modern laser production processes
This would make possible the reduction of weight in vehicles, ships and aircraft through the use of lightweight building technologies. Laser-optic measuring and analytical methods make possible gaining of a better understanding of combustion processes in modern combustion engines.
- Contributions from the area of energy-efficient information and communication technologies (ICT)

These may lead to energy savings in mobile telephony (e.g. through consistent application of gallium nitride) or to the production of extremely energy-saving electronic and opto-electronic components. Using such “spin transistors” or “spin diodes” could cover the growing demand for energy of e.g. future high performance computers in an energy-efficient way.

- The aim of this technology is to minimise use of energy and resources in industrial production and avoid harmful emissions and waste. Examples include joint projects exploring process technology in which material loss is minimised, or organisational models and information systems for operational environmental protection. The future focus will be on developing and researching innovative machine and facility concepts and on the development of energy-efficient process chains in production. There are also research activities into increasing the productivity of resources in production systems handling raw materials. The focus is on industrial application areas with high material consumption and strong dependence on raw materials, such as the refining and processing of ores, mineral raw materials or chemical base products.
- Bionics
Bionics involves utilising the vast repertoire of ideas from living nature to find the best possible solutions for product developments. With minimal utilisation of energy and resources, multifunctional optimisation and complete recycling of residual waste the systems used in living nature provide excellent templates for corresponding innovation. Bionics is also key to innovations in areas in which conventional methods have so far delivered only small steps toward improving the status quo, and has corresponding potential for greater resource and energy efficiency.
- Hydrogen or methanol micro fuel cells
These are likely in the foreseeable future to supersede the customary energy supply systems, such as lithium-ion batteries, in many portable electronic devices. To achieve industrialisation fundamental questions remain unanswered, such as the materials to use for the membranes and the hydrogen storage. The miniaturisation and system integration of individual components, and the

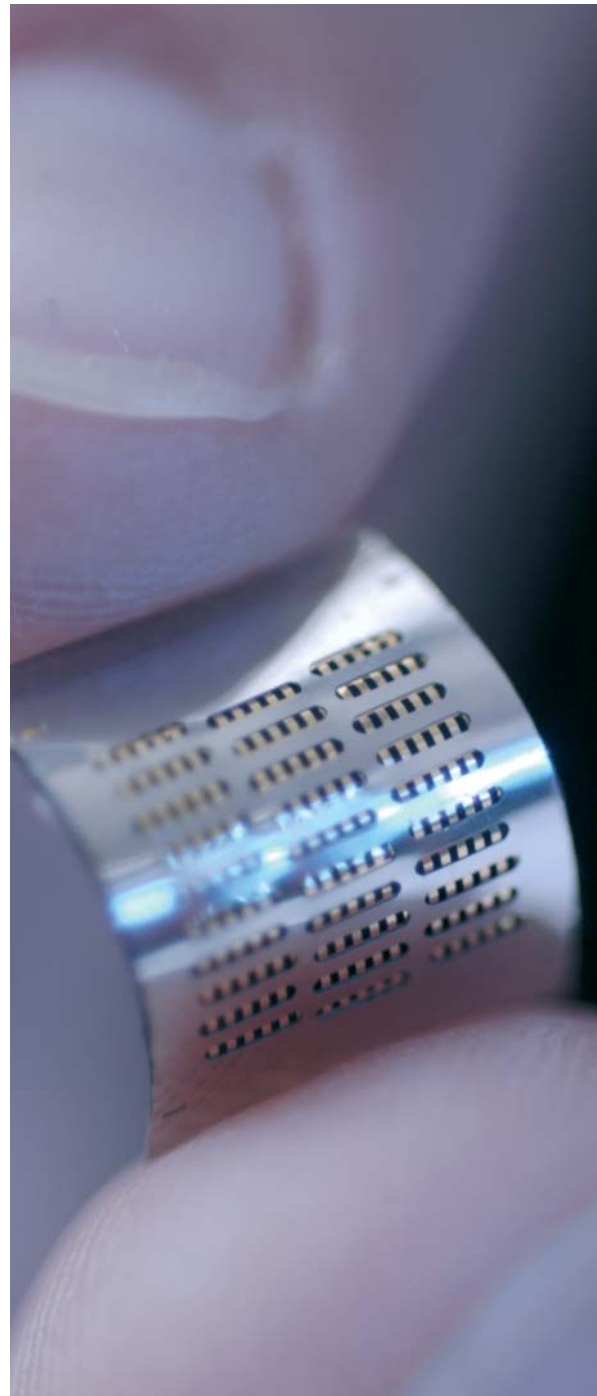
manufacture itself, of micro fuel cell systems do not yet meet the needs of a marketable product. “Lead innovation: micro fuel cells” will fund projects aimed at enabling access to the micro fuel cells market.

Social and business sciences studies focusing on energy efficiency

At the centre of BMBF project funding in the area of social sciences is research into the conditions and scope for energy-efficient consumer and production behaviour and corresponding lifestyles..

