Federal Ministry
of Education
and Research

IGNITING IDEAS!
The High-Tech Strategy for Germany

Research and Innovation for Germany

Results and Outlook

HIGH-TECH STRATEGY

Igniting ideas!

Published by
Bundesministerium für Bildung und Forschung /
Federal Ministry of Education and Research (BMBF)
Section 111 – Innovation Policy Framework
11055 Berlin

Orders:
Order in writing from the publisher:
Postfach 30 02 35
53182 Bonn

Or order via the following:
Tel.: 01805-262 302
Fax: 01805-262 303
(EUR 0.14 / min. from the German fixed line network)

E-mail: books@bmbf.bund.de
Internet: http://www.bmbf.de

Editing:
BMBF / Section 111

Production:
W. Bertelsmann Verlag, Bielefeld

Design:
Hauke Sturm Design, Berlin

Printed by:
WERTDRUCK GmbH & Co. KG, Hamburg

Photo credits
Agentur für Erneuerbare Energien (p. 52), Becker KG, Brakel (p. 40), BMBF (p. 30), participating projects (pp. 22, 28, 29, 36, 39, 47, 53, 54, 66, 67, 83), Corbis (p. 3), Getty Images (cover, p. 13, 14, 25, 27, 43, 69, 85, 91, 95), Paul Glaser (p. 49), iStock (p. 23, 24, 64), Picture Alliance (p. 88), Plainpicture (p. 4, 11, 17, 19, 31, 33, 62, 65, 71, 73, 87, 97, 99, 103), Jens Schicke (p. 57), University of Paderborn, C.I.K. (p. 46), Ulrich Baumgarten/vario images (p. 79)

Bonn, Berlin 2009

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Foreword

The Federal Government hereby submits to the German Bundestag a statement of its position with regard to research and innovation policy in Germany and to the 2009 report of the Expert Commission on Research and Innovation.

The financial and economic crisis is presenting Germany with enormous challenges. To emerge from this crisis even stronger than before, we will have to make immense joint efforts. In addition to managing the crisis in the short term, we will have to commit ourselves to a path of growth and economic success. Investments in education, science and research are the right way to make such a commitment.

The Federal Government's High-Tech Strategy, presented in August 2006, is Germany's first overarching national innovation strategy. A first progress report, presented in October 2007, provided a initial positive assessment of accomplishments under the Strategy. In the meantime, a second progress report has been prepared. It summarises the goals and the effects achieved to date, citing outstanding initiatives and examples by way of illustration.

The Federal Government thanks the Expert Commission on Research and Innovation for its detailed analysis.

