The Strategy of the Helmholtz Association

Top-level research for society, science and the economy

HELMHOLTZ
ASSOCIATION

Mission of the Helmholtz Association

We contribute to solving grand challenges which face society, science and industry by performing top-level research in strategic programmes in the fields of Energy, Earth and Environment, Health, Key Technologies, Structure of Matter, and Aeronautics, Space and Transport.

We research systems of great complexity with our large-scale facilities and scientific infrastructure and in cooperation with national and international partners.

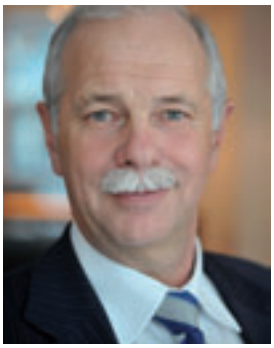
We contribute to shaping our future by combining research and technology development with perspectives for innovative applications and services for tomorrow's world.

Dear Readers,

The Helmholtz Association's 16 German research centres have a clear political objective: to concentrate their forces so that they can contribute to solving major challenges facing society, science and the economy. The 16 research centres have long-term goals formulated in cooperation with national policymakers, and their achievements are measured against two criteria – scientific excellence and strategic relevance. In recent years, Helmholtz staff members have discussed the best way to achieve these goals. A strategic paper was drawn up in coordinated dialogue involving the Helmholtz Centres and the steering committees of research fields: this brochure presents its key points in condensed form. The first part introduces the strategy of the Association as a whole and the second outlines our six research fields.

I would like to take this opportunity to thank all our staff members for their extraordinary commitment, without which the outstanding quality of our scientific work would be impossible.

In conclusion, I hope this brochure will convince you that the Helmholtz Association is on the right course to maintaining and enhancing its contribution as a major player in the German research community.



Prof. Dr. Jürgen Mlynek
President of the Helmholtz Association
Berlin, 2009

Helmholtz Association Strategy

The Helmholtz Association
An affiliation of major research centres

Sixteen German research centres have joined forces in the Helmholtz Association to investigate complex social, scientific and technological issues. The research centres concentrate their resources in cross-centre research activities in six major research fields – Energy, Earth and Environment, Health, Key Technologies, Structure of Matter, and Aeronautics, Space and Transport.

The Association provides the necessary framework for this work: scope for long-term planning, a high concentration of scientific expertise and an outstanding scientific infrastructure including a number of large-scale projects that are unique world-wide.

An example:
Membranes for clean power stations

Fossil fuel power stations will continue to contribute to meeting the growing demand for energy in the future. The Helmholtz Alliance “MEM BRAIN” unites researchers from four Helmholtz centres with research institutions, universities and industry, who work together to develop new technologies to radically reduce power-station emissions. Their solution are membranes – thin, porous layers made of ceramics or polymers that can filter out carbon dioxide so that it can ultimately be stored underground. The new systems have a sizable advantage over existing chemical filtering processes in that they have much less impact on power station efficiency. However, the scientists do not just develop customised materials for use in these membranes; they also coordinate power station and separation processes and analyse ecological and economic factors to prepare for the membranes’ widespread implementation.

The participating Helmholtz Centres are Forschungszentrum Jülich (leading the project), DESY, GKSS Research Centre Geesthacht and Helmholtz-Zentrum Berlin für Materialien und Energie.

The Helmholtz Association
Our goals

We aim

- to make substantial contributions to basic scientific issues and use our great potential to take an internationally leading position in all six research fields;
- to investigate complex scientific, social and economic issues with a holistic approach and to offer appropriate solutions;
- to identify and realize solutions, working from the base up and translating solutions into applications;
- to develop appropriate methods, technologies and services, and to advise both policy-makers and society;
- to contribute significantly to the effectiveness and standing of the entire scientific system in Germany.

An example:
Energy for the future

Nuclear fusion reproduces the process occurring in the sun. At very high temperatures the atomic nuclei of hydrogen fuse to form helium, releasing large amounts of energy. In order to harness this energy source, one of the requirements is to confine the fuel heated to 100 million degrees Celsius – a plasma composed of charged particles – in a magnetic field. Helmholtz researchers are investigating the underlying physical principles and developing the necessary technologies. For example, the Max Planck Institute for Plasma Physics, an associate member of the Helmholtz Association, operates the ASDEX Upgrade, an experiment of the tokamak type. In this device, currents produced in the plasma are used to create part of the magnetic cage needed to confine the plasma. The next step in the international fusion programme is the ITER tokamak, which is being built in France. It is expected to be able to produce an energy-yielding plasma. The Max Planck Institute for Plasma Physics is at present also building the Wendelstein 7-X stellarator experiment. Here, the concept involves the magnetic field being generated solely by complexly shaped, external magnet coils. Other participating Helmholtz Centres: Karlsruhe Institute of Technology, Forschungszentrum Jülich.

Characteristics | 01
Research in programmes

The scientists at the research centres of the Helmholtz Association define their research topics in strategic programmes within their respective research fields. The research policy requirements are laid down by the funding partners, having previously been discussed by the Helmholtz Centres, the Association's senate and policy-makers.

The Helmholtz Association concentrates its energies within multidisciplinary teams and has access to the many diverse resources of the Helmholtz Centres. This puts it in the unique position of being able to take a holistic approach to providing solutions to both individual issues and complex questions of relevance to science, society and industry.

An example:
The Helmholtz Cohort

The Helmholtz Association is conducting a large population study, the Helmholtz-Kohorte (Helmholtz Cohort), to collect data for a variety of epidemiological studies. The study involves 200,000 healthy volunteers who will undergo regular examinations and questioning over a ten to 20-year period. The study will take lifestyle and environmental factors into account alongside clinical parameters and will thus enable researchers to investigate the long-term role of genetic, environmental and lifestyle factors in diseases and develop ways of preventing them.

The cross-programme initiative will involve several universities, Leibniz Association institutes, German Cancer Research Center, Helmholtz Zentrum München – German Research Center for Environmental Health, Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch, Helmholtz Centre for Infection Research, the German Centre for Neurodegenerative Diseases and Forschungszentrum Jülich. The whole project is estimated to cost between 150 and 200 million euros over the next ten years.