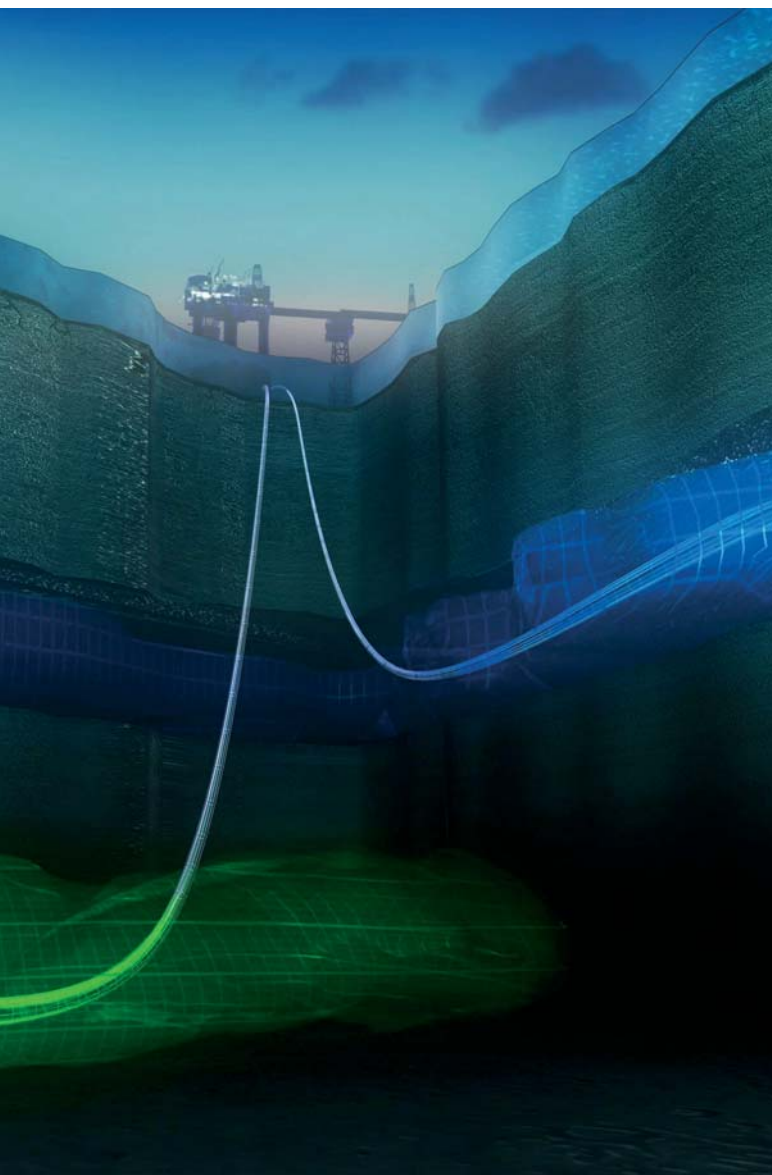
Research and development projects are funded within the framework of socio-ecological research into the core theme “From knowledge to action – new approaches to sustainable consumption”. Particular importance is attached to the aspect of energy efficiency. The funded projects aim inter alia to demonstrate new ways of changing everyday consumption routines, to strengthen consumer power by forging innovative relationships between consumers and producers, and understanding – and where necessary changing – traditional ideas about quality of life.

The funding initiative “Business sciences for sustainability” is to fund innovative approaches from a macroeconomic perspective that offer practicable solutions in the area of sustainability policy and help anchor business science arguments more firmly in German and international debate on sustainability. The focus of this research should thus be more strongly directed towards the economic conditions and mechanisms of an energy-efficient economy. In addition to looking at relationships between consumers and producers, this will primarily be examining how to achieve a sustainable economy even under the conditions of global competition



Micro fuel cells in a film construction

Sustainable CO₂ storage and use



Injection of captured CO₂ into saltwater bearing sand layers (green: stratum conveying natural gas, blue: CO₂ injection stratum)

Approximately 40% of CO₂ emissions, both in Germany and worldwide, come from fossil-fired power plants. Current forecasts by the International Energy Agency (IEA) predict that the quantity of power generated globally based on fossil

energy sources will by 2030 be more than double today's levels. In Germany black and brown coal alone account for 24% of energy generation. In addition to increasing the efficiency of existing fossil-fired power plants, in order to reduce harmful emissions it is then necessary to develop and test new technologies for the capture and storage of CO₂ for future energy provision.

Carbon capture and storage technologies (CCS) are of key importance in this respect for the implementation of a sustainable climate policy. In the next few years, German energy supply companies are planning to construct pilot and demonstration installations for CO₂ capture based on the so-called clean coal technologies. A number of different processes for CO₂ capture are to be tested in pilot and demonstration systems. This is just as valid for existing power plants, in the form of retrofitting CO₂ capture, as for new, modern clean-coal power plants with integrated CO₂ capture.

The captured CO₂ must be transported and then put into carrier rock in geological formations. In Germany, CO₂ storage in geological formations is available in the form of natural gas and natural oil fields that have been exploited to a greater or lesser extent, together with deep-lying aquifers on land or beneath the ocean floor of the North Sea and Baltic Sea.

While the BMWi funds research and development work in the area of "Modern power plant technologies incl. CO₂ capture" as part of its COORETEC program, the BMBF focuses on research and development work into underground storage of CO₂ in its activities within the scope of the federal government's CCS strategy. Research work primarily concentrates on natural gas reservoirs and saline aquifers at specific sites, as well as basic research into determining the geochemical and geomechanical reactions of carrier rock with CO₂ over the course of time. In this respect, funding projects incorporate storage technologies and monitoring techniques for the operational phase, as well as appropriate long-term monitoring including primarily local public relations work. To implement the results of the prototype and/or demonstration projects, the corresponding legal requirements must be defined, particularly with respect to the large-scale application of CO₂ storage at specific sites.

BMBF project funding

The BMBF has been funding research work into the area of underground storage of CO₂ since 2005 as part of the GEOTECHNOLOGIEN programme run by BMBF and DFG. The corresponding expertise has thus been accumulated at German research institutions. Existing research approaches, based on non-site-specific studies, are to be further developed as from 2008 as part of this BMBF funding concept. Existing shortcomings are to be targeted, to create a broad foundation for future technological applications. In particular, alternative concepts are to be re- and/or further developed, which in combination with other technologies may in future provide economically as well as technologically attractive options and/or contributions to climate protection.

Science and technology must be further developed on both site-specific and non-site-specific bases. Funding notices regarding basic non-site-specific research into CO₂ storage are in particular aimed at research alliances between science and industry involving interdisciplinary issues.

The test storage system at Ketzin (Brandenburg), which was initiated with the first deposit of CO₂ in a deep saline aquifer under a depleted gas reservoir as part of a project financed by the EU (CO₂SINK) in 2007, forms an important starting point for future commercial storage in deep saline aquifers. The behaviour of the rock in response to CO₂ storage, the mobility behaviour of the CO₂ and the integrity of the storage stratum will be studied as part of an extensive technological programme in subsequent long-term experiments.