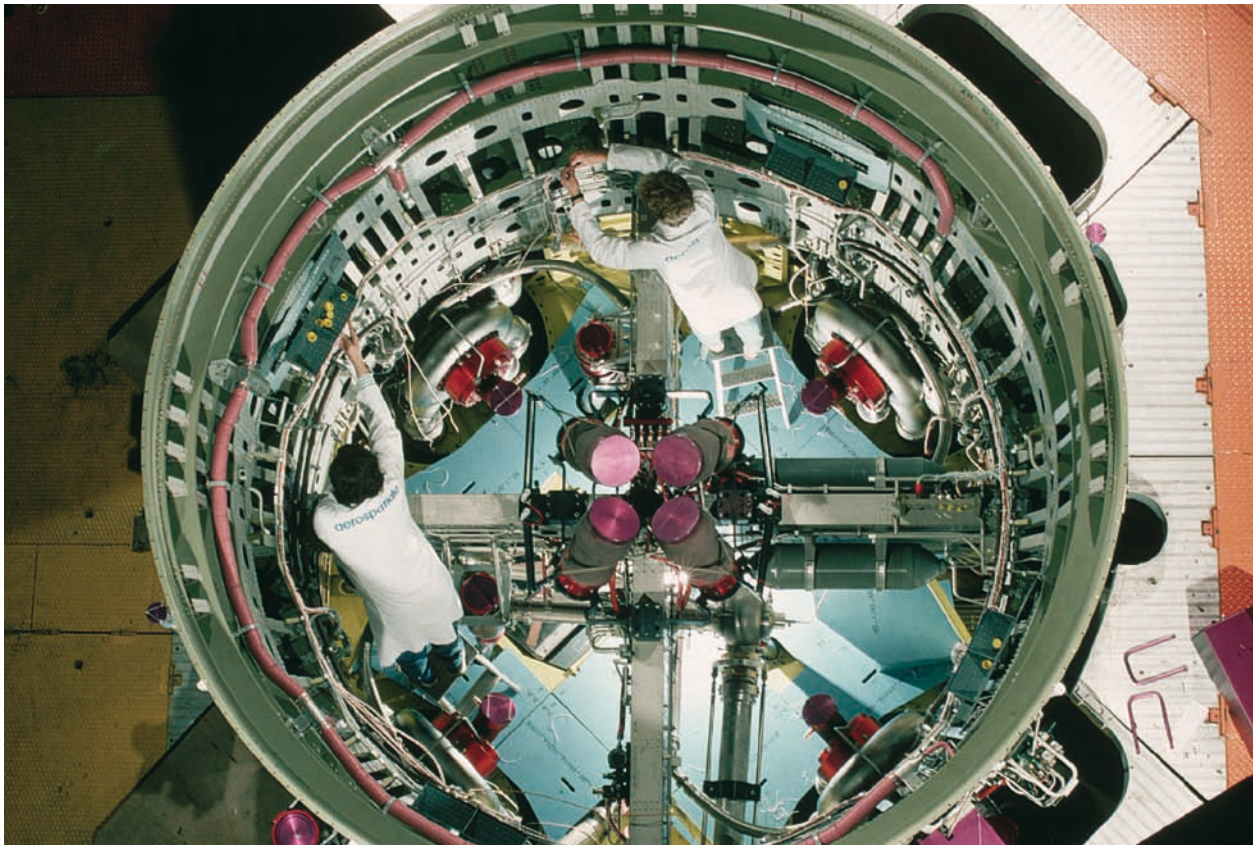
Prof. Dr. Annette Schavan,
Member of the German Bundestag,
Federal Minister of Education and Research

Contents

1. New growth via research and innovation 3
2. The High-Tech Strategy for Germany – results and outlook 11
   - 2.1 Lead markets have developed – priorities have been set 17
     - Health 19
     - Climate protection, resources conservation, energy 31
     - Security 43
     - Mobility 49
     - Key technologies 57
   - 2.2 Concentrating and mobilising resources – bringing industry and science together 71
   - 2.3 Improving framework conditions 79
3. Assuring the availability of a highly trained, skilled workforce 85
4. Science policy 91
5. Internationalisation and the European Research Area 97

Outlook 103

1. New growth via research and innovation



Emerging strengthened from the crisis

The economic and financial policy challenge now confronting Germany is the largest the country has seen in decades. The German economy's growth outlook has worsened dramatically in recent months. The crisis in the world's financial markets has made banks extremely cautious in their loan operations, and capital has become scarce. More over, the crisis has not spared innovative companies, nor has it been without impact on efforts to finance new technologies and ideas.

In the medium and long terms, however, the current financial and economic crisis will not stop the global race for knowledge from re-accelerating. International competition for talent, technology superiority and market leadership will continue to grow. In countries relatively poor in natural resources, such as Germany, enhanced innovation will provide the decisive basis for growth, new jobs and prosperity. Innovation is the key to a rapid recovery.

From the 2008 and 2009 reports of the Expert Commission on Research and Innovation:

"In the current, economically difficult period, it is especially important for research and innovation policy to play a central role"

"Research and innovation are indispensable for highly developed, resources-poor countries such as Germany. Innovative goods and services keep the economy moving, creating jobs and high incomes. Production, value creation and employment grow far more strongly in highly innovative companies than they do in weakly innovative ones. The prosperity of the country, and of its citizens, depend on research and innovation, as does the country's ability to provide for its citizens' futures and their quality of life."

The Federal Government has taken the steps that are necessary in the current environment. The comprehensive, targeted measures contained in the country's economic stimulus programmes are the answers to the question of how Germany can move safely through the crisis. With intensified investments in research and innovation, as well as an overarching High-Tech Strategy, the Federal Government has acted in a timely way to provide the basis on which Germany can emerge from the crisis even stronger than before.