Characteristics | 02
Large-scale facilities and infrastructures

Research at the Helmholtz Association generates such extraordinary results thanks to the wide and complex range of scientific facilities and instrumentation at the Association's disposal. These include unique national and international large-scale facilities such as particle accelerators, reactors, supercomputers, research ships and research aircraft. Large-scale facilities are the driving force behind technological development and can foster the emergence of new disciplines. They attract many of the world's leading scientists as well as the next generation of researchers.

The qualified staff who operate these facilities provide outstanding conditions for research and a first-class service for the Helmholtz and visiting researchers, who are selected in a competitive process. This combination of these specialised resources and experience in building and operating such large-scale facilities is to be found at only a small number of scientific institutions around the world. The unique research environment offered by the Helmholtz Centres contributes to their own international standing and also to Germany's status as an attractive location for science and research.

An example:
BESSY II: brilliant light gets to the heart of matter

Whether they want to learn more about water molecules, the behaviour of dangerous pathogens or the magnetic materials that will be used for data storage in the future, researchers need light that goes far beyond the visible spectrum to investigate the processes that take place within the building blocks of animate and inanimate matter. Scientists can choose the type of electromagnetic radiation they need to investigate specific questions – from long-wave terahertz frequencies all the way to short-wave X-ray radiation.

The BESSY II synchrotron radiation source at the Helmholtz-Zentrum Berlin für Materialien und Energie in Berlin's Adlershof district provides light with unique qualities – highly concentrated, particularly brilliant light of an extremely high intensity, which can be generated in a consistent beam or in ultra-short pulses. This allows researchers to precisely measure the tiniest particles in atomic structures, in terms of both space and time, and to understand the structure of complex molecules as well as their chemical and physical behaviour. Over 400 work groups from universities, research institutes and businesses from around the globe utilise the approx. 50 beamlines on the 240 m storage ring for their experiments.

Characteristics | 03
Efficient systems

A characteristic strength of the Helmholtz Association is that it takes an interdisciplinary, cross-centre approach and is able to apply the various scientific resources available throughout its Centres to find solutions to complex questions. The Association is thus able to react swiftly even to emerging challenges.

To do this it can draw upon teams of scientists, engineers and technicians who are used to working together in an efficient manner guaranteed to bring about results. Management structures adapted to the specific requirements support the projects.

Interdisciplinary research methods that take social science and systems science aspects into account allow us to assess the effects of our activities on society and the environment. This enables us to keep all facets of a problem in mind when searching for solutions.

An example:
Quick response: the tsunami warning system

The Sumatran earthquake in December 2004 was the second most powerful seismic shock ever recorded. Its shock-waves were felt around the world – and were automatically recorded and evaluated in Potsdam, Germany 12 minutes after they hit. Although the tsunami waves had not yet reached the coast of Sumatra at this point, there was no way of warning the people there in time. The question quickly arose as to how it might be possible to give coastal populations adequate warning of this type of pending natural disaster. Within a short space of time, the Helmholtz Centre Potsdam German Research Centre for Geo-sciences had teamed up with the German Aerospace Center DLR, Alfred Wegener Institute for Polar and Marine Research, the GKSS Research Centre Geesthacht and five other partners to develop a tsunami early-warning system. The system has now been extensively developed to quickly and reliably determine the strength of earthquakes, create tsunami forecast models and to assess the local situation. The early-warning system began operating on 8 November 2008, when it was inaugurated by the Indonesian President. After an initial testing and optimisation phase involving both German and Indonesian scientists, the system will be handed over to the Indone-sian authorities in March 2010.

The Way Forward | 01
High quality through competition

The high level of international research carried out in the centres of the Helmholtz Association makes it one of the world's leading research institutions. Panels of external experts regularly evaluate the research programmes and their results. The panels are staffed by distinguished representatives of scientific institutions, universities and industry from Germany and abroad.

In addition to purely scientific performance, the reviewers also consider the relevance of the research topics, their practical potential, knowledge transfer ability and applicability, and their potential interest for decision-makers. The system of programme-oriented funding is characterised by transparent, scientifically-based decision-making processes, and enables the Helmholtz Association to effectively manage the allocation of its financial resources. The Helmholtz Association takes care to continually update its organisational structures and processes to ensure they remain efficient.

A further key instrument is the President's Initiative and Networking Fund which allows the Helmholtz Association to react quickly and flexibly to boost those areas where strategic goals need to be achieved rapidly. It is used to inject significant amounts of money into new future-oriented topics, focusing on five key strategies: expanding networks with universities; promoting young scientists; ensuring equal opportunity; creating frameworks that belong to top-flight research; and assuring excellence in research.

An example:
German Centre for Neurodegenerative Diseases

Dementia and other neurodegenerative diseases are one of the greatest challenges facing our aging population. In Germany alone approximately one million people over the age of 65 suffer from dementia, with approximately 200,000 people developing the disorder each year. In order to pool existing expertise, close gaps in research and drive progress forward so that patients in Germany can benefit sooner, the Helmholtz Association is setting up the German Centre for Neurodegenerative Diseases on behalf of the Federal Ministry of Education and Research.

The main centre is located in Bonn and will work closely with university groups in six other locations. Research will focus on the causes of disease, prevention and early-diagnosis methods, the development of effective therapies and the best forms of care. The annual budget for the centre and its partners is 66 million euros.

The Way Forward | 02
Strategic alliances

Modern research projects require cooperation with other high-performance institutions and organisations. The Helmholtz Association therefore directly targets partners in universities, research organisations, industry and politics in order to build alliances which span disciplinary, organisational and national borders.

And the Helmholtz Centres are attractive partners. Their research programmes and working environments appeal to internationally acclaimed scientists and research groups. Where this helps them to achieve their own programme objectives, the Helmholtz Centres also participate in research programmes run by other organisations from all over the world.

In the case of projects which have the potential to function as best-practice models in the future, cooperation goes a step further. Here the Centres establish innovative partnerships: long-term, strategic collaborations based on binding agreements, with regulated funding strategies and clearly defined contributions from each partner.