Project alliances between industry and science are also desirable for site-specific research work into CO₂ storage. While industry is responsible for the construction of its facilities both in the areas of clean-coal power plants and safe deposition, the BMBF together with business will fund on-site geoscientific research in parallel with the building work. The approval authorities are to be included in these pilot projects in order that approval steps for a subsequent large-scale plant are simulated in parallel to the approval procedure during the pilot phase. In this way, open questions relating to the subsequent industrial use of CCS technology can be specifically identified and tackled at a very early stage.

Research activities include questions relating to the exploration, selection and evaluation of sites, as well as the analysis and evaluation of the interactions of CO₂ with the reservoir medium and overlying rock, and the development of up-to-date monitoring and injection technologies. Questions relating to risk assessment and the security of long-term storage must be answered comprehensively.

In future, consideration will also be given to research work into alternative uses of CO₂ as a raw material for industry.

Nuclear fusion



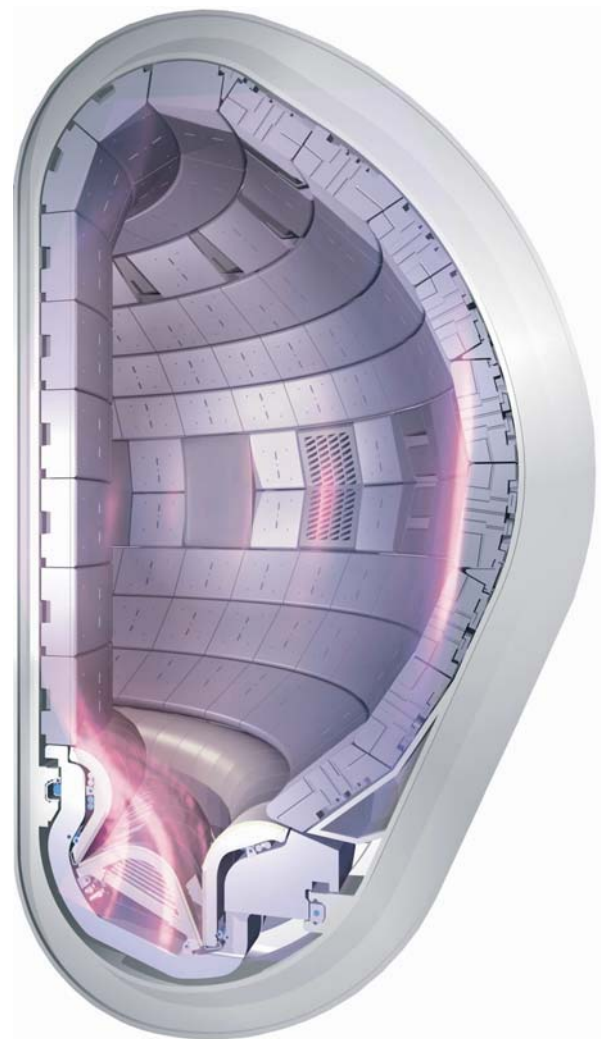
Installation work in the combustion chamber of the TEXTOR experiment

Nuclear fusion is a long-term option for energy supply that emulates the process by which the sun produces energy. It possesses a number of desirable features: Large fuel reserves, good safety characteristics and climate neutrality. Generation of energy via nuclear fusion releases no greenhouse gases, nitrogen oxides or sulphur oxides.

The German fusion research institutes are among the global leaders. This excellent basis of expertise is to be retained and further expanded for the future, in order that it may also play an intensive role in the ITER international research and development programme. Through its funding the BMBF intends to ensure that the potential in fusion research is optimally utilised and that Germany's leading position in terms of knowledge and know-how in this area is retained.

For the technical realisation of nuclear fusion Germany is pursuing two concepts for the magnetic confinement of the fusion plasma: The tokamak and stellarator principles. ITER, the international large-scale project being jointly built by Europe, Japan, China, India, Russia, South Korea and the US, is based on the tokamak principle. The largest and most

advanced experimental stellarator in the world, Wendelstein 7X, is being built in Greifswald with the aim of demonstrating the suitability of this type of facility for power plants. Unlike tokamaks, the different magnetic confinement concept used by stellarators enables them to run in permanent operation right from the outset. Once the knowledge gap with the tokamak experiments, which have now been undergoing development for many years, has been successfully reduced, it will be possible to build the demonstration power plant succeeding ITER following the stellarator principle.



Cross-section through the ITER plasma vessel with animated plasma

Research in BMBF funded institutions

To date, fusion research in Germany has been funded institutionally only at the Helmholtz centres (Jülich research centre, Karlsruhe research centre and Max-Planck Institute for Plasma Physics in Garching and Greifswald). In addition to research work (including theory development) based on plasma physics exploring tokamak and stellarator physics, technological and engineering work having regard to ITER and DEMO (the future demonstration power plant) is also carried out into plasma-wall interaction, plasma heating and the development of materials for future fusion reactors. Commissioning of the Wendelstein 7X experimental fusion reactor in Greifswald is therefore a priority goal of German fusion research.

With the realisation of ITER the feasibility of power generation from fusion processes using burning fusion plasma in the 500 MW class will for the first time be demonstrated. In addition to the construction and operation of large-scale fusion experiments, further steps in the

implementation of a fusion power plant are indispensable. Such steps include in particular further progress in the areas of plasma modelling and plasma-wall interaction, as well as research and development work into the fuel cycle and tritium cycle, the development of diverters, magnet technology and suitable structural materials for a fusion-reactor. As fusion experiments come ever closer to the achievement of a power reactor, work in the area of fusion technology takes on an increasingly important role

BMBF project funding

To support the German fusion research institutes and German industry in their efforts to attract orders for ITER, within the scope of the present funding concept is initiated project funding that goes beyond the level of institutional funding, in which broader approach activities are also to be incorporated. By setting up consortia between industry and research institutes, rapid transfer of know-how from research to practical application should be underpinned. These efforts that go beyond institutional funding are particularly necessary in view of the massive support given by their governments to research institutes in some EU Member States in the procurement (and subsequent implementation) of orders for industry.