Germany has good chances of emerging in a stronger position than before, because over the past few years it has moved promptly to set a suitable course for science, research and innovation:

- State support for research and development has been greatly expanded.
- For the first time ever, a consistent national innovation concept – the country's High-Tech Strategy – has been presented and systematically implemented, with the aim of enabling research findings to be translated more quickly into marketable products and even new markets. Suitable emphases have been placed on the global challenges of health, climate, energy, mobility and security. In difficult times, global economic demand will orient itself to the most urgently required areas.
- German science has enhanced its visibility and its reputation. Germany has become a more attractive location for science as a result of its efforts "Initiative for Excellence", "Higher Education Pact" and "Pact for Research and Innovation."
- In recent years, German business and industry have positioned themselves strongly in the world's technology markets. The creativity and technological performance of German companies attest impressively to the potential that new ideas can have in developing new, emerging markets and international market leadership.

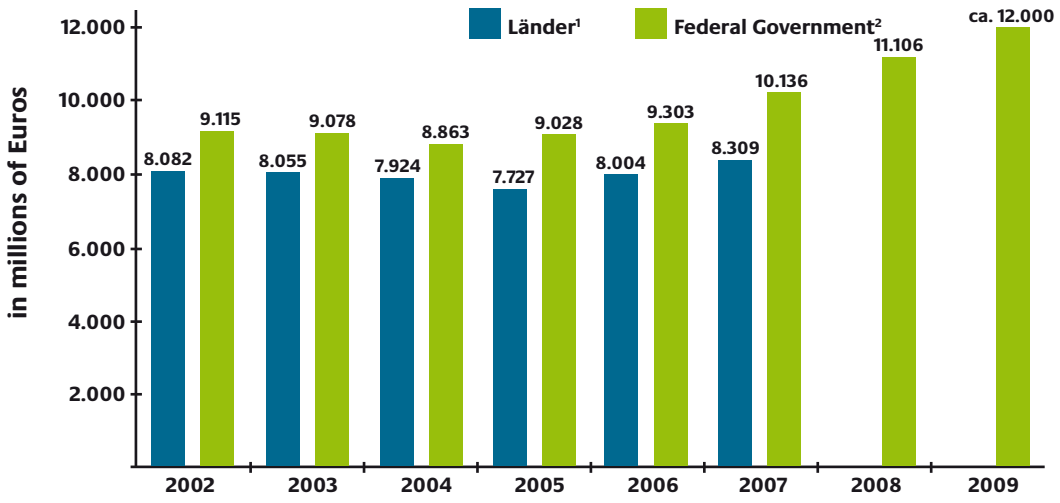
Economic stimulus – measures for education, science and research

With its bank-bailout programme and its economic stimulus packages, the Federal Government has moved quickly to address the crisis efficiently and precisely. The Federal Government is investing more than EUR 80 billion to overcome the crisis. That sum represents enormous growth impetus that certainly does not pale in comparison with the efforts of other countries.

The investment priorities include investments in education, research and innovation. The second economic stimulus programme (Konjunkturprogramm II) alone will provide an additional EUR 11 billion, this year and next year, for these areas. The first economic stimulus package (Konjunkturpaket I) expanded innovation-loan programmes of the state-owned KfW Bank. As a result, Germany will be able to emerge from the current economic crisis with a modernised education and research system. And that will protect and assure our country's future in the globalised knowledge society.