An example:
Together under one roof

The founding of the Karlsruhe Institute of Technology (KIT) for the first time turns a unique strategic partnership of a Helmholtz Centre and a university into a single institution under one roof. KIT was set up as a public corporation according to the laws of the State of Baden-Württemberg on 1 October 2009. The merger allows for joint structural and development planning as well as a common policy for appointing scientific staff. KIT undertakes the tasks of both the university and the Forschungszentrum Karlsruhe and will remain a member of the Helmholtz Association with its national commission. Its research will continue to be evaluated and supported within the Association's programme-oriented funding scheme.

The KIT management board is headed by two presidents appointed jointly by the Helmholtz Centre and the university. KIT employs approximately 7,000 people and its annual budget amounts to 700 million euros.

The Way Forward | 03
Cooperation with universities and the European Research Area

Within their strategic alliances, the Helmholtz Centres of the Helmholtz Association place particular value on networking with universities. The universities have the opportunity to participate in Helmholtz research programmes, using the Association's infrastructure.

To strengthen their cooperation, the Helmholtz Centres and universities appoint leading scientists to joint professorships. Helmholtz Centres also establish collaborative institutes with universities, and scientists from Helmholtz Centres participate in programmes to promote excellence in universities and also engage in teaching practice at the universities.

The Helmholtz Association is a powerful player contributing to the development of the European Research Area and is participating in the process of defining the EU framework programmes. By acquiring EU funding Helmholtz aims to strengthen its own research programmes.

An example:
Mouse clinic helps scientific progress

As mice and humans share 95 per cent of their DNA, mutant mice provide ideal subjects for modelling human diseases like diabetes, osteoporosis, asthma, Alzheimer's or depression. The German Mouse Clinic at the Helmholtz Zentrum München has already analysed around 100 different mouse strains for geneticists and clinicians from the centre, for research groups in the National Genome Research Network (BMBF) and for international research centres. Researchers at the clinic observe the changes that genetic mutations produce in mice. Crucial to their success is a systematic approach that aims to test all vital organ systems by means of eye examinations, blood analyses, bone density measurements and behavioural tests. This enables researchers to understand the genetic causes of certain diseases and establish basic premises for new treatment methods. The mouse clinic will be extended as part of the INFRAFRONTIER project (The European Infrastructure for Phenotyping and Archiving of Model Mammalian Genomes) and incorporated into a pan-European infrastructure. This will make mouse models available to the biomedical research community in the long term. The Helmholtz Zentrum München is responsible for managing and coordinating this project.

The Way Forward | 04
Transfer of results

The Helmholtz Association handles research topics from the fundamental principles through to application; long-term basic research and applied research form equal parts of its mission. It not only pursues scientific goals, but also systematically opens up new fields of research and technology. The results are transferred into practical application at an early stage.

Applied research also involves providing expert and independent advice for the public and policy-makers. In this way the Helmholtz Association is able to play a part in ensuring a high standard of living and safeguarding Germany‘s technological competitiveness.

Where possible, the Centres of the Helmholtz Association utilise their research results through private enterprises and have a range of intellectual property portfolios. The Association sets up transfer funds and supports spin-off projects at the Centres by financing the preseed phase – the initial stage before profits can be expected to arise.

An example:
Nobel Prize for papilloma virus vaccine to protect women from cancer

The world’s first vaccine specifically developed to provide protection against a type of cancer was launched in 2006. The vaccine prevents infection by the two most significant types of cancerous human papilloma viruses (wart viruses), which are responsible for around 70 per cent of all cases of cervical cancer.

Prof. Harald zur Hausen, the long-time chairman of the German Cancer Research Center, recognised the link between papilloma viruses and cancer, and used this knowledge to develop the vaccine. He received the Nobel Prize for Medicine in 2008 for his discovery.

The Way Forward | 05
Promoting young scientists

The Helmholtz Association works in close cooperation with universities to train the scientists of the future. The Association places particular value on paving the way to successful scientific careers.

In order to achieve this it has adopted the following measures:

- → Postgraduate students receive structured, specialist training.
- → Junior scientists are allowed to work independently at an early stage.
- → Leading positions in Helmholtz-University Young Investigators Groups are available with a tenure option. That means the cream of the crop have the possibility of gaining a permanent contract.
- → Individual achievements are rewarded, as is excellent performance of research teams.

The Helmholtz Association's support for future generations of scientists does not begin at universities, however. It is also developing learning and training opportunities for young children and school pupils with the goal of awakening in them a sustained interest in the natural sciences and technology.

An example:
Supporting future scientists together

There are around 100 Young Investigators Groups funded by the Initiative and Networking Fund at the Helmholtz Centres. The leaders of these groups have a unique opportunity: the chance of gaining a tenure-track position. If their performance is judged positively in an interim evaluation after three to four years, they may begin working at the centre permanently. This offer is unique in Germany and has already succeeded in attracting foreign researchers from renowned institutions abroad and in persuading German scientists working in other countries to return to Germany.

Cooperation with universities is a top priority – the heads of Young Investigators Groups work closely with university partners, hold lectures and seminars at the universities and gain qualifications that equip them for academic careers. The Helmholtz Association aims to work with the universities to create junior professorships for all heads of Young Investigators Groups.

The Way Forward | 06
Positive working environment

The Helmholtz Association gives the men and women working in its centres the freedom to pursue creative research even within the set programmes. In addition, they have access to research funding that is not bound to specific programmes. In this way the Helmholtz Association is able to guarantee scientific autonomy alongside planning security.

And our excellent results would be impossible without personnel supporting the researchers at the centres. The Helmholtz Association therefore trains young technical and administrative talent alongside the junior scientists. It enables them, like all other employees, to gain professional qualifications, and starts them off on auspicious career paths. The potential of its female employees is an indispensable resource for the Helmholtz Association. It therefore intends to increasingly incorporate women at all decision-making levels and initiate approaches to ensure that many more women can take leading positions in the research centres.