Examples of participation in ITER-related projects include the construction and operation of

a helium loop at FZK (HELOKA), with which helium-cooled solid blankets are to be tested for use in ITER, and further tests on advanced scenarios for plasma control being conducted at IPP. One possibility for the management of instabilities in the plasma is the use of a conductive wall in combination with internal control coils. ASDEX Upgrade, the tokamak built by IPP Garching, is optimally suited to the testing of this process. If successful, this process would then be applied in ITER – this would be an outstanding result even by comparison with international competition.

Together with Belgian and Dutch institutes, the FZJ is currently processing bids for the building of a diagnostic port for ITER. Socio-economic studies are also to be carried out with respect to a future fusion power plant.

Nuclear safety and disposal research

In the area of nuclear safety and disposal research, R&D work is carried out on the scientific and technological aspects of safety in existing nuclear reactors, the safety of nuclear disposal and the minimisation of highly radioactive substances ultimately requiring disposal. Research work focuses on long-term aspects for which costly testing facilities specific to large-scale research are required, major computational capacities, and/or infrastructures. The work performed is in accord with the resolution for the structured phasing-out of the use of nuclear power, as until the last nuclear power plant is shut down it is absolutely essential that the safety of these nuclear reactors is ensured in line with the respective state of the art of science and technology. In addition, expertise in nuclear technology is also necessary for the dismantling of nuclear facilities and their safe disposal.

To enable industry, power plant operators and approval authorities to carry out this task, expertise in nuclear technology must be available and developed at the highest levels of science and technology. This requires not only extensive (fundamental) academic training in nuclear technology at universities and colleges, including training for the next generation of scientists, but also the further training of those personnel working in power plants and approval authorities.

Non-university establishments in conjunction and close co-operation with universities and colleges contribute to both aspects.

Research in BMBF funded institutions

Two Helmholtz research centres (FZK and FZJ) and the Dresden-Rossendorf research centre (FZD) belonging to the Leibniz Association, which are institutionally funded by the BMBF, work in the area of nuclear safety and disposal research. Since 2000, the Alliance for Competence in Nuclear Technology in Germany has pooled the available capacities and coordinated research and teaching activities. This alliance brings together the non-profit company for plant and reactor safety (Gesellschaft für Anlagen- und Reaktorsicherheit mbH, GRS), the Federal Institute for Geosciences and Natural Resources (Bundesanstalt für Geowissenschaften und Rohstoffe, BGR) and the Materials Testing Unit (Materialprüfungsanstalt, MPA) of Stuttgart University, in addition to the two Helmholtz centres – FZK and FZJ – and the FZD. Partners include neighbouring universities (RWTH in Aachen and FH Aachen/Jülich; the

universities of Karlsruhe, Stuttgart and Heidelberg; TU Dresden and FH Zittau/Görlitz; TU Munich). Other permanent guest participants are the European Institute for Transuranium Elements, the IAEA and the European Nuclear Education Network (ENEN). The aim of the Alliance for Competence in Nuclear Technology is to further intensify co-operation between research institutions and neighbouring colleges, and to coordinate and pool publicly funded nuclear safety and disposal research. With the active involvement of nuclear facility operators and producers, the Network for Competence in Nuclear Technology in Germany significantly contributes to the funding of the next generation of qualified scientists, offering postgraduate scholarships and establishing endowed chairs.

Within the framework of the nuclear safety research programme run by the Helmholtz Association, topics such as safety research for nuclear reactors, minimisation of highly radioactive waste via partitioning and transmutation, and safety research into nuclear disposal are worked on by the Jülich and Karlsruhe research centres. The Rossendorf research centre carries out research work into the integrity evaluation of reactor components, simulation of incident procedures in nuclear facilities, radiochemistry and radioecology, particularly with respect to contaminated sites from uranium ore mining.

A key feature of all research and development work is close involvement in European and international joint ventures (such as the EURATOM framework programme, IAEA and OECD/NEA activities) and projects, to integrate international findings and safety concepts into its own research.

Within this context must also be viewed the participation of German researchers in international activities (such as Generation IV International Forum and INPRO/International Project on Innovative Nuclear Reactors and Fuel Guides) with the aim of harnessing international know-how in the areas of passive safety systems and waste minimisation for use in Germany. The aim in future is for the Helmholtz centres to have greater involvement in these activities with resources provided by institutional funding.

BMBF project funding

With the “Basic Energy Research 2020+” funding concept, institutionally funded work is to be supplemented in a few core areas to further extend co-operation with universities. Close coordination between institutional and project funding will be ensured via the Alliance for Competence in Nuclear Technology in Germany.

The planned funding notice is to focus on the following areas:

Safety research for nuclear reactors

- Numerical computational tools for reactor and facility design
The aim is the development and qualification of linked programming systems that are based on three-dimensional neutron kinetics programmes, multiphase fluid models and structural mechanical models of reactor components (multi-scale and multi-physics approach). Of particular interest are three-dimensional computational fluid dynamic processes having high temporal and spatial resolution (CFD codes).
- Thermohydraulic and material-specific experiments
The objective is to perform high spatial- and temporal-resolution thermohydraulic experiments to obtain a better understanding of flow phenomena resulting from design-attributable accidents. Funding may also be directed towards material-specific experiments to analyse the operation-dependent aging of power plant components, due for example to cyclical loads and radiation, as well as the setting-up of a universal database for validating the computational tools developed under point 1.

Safety research into nuclear disposal

- Characterisation of radioactive waste
The aim is to develop methods, particularly for the characterising, sorting, separating and then conditioning of radioactive materials, as well as to further develop neutron activation analyses for characterising waste.
- Proof of safety of permanent disposal
The development and validation of computational tools that can be used to provide long-term geochemically-based proof of safety of permanent disposal.
- Disposal of nuclear waste
Development and optimisation of innovative processes for the effective separation of long-lived radionuclides from highly radioactive waste (partitioning), for transmutation or immobilisation for final storage, including quantum chemical studies.

Radiation research

The funding of radiation research, e.g. research into the impact of small dose values on biological systems, is to be extended.

Funding new blood

Project funding in the above research areas is directed particularly toward the supporting of the next generation of scientists. In this respect, funding activities will be developed that are geared toward new scientists (such as PhD programmes, post-doctorate funding).