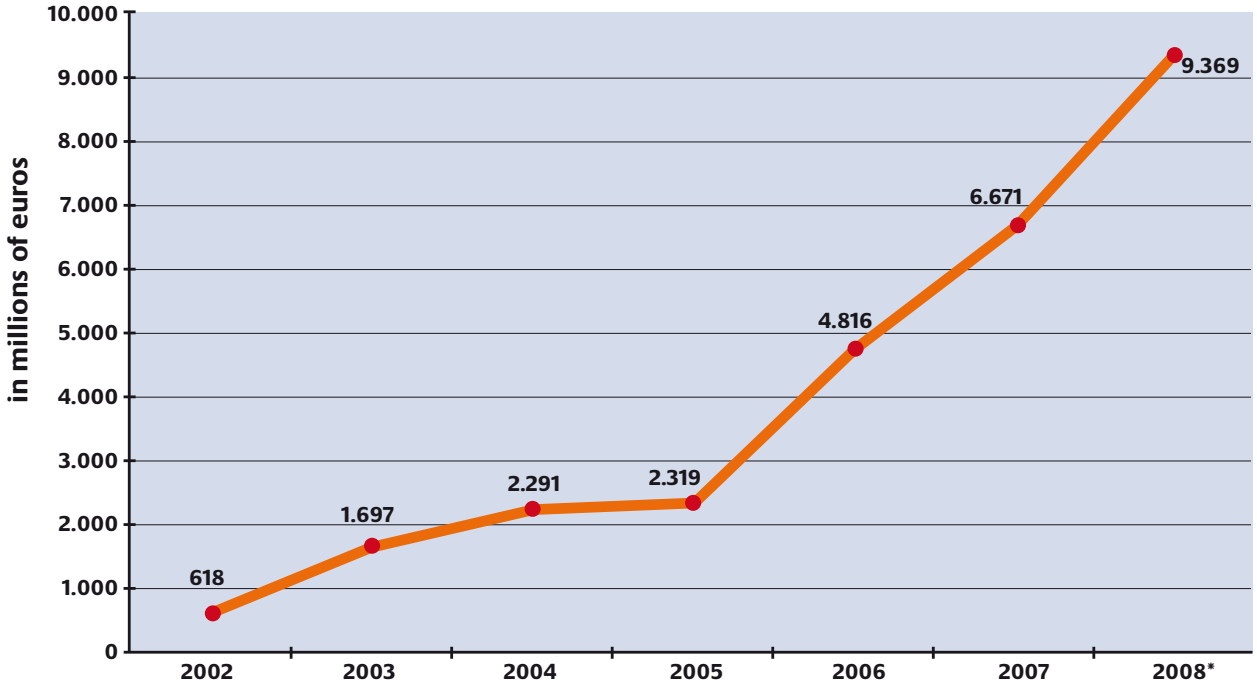
- A total of over EUR 8.66 billion are being invested in education and science: conditions for learning, teaching and research are being markedly improved (structural renovation and equipment / resources purchases in/for kindergartens and children's daycare centres, schools and further training centres, higher education institutions and non-university research institutions).
- Some EUR 500 million are being invested in application-oriented research in the area of mobility (especially for building skills and resources in electrochemistry; for the "electromobility" research network; and for a pilot research facility for the industrial production of lithium-ion batteries).
- Up to EUR 500 million are being made available for the basic renovation and energy-oriented modernisation of buildings, with recipients of the funding including research institutions such as the Helmholtz Association of National Research Centres (HFG), the Gottfried Wilhelm Leibniz Science Association (WGL) and the Fraunhofer-Gesellschaft.
- Any gaps remaining in broadband Internet network access will be eliminated by 2010. Such investments in high-tech infrastructures are providing stimulus for industry.
- In 2009 and 2010, the Central Innovation Programme for SMEs (ZIM) will receive EUR 900 million in additional funding, and the programme is being expanded to include larger companies with up to 1,000 employees
- The Federal Employment Service will receive additional funding of about one billion euros for the intensified training of employed persons and job-seekers.

R&D expenditures of the Federal Government and the Länder (financing)



Source: Federal Report on Research and Innovation, budget plans [1] 2007: estimate [2] As of 2008: planned

Cumulative growth in internal R&D expenditures of business enterprises since 2002



* Plan data from the 2007 R&D survey

Source: Stifterverband Wissenschaftsstatistik; last revision: 28 November 2008

The Federal Government's research and innovation policy is beginning to make itself felt. It is providing the basis for significantly greater investments in research and development. In the long term, such investments in the country's future are the best possible economic stimulus programme and the best possible driver of growth. The present report describes in detail the Federal Government's widely diverse range of initiatives and measures for relevant implementation.

National and international studies confirm that Germany is well positioned as a centre for innovation. The Expert Commission on Research and Innovation (EFI), for example, has attested to the German innovation system's international competitiveness. The current innovation report of the German Chambers of Industry and Commerce (DIHK) describes how the climate for innovation has improved palpably since the end of 2008: some 30 percent of all companies attribute their innovations to improved federal research and innovation policy. At the same time, companies are intensifying their research and development activities, in the interest of long-term competitiveness. In addition, companies' business policies are continuing to give greater and greater priority to close cooperation between the science and business sectors, especially with regard to research and development, and they are maintaining such emphasis in times of crisis. In this orientation, they have been supported by the High-Tech Strategy, which emphasises cooperation between the science and business sectors and formation of relevant clusters and networks.