The Helmholtz Association offers family-friendly working conditions in all the centres including childcare tailored to the needs of the employees, a dual-career service, flexible hours and a modern management system. Foreign employees and temporary guests are very welcome at the Helmholtz Association and we take care to ensure that they feel at home.

An example:
A Nobel Prize for the GMR effect

Being awarded a Nobel Prize is the moment all scientists dream of, but scientific breakthroughs are rarely achieved by individuals working on their own. This is something that Prof. Peter Grünberg emphasised when he was awarded the Nobel Prize for Physics in 2007. Forschungszentrum Jülich provided Prof. Grünberg with the ideal conditions to conduct his pioneering research on the GMR effect. Today GMR (giant magnetoresistance) is exploited in the read heads in virtually all computers – these contain magnetic material that is influenced by the varying magnetism of bits in the hard drive.

Due to the GMR effect, this results in widely varying electrical resistance in the read head which can be detected easily and thus allows extremely dense amounts of data to be read quickly and accurately – providing the foundation for gigabyte hard drives and for an entirely new field of electronics called spintronics. In 2007 Peter Grünberg became the first scientist to be appointed to a Helmholtz Professorship. The three-year Helmholtz Professorships were created by the Helmholtz Association so that the creativity and experience of outstanding researchers is not lost to the world of science when they reach retirement age.

The Way Forward | 07
The trust of society and politics

Science depends on the trust and support of society and politics. The Helmholtz Association therefore takes an active role in debate on the topics, results and effects of modern research. It keeps the public informed about its work and offers expert, independent advice to decision-makers.

Research findings reveal options for damage prevention, and the applied use of knowledge can help to resolve conflicts of interest. Scientists from the Helmholtz Association are perceived as independent and far-sighted experts, and are regularly appointed to policy advisory committees.

In order to live up to its reputation and to continue playing a leading role in the research landscape of the future, the Helmholtz Association will constantly evaluate its performance and set itself new challenges.

An example:
Research in the Antarctic

The Antarctic is of vital importance to the climate of our entire planet. Scientists at Neumayer Station III conduct basic research that gives them a better understanding of climate change and puts them in a position to inform the public and advise policymakers. The Alfred Wegener Institute for Polar and Marine Research has maintained a research station in the Antarctic year-round since 1981, with the third generation – Neumayer Station III – being inaugurated in 2009. Its predecessors had already provided unique long-term data series. For example, data collected at the meteorological observatory have contributed greatly to research on the hole in the ozone layer, the air chemistry observatory has been measuring concentrations of harmful gases, the geophysical observatory focuses on seismic events all over the world and on changes in the earth's magnetic field, and the Perennial Acoustic Observatory in the Antarctic Ocean investigates natural sounds in the ocean and the behaviour of marine mammals. Since 2002 the infrasound station IS27 has been monitoring compliance with the nuclear testing ban. These observatories are now all incorporated into the new station, which, with its cutting-edge technology, is playing an even more important role in the global scientific observation network.

Strategies of the individual Research Fields

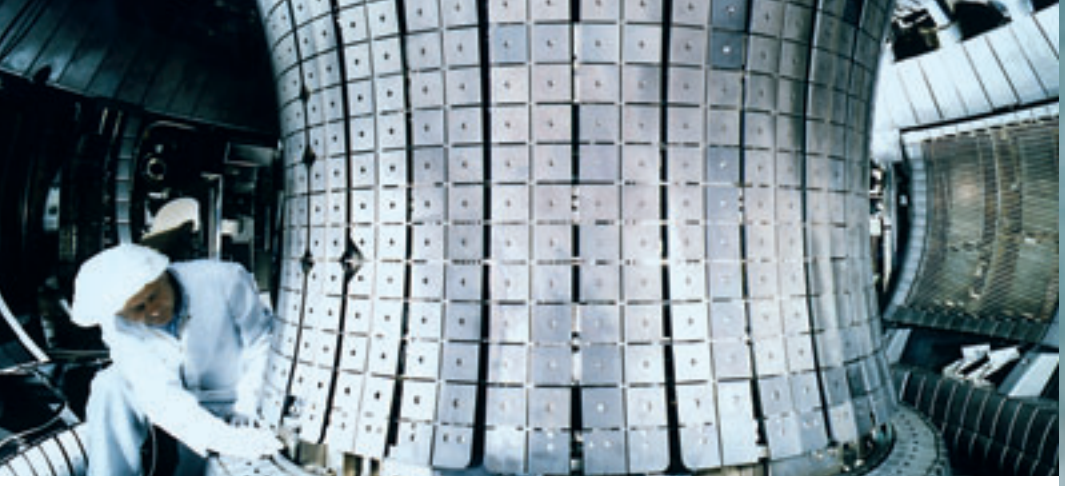
16 Research Centres have joined forces
in the Helmholtz Association:

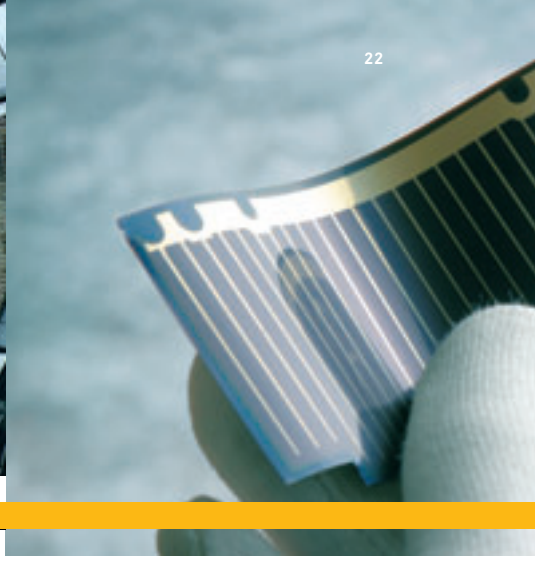
Alfred Wegener Institute for Polar and Marine Research I Deutsches Elektronen-Synchrotron DESY
German Cancer Research Center I German Aerospace Center DLR
German Centre for Neurodegenerative Diseases I Forschungszentrum Jülich
GKSS Research Centre Geesthacht I GSI Helmholtz Centre for Heavy Ion Research
Helmholtz-Zentrum Berlin für Materialien und Energie I Helmholtz Centre for Infection Research
Helmholtz Centre for Environmental Research – UFZ I Helmholtz Zentrum München –
German Research Center for Environmental Health I Helmholtz Centre Potsdam, GFZ German
Research Centre for Geosciences I Karlsruhe Institute of Technology I Max Delbrueck Center for
Molecular Medicine (MDC) Berlin-Buch I Max Planck Institute for Plasma Physics *

and organise their activities in six Research Fields:

Energy I Earth and Environment I Health I Key Technologies
Structure of Matter I Aeronautics, Space and Transport

*Associate Member





Research Field
Energy

→ | Mobility, adequate food supply, prosperity – scientists and engineers are working full throttle to provide the energy we need to ensure we still have all these things in 50 years' time. The Research Field Energy is developing technologies which will allow us to use solar energy, geothermal power and biomass more economically and to exploit nuclear fusion as an additional source.

The Research Field Energy is also trying to improve the efficiency of existing technologies, e.g. gas-fired power stations, as it will not be possible to do without these in the immediate future. And every step we make towards improving efficiency saves resources and protects the environment.

The greatest challenge for us is to link sustainable, economic sources of energy with environmental protection.

The earth's population is set to rise almost 40 per cent by 2050 to around nine billion people, all aspiring to more prosperity. This combination of factors will lead to a dramatic increase in energy requirements.

The Research Field is contributing to solving the problem at many levels. Its programmes range from basic research into new materials, for example, to the development of large-scale technical applications.

Many energy research projects have long development phases and, what's more, there is often only a small chance of success. A key task of the Research Field Energy is to push forward promising projects in cooperation with universities, other research institutions and industry.

As a publicly funded research organisation, the Helmholtz Association is working in five core areas to try to ensure a sustainable energy supply in the future:

- → Renewable Energies
- → Efficient Energy Conversion and Use
- → Nuclear Fusion
- → Nuclear Safety Research
- → Technology, Innovation and Society

Forschungszentrum Jülich I German Aerospace Center DLR
Helmholtz Centre Potsdam – GFZ German Research Centre for Geosciences
Helmholtz-Zentrum Berlin für Materialien und Energie I Karlsruhe Institute of Technology
Max Planck Institute for Plasma Physics (Associate Member)

Two examples

01 Solar cells “made in Germany”

Highly effective solar cells that transform sunlight into electrical energy have been around for 20 years. But their relatively high cost is a hindrance to the marketing of solar energy, as the cost per kilowatt hour is what ultimately counts. Two Helmholtz Centres are now making headway with new developments that will enable a satisfactory compromise to be made between cost and efficiency.

During the 1990s, researchers at the Hahn-Meitner-Institut Berlin (today Helmholtz-Zentrum Berlin für Materialien und Energie) started looking at the possibilities of making solar cells from layers of copper-indium-sulphide, and in 1998 they made a breakthrough. The scientists developed a quick, energy-saving process for producing solar cells, which makes them relatively cheap. Now the company Sulfurcell – a spin-off from the Helmholtz-Zentrum Berlin für Materialien und Energie – is using the technology in the production of solar cells.

The Forschungszentrum Jülich has also fully developed a new technology through to the production stage during the past decade. In this case the solar cells are made from thin layers of silicon.

Their advantage over the solar modules available today is that they can be economically manufactured using very little material and are relatively efficient, making them attractive for companies.

02 Efficient energy conversion and use

Many small steps can add up to a significant achievement. In today’s gas-fired power stations around 60 per cent of the energy utilised is converted into electricity, while the rest is released into the environment as waste heat. Scientists at two Helmholtz Centres (Forschungszentrum Jülich, Deutsches Zentrum für Luft- und Raumfahrt) are working on improving efficiency – and they might be able to stop as much as ten per cent being wasted. If they succeed, the corresponding amount of resources can be saved and climate-damaging carbon dioxide emissions reduced.

To achieve this, the temperature within the turbines needs to be increased, so researchers are working on the development of more heat-resistant materials. And the combustion processes at these higher temperatures must be kept stable and clean. Another step towards stopping the energy loss can also be taken by coupling high-temperature fuel cells with gas and steam turbines.

Research Field
Earth and Environment

→ | Prosperity can only be sustainably ensured if economic practices pay due attention to environmental protection. Humanity is dependent on the earth's natural resources, but in using them we cannot afford to overburden the ecosystem. So that we can assess the impact of humankind's sometimes drastic interaction with the planet, scientists in the Research Field Earth and Environment are working on the fundamental understanding of how the System Earth works.

Human society and the economy are also threatened by natural disasters, so an important part of this research field's work is the investigation into how to predict such events and how to protect ourselves when they occur.

We want to use our knowledge to make recommendations on how humanity can use the earth's resources in a sustainable way and deal with natural disasters more effectively.

Environmental research can only be successful if it considers all the subsections of this system, i.e. the atmosphere, biosphere, hydrosphere, cryosphere and geosphere, in relation to one another. The centres working in this research field thus cover all these areas in four programmes.

This necessitates research of many different types, from application-oriented basic research to pre-competitive research, from molecular investigations to field studies using large-scale facilities. The findings of these diverse research activities allow the Helmholtz Association to give well-founded advice to political decision-makers.

To meet the challenges effectively, this research field addresses the following issues:

- → Geosystem: The Changing Earth
- → Marine, Coastal and Polar Systems
- → Atmosphere and Climate
- → Terrestrial Environment

Alfred Wegener Institute for Polar and Marine Research I Forschungszentrum Jülich
GKSS Research Centre Geesthacht I Helmholtz Centre for Environmental Research – UFZ
HelmholtzZentrum München – German Research Center for Environmental Health
Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences
Karlsruhe Institute of Technology

Two examples

01 Growing giants and shrinking dwarves

A megacity like Mexico City, whose current population is around 18.7 million, needs 3.2 billion litres of water per day and produces a daily quantity of approx. 20,000 tonnes of waste. And the city is still expanding; the infrastructure will not be able to keep up without a sustainable urban planning strategy.