BMBF funding in the area of “Nuclear safety and disposal research” is provided in addition to and in close coordination with BMWi project funding.

Funding resources



The BMBF provides resources for energy research in two areas:

- Resources for direct project funding in energy research
- Resources for institutional funding of the “Energy” research area of the Helmholtz Association (HGF)

The medium term planned utilisation of resources is set out in the following tables.

Microalgae as a hydrogen plant in a photobioreactor

BMBF energy research (project funding)				
	2007 in € millions	2008 in € millions	2009 in € millions	2010 in € millions
Networks - basic research into renewable energies and rational energy use	+12,0			
Rational energy conversion ¹⁾	+65,3	+90,4	+91,0	+91,0
Renewable energies		+14,0	+14,5	+13,0
Nuclear safety and disposal research		+7,0	+9,0	+10,0
Radiation research		+3,0	+4,0	+4,0
Fusion research		+11,0	+11,0	+12,0

¹⁾ Includes resources from the areas of key technologies and sustainability

BMBF energy research (resources for the Helmholtz Association)				
	2007 in € millions	2008 in € millions	2009 in € millions	2010 in € millions
Rational energy conversion, renewable energies	+53,0	+54,8	+56,8	+58,8
Nuclear safety and disposal research	+33,5	+33,5	+33,5	+33,5
Fusion research	+114,9	+114,9	+114,9	+114,9

International co-operation

International co-operation now plays a major role in BMBF funded energy research activities. This is true particularly for the funded research institutions. This co-operation work is where possible to be further extended, since - especially where significant investment is required in the research infrastructure - breakthrough discoveries in energy research are not usually achieved through national work alone.

Multilaterally the BMBF takes part primarily in projects within the framework of the International Energy Agency (IEA), the OECD and the European Commission.

In its 7th research framework programme the European Union prepares not only a broad foundation for basic research, with the establishment of the European Research Council, but also in calling for energy-specific work programmes focuses on a large number of highly innovative research topics, covering in part explicit aspects of basic research. Additionally within the European research area basic research and energy research are specifically linked in the framework of the ERA-Net INNER project (INNovative Energy Research). As part of this project, with the support of BMBF and coordinated by Project Management Jülich (Projektträger Jülich, PtJ), organisations from nine European countries work on topics and modalities for jointly funded activities. The first funding notice issued by the ERA-NET INNER project, published in spring 2007 jointly by Germany and Scandinavian countries, was not only extremely well received, but also proved – including with respect to the substantive quality of the project proposals presented – that European co-operation can add value in working on a large number of topics in the area of basic research.

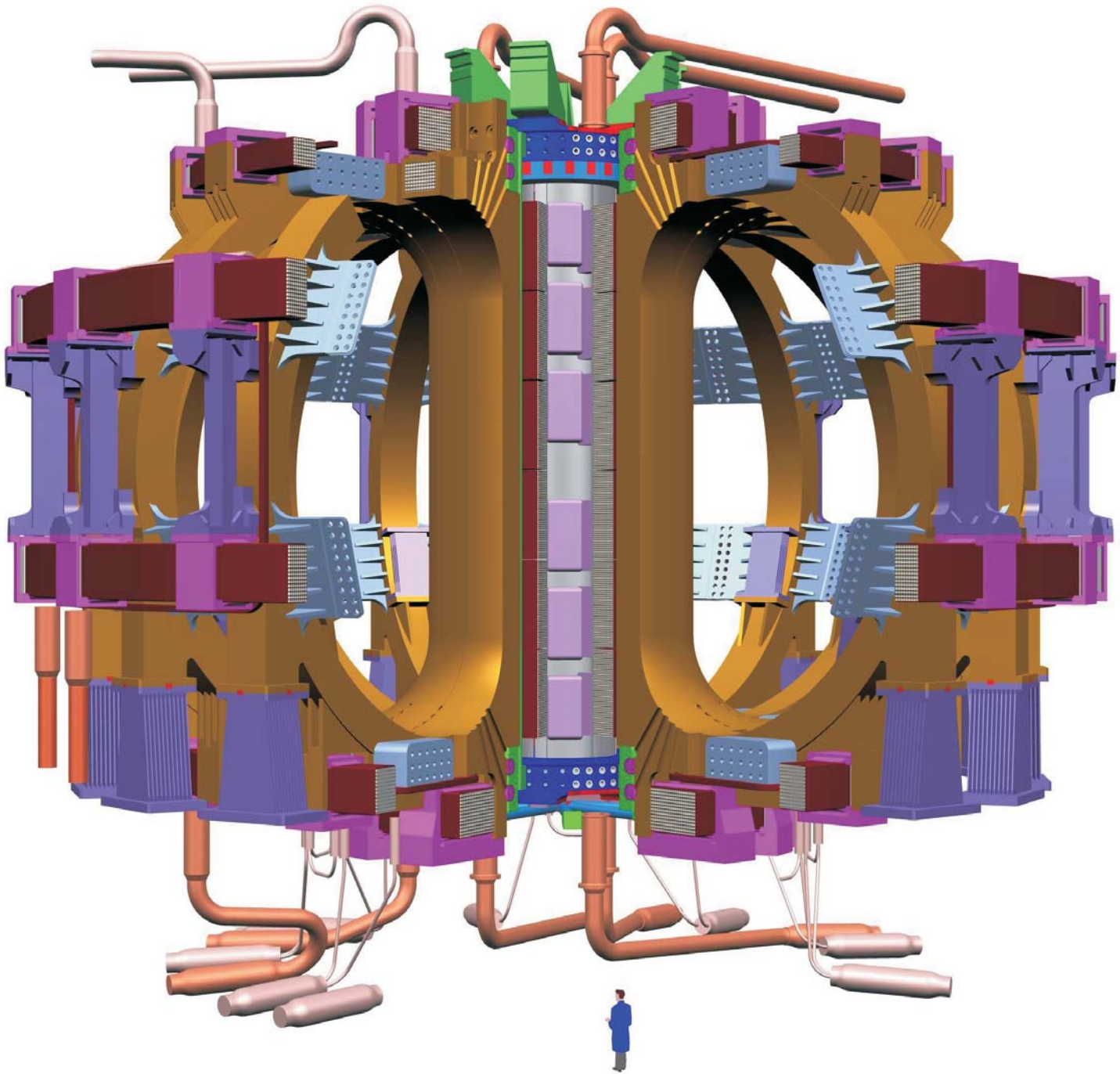
Germany is involved in European activities via the EURATOM treaty. This applies in particular in the area of fusion research. The BMBF is involved via Euratom in the international fusion experiment ITER (Latin for 'the way'), which is being built by the European Union, China, Russia, Japan, the US, India and South Korea in Cadarache, France. Construction costs amount to approximately € 5.3 billion.