Impacts and successes of research and innovation policy, from 2005 until 2009

- **Reversing the trend – Germany is again increasing its investments in research and development**
  - From 2005 to 2007, Germany's total expenditures (includes expenditures of the Federal Government, the Länder and business enterprises) in R&D increased by 10.4 percent, from EUR 55.7 billion (2005) to EUR 61.5 billion (2007)*.
- **The Federal Government has massively increased its state support for research and development**
  - Since 2005, the Federal Government has increased planned R&D investments by some EUR 3 billion, from EUR 9 billion to about EUR 12 billion in 2009. In addition, the second economic stimulus package (Konjunkturpaket II) provides still more funding for R&D for the period 2009 to 2011.
- **More R&D investments in the business enterprise sector**
  - Over the past three years, the business enterprise sector's R&D expenditures (volume of R&D carried out within the companies themselves) have grown much more rapidly than they did in the first half of the decade: from 2000 to 2005, they grew by nearly EUR 3.1 billion (8.6 percent), while from 2005 to 2007, i.e. in only two years, they grew by EUR 4.4 billion (11.3 percent).
  - For 2008, business enterprises reported plans to invest an additional EUR 2.7 billion in R&D, thereby bringing their total R&D investments to EUR 45.7 billion (+ 6.3 percent).
- **Strong growth among SMEs**
  - Already in the first year after the start of the High-Tech Strategy, SMEs' internal R&D expenditures grew by more than 12 percent (from EUR 6.6 billion in 2006 to EUR 7.4 billion in 2007).
  - From 2005 to 2007, the Federal Government increased its R&D support for SMEs by 20 percent.
  - Furthermore, the second economic stimulus package (Konjunkturpaket II) provides additional funding in support of SMEs' R&D during the economic crisis, for a range of efforts that include the Central Innovation Programme for SMEs (ZIM).
- **Germany is an international leader**
  - In terms of absolute figures, Germany is Europe's leading investor in R&D. Internationally, only the U.S., Japan and China have larger national R&D budgets. In 2007, Germany was also a leader with regard to R&D expenditures as a share of GDP, with a figure of 2.54 percent (for comparison: the OECD average in 2006 was 2.26 percent).
- **Positive impact on employment**
  - **Employment has been growing via research, knowledge acquisition and innovation**
    - From 2005 to 2007, manufacturing sector employment increased by 43,000 employees subject to social insurance requirements, and all of this growth occurred in research-intensive and knowledge-intensive areas. In spite of decreases in the financial services sector , the area of knowledge-intensive services also rose by 43,000 employees.
    - The positive employment market trends of recent years have especially benefited highly qualified persons. The percentage of employees with higher education qualifications in the German business enterprise sector grew from 6.9 percent in 1998 to 8.6 percent in 2007. The long-term trend indicates that German employment growth occurs especially in the category of jobs involving research, development and innovation, and requiring high levels of qualifications.
  - **Additional R&D workforce added**
    - In 2007, an unprecedented number of men and women at Germany's public sector research institutions and higher education institutions were involved in research and development. The R&D workforce in that area amounted to some 179,000 full-time positions. The positive budget trends seen in 2008 and 2009 give reason to expect a further increase of 20,000 to 30,000 employees.
    - Pursuant to the Stifterverband innovation agency, as of 2008, the business enterprise sector was planning on employing some 322,000 highly qualified and specialised staff in R&D. This figure represents a 6 percent increase over the corresponding figure in 2005.
    - As of June 2008, the number of persons employed in the economy's research and development sector, which primarily includes public and private research companies (i.e. does not include higher education institutions), had increased to some 162,000, or by about 15 percent over the corresponding figure in 2005.