The prerequisites for such a strategy are being investigated by scientists from five Helmholtz Centres and partners from Latin America, coordinated by the Helmholtz Centre for Environmental Research – UFZ. They are also studying how vulnerable the populations of megacities are to the threats posed by nature and man-made interventions, e.g. through settling on land exposed to a high risk of landslide or flooding. But the expansion of megacities is not the only challenge facing urban planning.

Urban shrinkage, such as is occurring in Germany, also needs careful management. For example, our scientists are concerned with how urban restructure can be effectively administered, so that decisions on the demolition of housing are well-coordinated and citizens included in the decision process.

02 Flight to the ice clouds

German atmospheric scientists will soon be able to enter an entirely new dimension with the ultramodern HALO (High Altitude and Long Range Research Aircraft).

It is currently being prepared for operation by scientists and engineers at three Helmholtz Centres (FZJ, KIT and DLR) and will be put into the service of science from mid-2009, flying at a maximum height of 15 kilometres and with a range of 11,000 kilometres.

This outstanding flying capacity will enable HALO to enter ice clouds over ten kilometres up – and not only over central Europe, but also in the polar and tropical regions that are so important to the global climate. The aircraft is equipped with air scoops and other instruments that will enable researchers to investigate the internal composition of these clouds more accurately. It is believed that aerosols from anthropogenic sources encourage the formation of ice in the clouds.

This probably has an impact on the climate, as ice clouds influence thermal radiation into space, thus affecting temperatures on earth. Together, the plane and other facilities like the AIDA aerosol and cloud chamber at KIT form a unique platform for research on some of the most urgent questions related to global climate change.

Research Field
Health

→ | Although a great deal of progress has been made in biomedical research, we are still unable to cure most diseases. In addition, feasible methods for the early diagnosis and prevention of certain diseases are still lacking. Meeting this challenge is the aim of this research field.

We aim to be a driving force in national and international health research, and to make a significant contribution towards giving people the possibility of a longer, healthier life.

For this reason, applying the Research Field Health's findings in clinical practice through our alliances with universities and industry will become increasingly significant in the future. Another primary focus will be on disease patterns of frequently occurring diseases.

Chronic age-related diseases such as cancer and cardiovascular disorders, degenerative diseases of the nervous system and the skeleton, as well as chronic inflammatory diseases are gaining significance as the proportion of old people in the population grows.

At the same time, we have witnessed a sharp increase in cases of metabolic disorders like diabetes and metabolic syndrome in the last few years. This lies in the altered lifestyles of our modern society, characterised by overeating and lack of exercise. In connection with this, the Research Field Health must now also pay increased consideration to the complex interplay between individual genetic predispositions, lifestyle and environmental factors in ascertaining the likelihood of a person contracting a disease.

The third primary focus in the Helmholtz Research Field Health is the increase in infectious diseases. The research programmes therefore concentrate on:

- Cancer Research
- Cardiovascular and Metabolic Diseases
- Function and Dysfunction of the Nervous System
- Infection and Immunity
- Environmental Health
- Systemic Analysis of Multifactorial Diseases

Forschungszentrum Jülich I German Cancer Research Center I German Centre for Neurodegenerative Diseases I GKSS Research Centre Geesthacht I GSI Helmholtz Centre for Heavy Ion Research I Helmholtz Centre for Environmental Research – UFZ Helmholtz Centre for Infection Research I HelmholtzZentrum München – German Research Center for Environmental Health I Karlsruhe Institute of Technology Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch

Two examples

01 Putting basic research into practice

Since a central contact point for cancer sufferers was set up at the National Center for Tumour Diseases in Heidelberg, the patients are no longer looked after by individual specialists but by interdisciplinary teams. The centre combines all the disciplines involved in diagnosis, therapy and aftercare.

This approach revealed that the suggested therapy for pre-diagnosed patients had to be changed in up to a quarter of cases once the interdisciplinary team of doctors examined the patients. That was one of the first findings of this translational centre, which was founded in 2003 by the German Cancer Research Center, the University Hospital Heidelberg and the Thorax Clinic Heidelberg-Rohrbach.

At the same time, research and development of new diagnosis and treatment methods has accelerated at the centre thanks to regular meetings of doctors and researchers within collaborative oncological groups to work out common strategies.

Transfer centres have also been established at the Helmholtz Zentrum München – German Research Center for Environmental Health, Helmholtz Centre for Infection Research and Max Delbrück Center for Molecular Medicine (MDC) Berlin-Buch.

02 Getting to the root causes of disease

Scientists at the Max Delbrueck Center for Molecular Medicine (MDC) Berlin-Buch and other neighbouring institutions now have access to the new ultra-modern Medical Genomics Laboratory on the Berlin-Buch bio-technology campus. This will enable them to research the genetic causes of diseases even more intensively.

In order to push forward research, different approaches in genome research are brought together under one roof in Buch. The scientists will focus on questions such as which proteins in the body's cells are produced according to the genetic code and what functions they have. They will also research whether diseases within specific population groups can be linked to certain genetic variations.

Using a combination of both approaches, researchers are able to gain a better understanding of all the associations between genes, proteins and disease, enabling them to get to the root causes of a disease.

Research Field
Key Technologies

→ | Within the Research Field Key Technologies, scientists pave the way for new technologies that can drive forward innovation in science, industry and society. The researchers working in this field focus on technologies that demand complex systems solutions, that promise new methods and solutions for other research fields, and that are particularly interesting because of their potential applications for industry.

Such technologies include biotechnology, nano-technology, nano-electronics, microsystems technology, optics, advanced engineering materials and scientific computing. Further research focuses on promising areas so that specific practical applications can be identified and developed.

We want to make a major contribution to the competitiveness of German industry by advancing the key technologies useful to many other areas of science and technology.

This research field makes use of synergies with other research institutions, contributes to shaping government policy on strategic research in Germany and Europe, and builds bridges between theory and practice.