Burning fusion plasma in the 500 MW class, ITER aims to demonstrate for the first time the feasibility of producing power from fusion processes. ITER therefore represents a decisive step along the road to the establishment of a commercial fusion power plant.

The International Energy Agency (IEA) research programme, of which Germany has been a member since its formation in 1974, offers a particularly suitable platform for global co-operation. Structured after the core areas of energy technology, the programme incorporates a large number of co-operation projects, jointly defined by the Member States and open also to participants from non-Member States, which are run on the basis of formal rules. The projects encompass the entire spectrum, from research through development to preparation for market entry, for example in issues of standardisation and norms. The importance of science's contribution has also been argued in this context at various workshops and conferences. The findings have been summarised in the report "Science for Today's Energy Challenges" and are available to the public. For the implementation of these recommendations the approved IEA co-operation structures may be employed.

Bilateral co-operation is welcome in all of the above funding areas. It is intended to sound out in particular options for (more intense) co-operation with the US and Canada once the funding concept has been launched

⁴⁾ <http://www.iea.org/cert/ahgset/AHGSET.pdf>



Schematic drawing of the magnetic coils and cooling tubes of the international nuclear fusion experiment, ITER

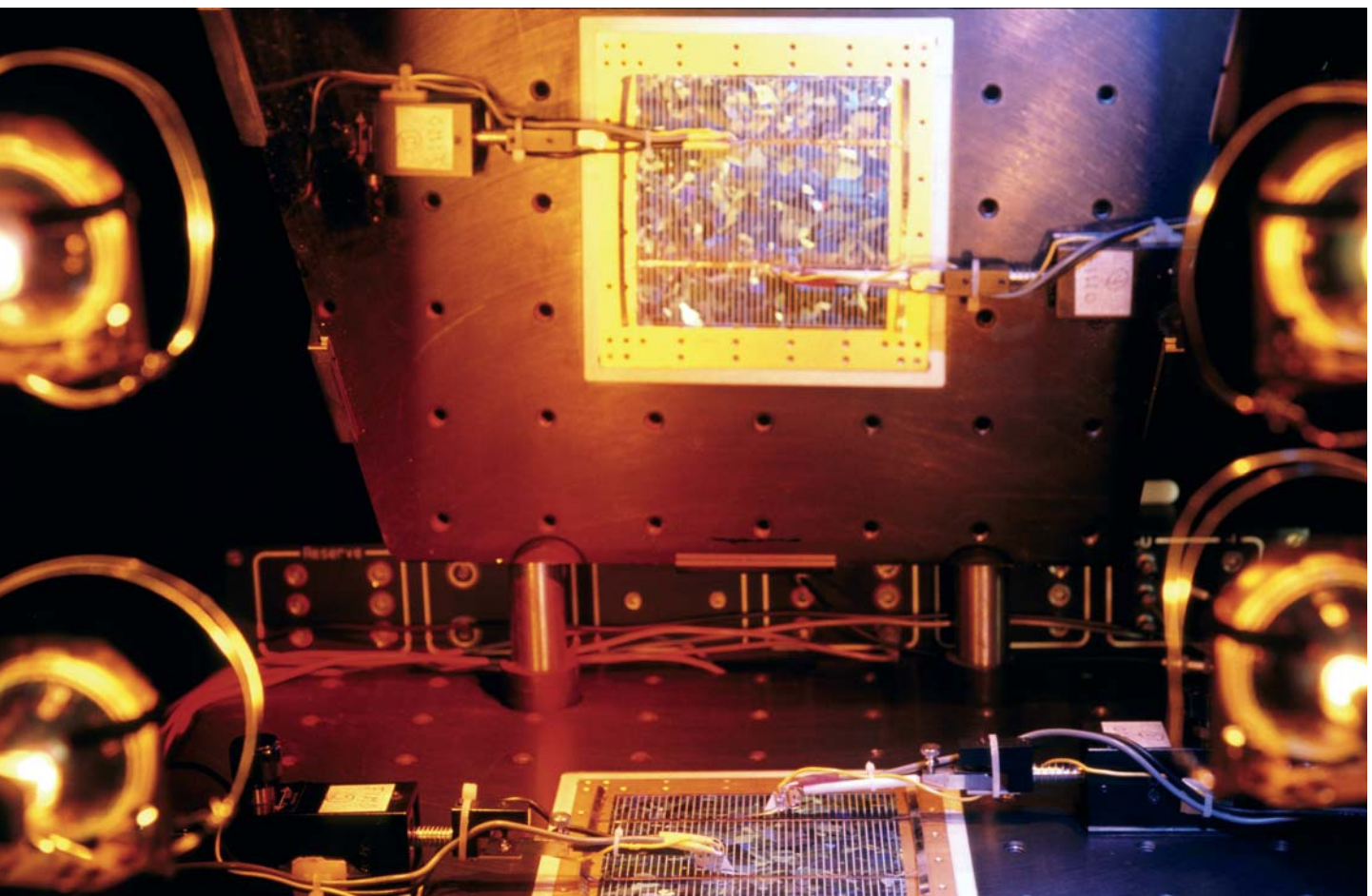
Instruments for implementation of the concept

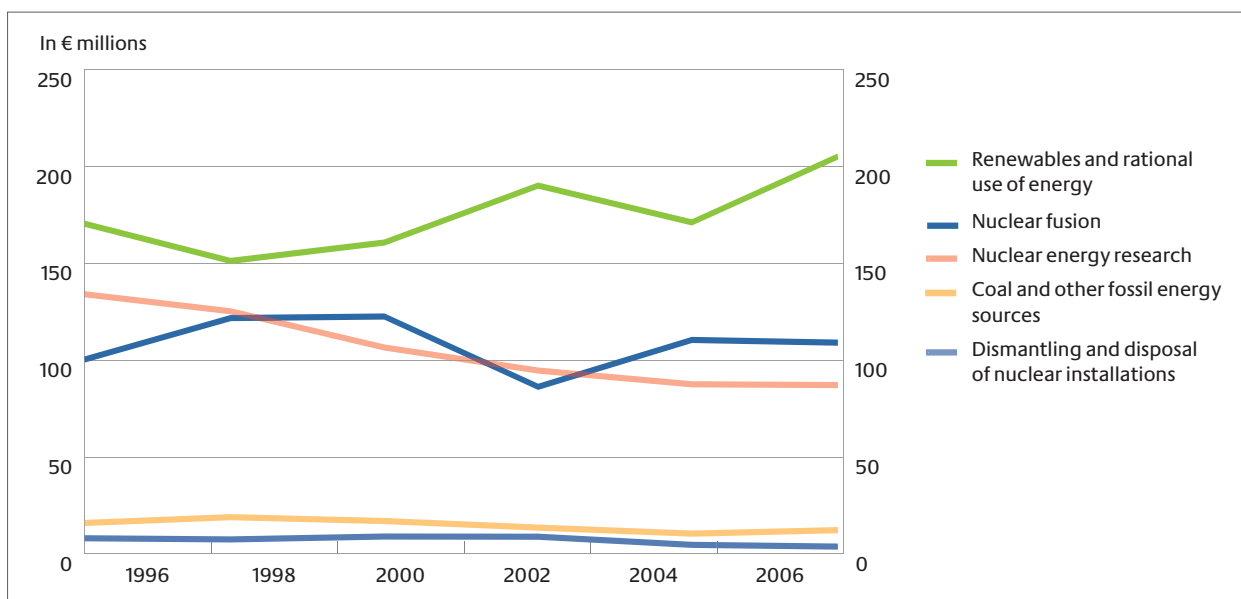
The BMBF funding concept “Basic Energy Research 2020+” is largely a component of the 5th federal government energy research programme. The BMBF concept is long term. Its core areas will be incorporated into an update of the federal government’s energy research programme

The concept is to be implemented at a number of levels and using varied tools:

- Institutional funding of the Helmholtz centres and the institutes of the Fraunhofer Society, Max-Planck Society and Leibniz Association. The Helmholtz centres in particular are closely involved within the framework of research policy guidelines in the federal government’s research policy goals..
- Project funding via the BMBF. This funding occurs primarily within research alliances. Public research institutions, universities and industry apply jointly for funding resources within the framework of funding notices for the purpose of carrying out joint projects. For research areas on the application side, to obtain funding business involvement is generally necessary; with activities more oriented towards basic research, university involvement is primarily important. In exceptional cases however applications based on excellent science may be considered.
- Creating strategic alliances. A systematic approach will be particularly highly valued in implementation of the concept. To this end, platforms on specific topics are to be established covering all areas and levels – science, business, government departments at national and Länder level – in order to drive a topic forward (e.g. energy storage or smart supply grids).

Measuring efficiency and spectral sensitivity of solar cells





Energy research in Germany

Sources: Federal Ministry of Education and Research, Association for the Promotion of Science and Humanities in Germany (Stifterverband für die Deutsche Wissenschaft)

- Funding new blood. Special attention is to be paid within this concept to the funding of young scientists. In addition to doctorate posts in research projects, special funding instruments are to be offered to promote the next generation of scientists, for example postgraduate programmes on clearly defined topics and the development of working groups led by postgraduates.
- Transfer of research findings. This is a particularly important aspect of research funding, to ensure that the results of research find their way to implementation. The financial funding of projects is therefore supported through activities to exchange information (e.g. seminars, workshops, conferences and summer schools).

Annex

Guidelines for project funding

Project funding is an instrument for the supporting of projects having defined subject areas and timescales that entail high scientific and technical risk and are of interest throughout Germany. It is aimed at companies, research institutes and universities and is only considered in cases in which the work cannot be carried out using the institutes' base financing or from the private sector's own resources. The general requirement for the granting of funds is for the funding resources to be used in the public interest and in accordance with legislative requirements. The funding is provided in the form of a non-repayable grant. As the awarding authority, the BMBF makes its decision at its due discretion within the scope of the budget funds available and based on the recommendation of project management. Applicants have no legal entitlement to a grant.

Higher education institutions and technical colleges, the Max-Planck Society, establishments in the Helmholtz Association, the Fraunhofer Society, institutes of the Gottfried Wilhelm Leibniz Research Association (Wissensgemeinschaft Gottfried Wilhelm Leibniz, WGL) and non-university establishments are all entitled to apply for funding. This should strengthen co-operation between universities and non-university research establishments. Application may also be made by companies producing in Germany in the commercial sector. In particular, the involvement of small and medium-sized enterprises (SME) in the funding initiative is expressly encouraged. Applicants must be legal persons that are prepared to enter into interdisciplinary co-operation both within and across networks, have expertise in organisational planning and have previous experience with this kind of work.

The best possible exploitation of project findings will determine the success of a project. Funding guidelines therefore stipulate that when submitting the application for funding, an accurate presentation of how the findings will subsequently be exploited is to be given in the form of an exploitation plan. The party executing the project undertakes to strive to implement this exploitation plan. In return this party will be entitled to exclusive use of the findings. Although with research projects where findings are expected to be put to industrial use it is necessary to ensure that the industrial property rights of the findings attained are protected, one of the key functions of project funding is that any new knowledge that is eligible should be patented. The corresponding costs can be funded for small and mid-sized enterprises and public research establishments. There is also

a general obligation to publish findings in the form of papers for conferences and/or the specialist press.