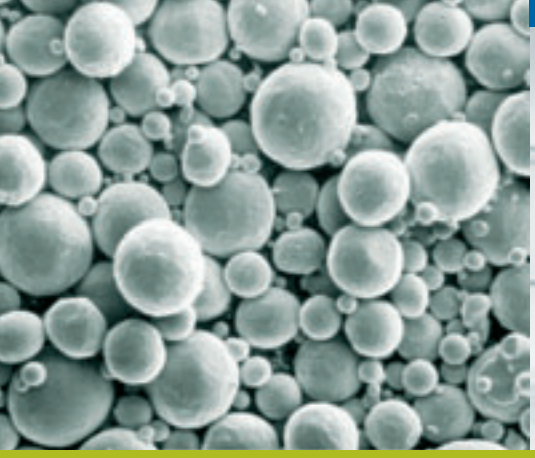
In this way it can contribute to solving the major challenges facing the other research fields, e.g. the sustainable use of resources or promotion of a healthy, active old age thanks to new technologies.

In order to thoroughly exploit the potential of innovations, the research field also analyses the political and social conditions for innovation and the possible effects of future technologies on society. This ensures that risks are recognised early and that political and social processes are taken into account in the development of new technologies.

The research activities are divided into seven cross-centre programmes:

- → Supercomputing
- → Fundamentals of Future Information Technology
- → NANOMICRO: Science, Technology, Systems
- → Advanced Engineering Materials
- → BioSoft: Macromolecular Systems and Biological Information Processing
- → BioInterfaces: Molecular and Cellular Interactions at Functional Interfaces
- → Technology, Innovation & Society

The programme Technology, Innovation and Society is conducted in collaboration with the Research Field Energy.



Forschungszentrum Jülich I GKSS Research Centre Geesthacht
Karlsruhe Institute of Technology

Two examples

01 Nanotechnology instead of lubricants

The cogwheels at the Karlsruhe Institute of Technology turn without the use of oil. They need to be extremely smooth in order to keep friction and wear to a minimum. This is achieved through the LIGA manufacturing process, which can produce components with a roughness of less than 50 nanometres.

Now LIGA technology is set to conquer the mass market. It has recently begun to appear in luxury Swiss watches. Escapements and escape wheels, the most important components of mechanical timepieces, are being mass produced using the technology. Cogwheels of this quality are ideal for mini or micro motors as used in computer hard drives.

In the process X-rays from a synchroton radiation source transfer a pattern onto a plastic film using a mask. When the mask is removed using a solvent, the spaces generated by its removal can be filled with metal by electroforming processes.

02 Faster supercomputer for independent research

Since June 2009, Forschungszentrum Jülich has boasted Europe‘s fastest supercomputer, an IBM Blue Gene/P that has a capability of 1 petaflop, i.e. a quadrillion calculations per second, and a central memory of 144 terabytes. That means it is 50,000 times more powerful than the average modern PC. Networked with the other supercomputers in Jülich, it has access to a memory of approximately five petabytes.

Scientists need these high speeds because simulation has now become a mainstay of research alongside theory and experiment. This is true of almost all areas of science from nanotechnology to biophysics to environmental research. Their systems are so complex that calculations without supercomputers would take decades.

The Blue Gene/P acquires its enormous computing power from the parallel operation of almost 300,000 energy-efficient processors. This gives us exceptional computational power in a compact space, using only a moderate amount of energy. The computer is used by research groups at Helmholtz Centres and at other German and European research institutions and universities.

Research Field
Structure of Matter

→ | The forces holding the building blocks of matter together play a decisive role not only at the microcosmic level; they also determine the development of the universe.

This research field's strategy is thus aimed at understanding the structure of matter and the forces which act upon it in completely different orders of magnitude. It also focuses many-particle systems which demonstrate new, complex properties.

We want to understand the fundamental laws governing the microcosmos and their role in the development of the universe; we want to predict the properties of complex systems and to use the knowledge acquired from this basic research to trigger innovative applications.

To achieve these goals, scientists working in this research field design, build and operate world-class large-scale facilities: accelerators for elementary particle physics; observatories for astroparticle physics; photon, neutron and ion sources for structural research in physics, structural biology, geology and chemistry. These large-scale facilities are essential tools for researchers from all over the world and attract many scientists to the Helmholtz Association.

The complexity of these highly technical facilities and the high financial cost associated with them means close international cooperation is required. Researchers from around the world discuss and decide together how the large-scale facilities can be used to benefit everyone. This research field therefore also plays an essential role in defining international research objectives.

The research field is structured around four core topics that are in some cases closely interrelated:

- → Elementary Particle Physics
- → Astroparticle Physics
- → Physics of Hadrons and Nuclei
- → Research with Photons, Neutrons and Ions

Deutsches Elektronen-Synchrotron DESY I Forschungszentrum Jülich
GKSS Research Centre Geesthacht I GSI Helmholtz Centre for
Heavy Ion Research I Helmholtz-Zentrum Berlin für Materialien und Energie
Karlsruhe Institute of Technology

Two examples

01 Unlocking the secrets of matter

FAIR, the Facility for Antiproton and Ion Research, is a new accelerator being set up at the Gesellschaft für Schwerionenforschung in Darmstadt in cooperation with international partners. It will deliver high-energy antiproton and ion beams with an intensity and quality never seen before.

Researchers will use the facility to examine particles and processes which would normally not exist on earth, but only in other parts of the universe.

These particles include atomic nuclei that play a key role in the creation of the chemical elements inside stars and in stellar explosions, and quark-gluon plasma, believed to be at the centre of neutron stars. FAIR, therefore, is expected to provide important insight into the structure of matter and the evolution of the universe.