The legal basis for approving, paying out and accounting for grants, as well as for verifying and examining their proper use, and (if necessary) revoking the award of funds or reclaiming the funds is set out in the administrative regulations pertaining to Section 44 of the Federal Budget Code (Bundeshaushaltsordnung, BHO) and Sections 48 to 49a of the Federal Law on Administrative Procedures (Verwaltungsverfahrensgesetz, VwVfG).

The General Auxiliary Conditions for Funds Provided by the BMBF to Commercial Companies for Research and Development Projects on Cost Basis (NKBF98) form part of any notification of the award of cost-based grants. General Auxiliary Conditions for Grants Provided for Projects on an Expenditure Basis (ANBest-P) and the Special Auxiliary Terms and Conditions for Funds Provided by the BMBF for the Promotion of Projects on an Expenditure Basis (BNBest-BMBF98) form part of any notification of the award of grants on an expenditure basis. Details on the terms and conditions of funding are published in the funding guidelines and respective funding notices.

Application forms, guidelines and leaflets, as well as terms and conditions governing grants, may be obtained from project management on request or accessed via the website <http://www.kp.dlr.de/profi/easy/formular.html>

List of funding notices already published

Guideline for the funding of research and development in the area of "Rational Use of Energy, Conversion and Combustion Technology" by the Federal Ministry of Economics and Technology (undated)

Notice on the funding of research and development in the area of renewable energies by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (undated)

Guidelines for the funding of research and development projects on the topic of "The Use of Underground Space for CO₂ Storage to Meet Global Climate Protection Targets" under the "Basic Energy Research 2020+" funding programme (31.8.2007)

Guidelines for funding in the area of "Organic Photovoltaics" under funding programmes "Optical Technologies", "WING – Materials Innovations for Industry and Society" and "Basic Energy Research 2020+" (14.10.2007)
Guidelines for funding in the area of "Next Generation Solar Energy Systems" under funding programme "Basic Energy Research 2020+" (31.10.2007)

Guidelines for the funding of research and development projects on the topic of "Nanotechnology in Building – NanoTecture: Creating Greater Potential for Resource and Energy Savings, Performance and New Functionalities" under framework programme "WING – Materials Innovations for Industry and Society" (30.11.2007)

Guidelines for the funding of research and development projects on the topic of "High Performance Materials for Greater Energy Efficiency and CO₂ Savings: Advances in Performance in Energy Conversion Processes" under framework programme "WING – Materials Innovations for Industry and Society" (14.12.2007)

Guidelines for the funding of research and development projects on the topic of "Developing Lithium Ion Batteries for Electrical Energy Storage" under funding programmes "WING – Materials Innovations for Industry and Society" and "Basic Energy Research 2020+" (31.01.2008)

Guidelines for the funding of research and development projects on the topic of "BioEnergy 2021 – Research for Using

Plant Biomass" under funding programme "Biotechnology – Taking and Shaping Opportunities" and funding concept "Basic Energy Research 2020+" (in preparation)
Further information on federal government funding of research and innovation work can be obtained from the BMBF's funding advice bureau (Förderberatung).

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List of abbreviations

ASDEX Upgrade	Axially Symmetric Diverter Experiment Upgrade, tokamak at the Max-Planck Institute for Plasma Physics
BER	Berlin experimental reactor
BESSY	Berliner Elektronenspeicherring-Gesellschaft für Synchrotronstrahlung (Berlin electron storage ring company for synchrotron radiation)
BioLiq facility	Biomass-to-Liquid facility
BMBF	Federal Ministry of Education and Research
BMELV	Federal Ministry of Food, Agriculture and Consumer Protection
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMVBS	Federal Ministry of Transport, Building and Urban Affairs
BMWi	Federal Ministry of Economics and Technology
BRG	Federal Institute for Geosciences and Natural Resources
CCS	Carbon-Capture-and-Storage-Technologie
CFD	Computer Fluid Dynamics
CO ₂ SINK	CO ₂ Storage by Injection into a Saline Aquifer at Ketzin
DEMO	Future demonstration power plant succeeding ITER
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Centre)
ENEN	European Nuclear Education Network
EPIA	European Photovoltaic Industry Association
ERANET	European Research Activities Network
EU	European Union
EURATOM	European Atomic Energy Community
FZD	Dresden/Rossendorf Research Centre (member of the Gottfried Wilhelm Leibniz Research Association)
FZJ	Jülich Research Centre
FZK	Karlsruhe Research Centre
GaN	Gallium nitride
GEOTECHNOLOGIEN	Geotechnology research and development programme funded by BMBF
GoFORSYS	BMBF-Research Project on Systems Biology
GRS	Non-profit company for plant and reactor safety
HELOKA	Helium Loop Karlsruhe
HGF	Helmholtz Association
HMI	Hahn-Meitner Institute Berlin
IAEA	International Atomic Energy Agency
IAEO	International Atomic Energy Organisation
IEA	International Energy Agency
IKT	Information and Communication Technologies
INNER	Innovative Energy Research
IPP	Max-Planck Institute for Plasma Physics

ISE	Fraunhofer Institute for Solar Energy Systems
ISFH	Institute for Solar Energy Research
ITER	International Thermonuclear Experimental Reactor
LED	Light Emitting Diode
MPA	Materials Testing Institute, University of Stuttgart
NanoTecture	Lead innovation: "NanoTecture – Nanotechnology for the Building Sector"
NEA	Nuclear Energy Agency of the OECD
OECD	Organisation for Economic Co-operation and Development
OLED	Organic Light Emitting Diode
OPV	Organic photovoltaics
Ptj	Project Management Jülich
Smart Grids	European Technology Platform "Smart Grids", Electricity Networks of the Future
Stellarator	Fusion reactor invented by Lyman Spitzer
Tokamak	Fusion reactor invented by Andrei Sakharov and Igor Yevgenyevich Tamm
UFZ	Helmholtz Centre for Environmental Research
Wendelstein 7X	Stellarator at the Max-Planck Institute for Plasma Physics
WING	Werkstoffinnovationen für Industrie und Gesellschaft (Materials Innovations for Industry and Society)

Notes

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