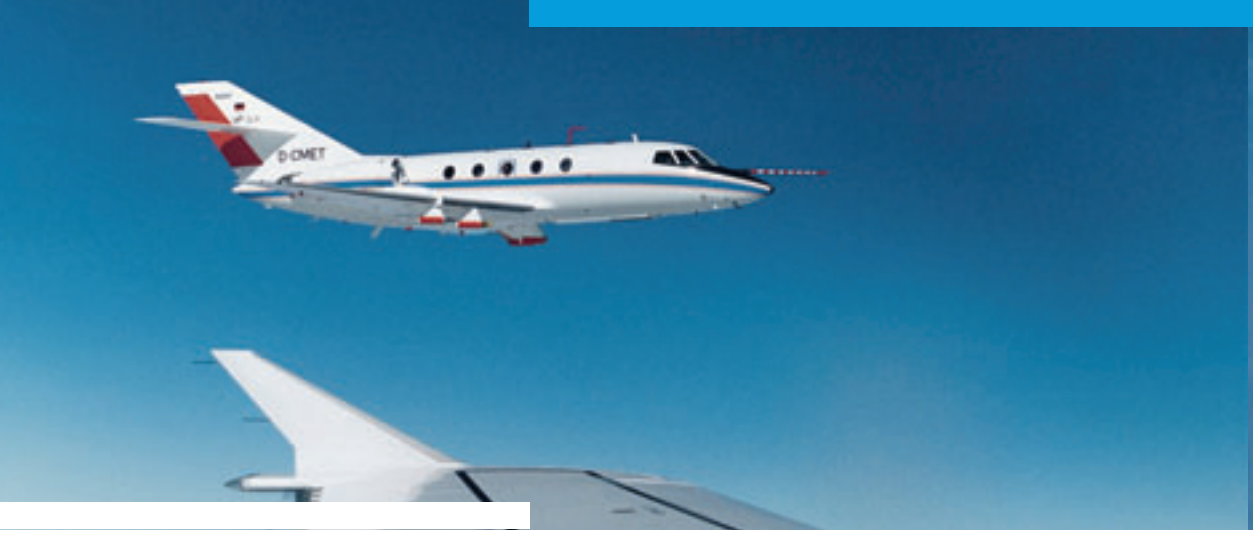
FAIR will offer unique research opportunities to over 2,500 scientists from all over the world. The accelerator is scheduled to be fully operational by 2015, although the first experiments could begin in 2012.

02 Films from the nanocosmos

The X-Ray Free-Electron Laser (XFEL) is a European project being built at the Deutsches Elektronen-Synchrotron DESY which is set to be operational in 2013. The high-performance properties of the new radiation source – extremely short and intensive “flashes” with wavelengths in the X-ray range – will allow researchers to film atomic processes for the very first time.

Scientists will be able to investigate how atomic structures change over time. For example, they will use XFEL to watch biomolecules at work, gain an understanding of the sequence of chemical processes and take three-dimensional images of the nanocosmos.

New user-groups have already been formed specifically with the XFEL in mind. For the past year, these groups have been gathering vital experimental experience with the X-ray laser’s pilot installation: the FLASH laser for X-rays.



Research Field
Aeronautics, Space and Transport

→ | Mobility, communication, safety and sustainable environmental management are decisive factors for the future of modern society.

The Research Field Aeronautics, Space and Transport has the aim of developing concepts and technological innovations that satisfy these needs in a sustainable way. Researchers in the field also use the technological opportunities available to them to gain basic insights into space and the planet earth.

We want to use synergies between the Aeronautics, Space and Transport programmes to make mobility as efficient, safe and environmentally friendly as possible.

Prime examples of such interdisciplinary system development tasks are concepts for applications of the future European satellite navigation system GALILEO, projects to improve linkage between airborne and ground traffic, and ideas for monitoring environmental parameters.

The Aeronautics programme investigates civil aviation concepts, coming up with technologies that make planes and helicopters safer and more comfortable and at the same time reduce the amount of noise they produce and the burden they place on the environment. This is in accordance with the national aeronautics research programme and the European Research Agenda.

The Space programme is devoted to earth observation and space exploration, communication, navigation and research in zero-gravity conditions, and space transport. The programme's goals are defined in close cooperation with the national and European space programmes.

The Transport programme focuses its activities on ground-based vehicles, traffic management and transport systems. One of the areas its scientists are exploring is how to make vehicles more energy-efficient and how to improve traffic safety.

Transport research and the further development of aerospace technology have a great many spin-offs because they are often closely connected to practical applications. The research field encourages such developments and for this reason scientists in the field work closely with the manufacturing and service industries.

German Aerospace Center DLR

Two examples

01 Next-Generation Train

A lot is expected of the trains of the future. Not only are they to be 25 per cent faster than the ICE3, they are to consume half as much energy and be quieter, safer, more comfortable and more reliable. The Next-Generation Train (NGT) project has pooled the DLR's rail vehicle engineering resources in order to develop a new double-decker high-speed train that should go some way to fulfilling these goals.

DLR researchers hope to develop a lighter structure using new composite materials, to optimise aerodynamics, and to initiate intelligent energy and bogie management. For example, they hope individually steerable wheels will improve contact between the wheels and the tracks. To achieve their aims they have devised new, higher-performance simulation vehicles, experimental analysis and testing methods, and specialised manufacturing processes.

The new trains will be built in modules to reduce development, construction and operational costs. As many results can be applied to all rail vehicles, regional trains are also set to benefit in the future. The NGT project has the potential to bring technological progress to the entire European rail network.

02 DLR radar in space

Since June 2007 Germany's first national radar satellite has been orbiting the earth and gathering data that is used to generate impressive images. The pictures document, for example, the dramatic effects that global warming has had on Arctic glaciers. TerraSar-X circles the earth from pole to pole at a height of approx. 514 km, using radar to scan the earth's surface with radar waves. It is able to deliver data regardless of weather, cloud coverage and light conditions, and the image resolution is so detailed that one pixel corresponds to one metre. The images are mostly of landmasses. Thanks to its sophisticated sensor technology, the satellite can identify and map different land-use types, such as forests or fruit crops. The satellite also monitors geologically active areas such as volcanoes or fault lines.

The five-year mission is being conducted in a private-public partnership between DLR and Astrium GmbH. Astrium built the satellite, and its subsidiary Infoterra GmbH markets the data for commercial clients. The DLR is responsible for managing the project, operating the satellite and providing the data to scientific institutions. In October 2009 the partnership plan to launch the TerraSAR-X's sister satellite, the TanDEM-X, which will fly in close formation with the TerraSAR-X to produce digital elevation models of all the planet's landmasses.

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Top-level research for
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