* Preliminary figures of the Federal Statistical Office

The successes of the country's research and development policy are particularly obvious in a number of sectors:

- **Environmental technology**
  Thanks to its innovation-friendly legal framework, and state research support, Germany is a leader in environmental technologies and global trade in products for environmental protection (world trade share of 16 percent). Germany's environmental industry sector employs some 1.5 million people, and its workforce is growing. In 2007, the renewable energies sector alone accounted for about 250,000 jobs in Germany.
- **Optical technologies**
  An impressive industrial sector has developed and thrived with the help of state support. German companies are among the world market leaders in the area of laser technology (about 110,000 employees, or 16 percentof all employees in the manufacturing sector; 9.5 percent involved in R&D; some EUR 2 billion in R&D expenditures per year).
- **Biotechnology**
  With the help of state support, Germany has become Europe's leader in biotechnology (the sector has some 500 companies, and annual revenue of about EUR 2 billion – with that figure, for 2007, representing an increase of 14 percent over the previous year; more than EUR 1 billion in R&D expenditures per year; and a total of about 30,000 employees – amounting to a 24 percent workforce increase for the period 2005 to 2007).
- **Nanotechnology**
  With the help of state research support, some 740 innovative companies, and about 50,000 industrial jobs, have emerged in Germany's nanotechnology sector. As a result, this technology field is contributing significantly to positive trends in the area of start-ups in Germany.
- **Lithium-ion battery**
  Research support is providing the basis for evolution in this area from basic research to series production. The firms Li-Tec GmbH, Evonik AG and Daimler AG are planning to develop lithium-ion batteries for motor vehicles to series maturity. Production of the new high-technology batteries is to take place in Kamenz (near Dresden) and is expected to generate some 1,000 additional jobs

Current results of the "European Innovation Scoreboard", the OECD report "Science, Technology and Industry Outlook 2008" and the Bertelsmann Foundation's study "Sustainable Governance Indicators 2009" confirm that a comparison of OECD countries shows that Germany is well prepared for the challenges of globalisation. Moreover, Germany is seen to have a leading role especially in the area of research and innovation policy. It is true that other countries, including China, India and Brazil, are catching up rapidly. And the new U.S. administration will promote innovation in the areas of climate protection, energy and health care. Nonetheless, Germany clearly remains among the international leaders in terms of both the level and the pace of innovation in recent years. An international comparison thus shows that Germany is eminently well prepared to overcome the economic crisis, and to do so with the help of research and innovation.

Innovation is Germany's opportunity

We now need to ensure that we make the best possible use of this favourable basis. This means that Germany needs to make its own specific contribution to efforts to meet global challenges, while also gaining global competitive advantages via state-of-the-art technologies and services. This is all the more evident in that, in the present crisis, the world stands at the beginning of a new wave of innovation, a new momentum that will profoundly shape the coming decade via technological and social changes and through efforts to tackle global challenges. Climate change, efficient use of energy and resources, a continually growing world population and a changed security framework are all creating challenges that can be met only through joint efforts of the international community, drawing on strong science and research sectors, and applying technological innovation and creative new solutions. Germany's opportunities in the global competition shine especially in the following research and requirement areas:

Climate protection, resources conservation, energy – Sustainable economies, technologies that save energy and resources (in particular, highly energy-efficient technologies; improved, cost-effective renewable energy sources; new materials) will help protect the basis for our future and improve adaptation to environmental and climate changes.

Mobility – New drive systems and fuels, as well as intelligent traffic infrastructures, will help move people and goods quickly, safely, conveniently, comfortably and efficiently – and, thus, in ways that conserve resources (and produce low CO2 emissions).

Health – Molecular-biological and biomedical research provides the basis for individualised diagnosis, therapy and medications, and will improve the health and quality of life of an ageing population.

Security – Innovative security technology concepts, applications and products will protect our society, and its vital infrastructures, against terrorism, sabotage, organised crime and the consequences of natural disasters and major accidents.

The Federal Government has recognised these opportunities for Germany. With its High-Tech Strategy, it has placed key emphases on these global requirement areas and future technologies. In the process, specific initiatives have been launched in areas in which new lead markets can build on industrial strengths, such as environmental technologies, energy efficiency and medical technology.

We plan to protect and expand these areas in the coming years. The Federal Government is working to meet this challenge via:

- Innovation strategies that build systematically on existing technology developments and innovation processes and that develop new, innovative fields;
- New, optimised and overarching technology initiatives aimed at expanding successful cooperation between the business enterprise and science areas and accelerating transfer of ideas to products and markets;
- Improved framework conditions that boost innovation.

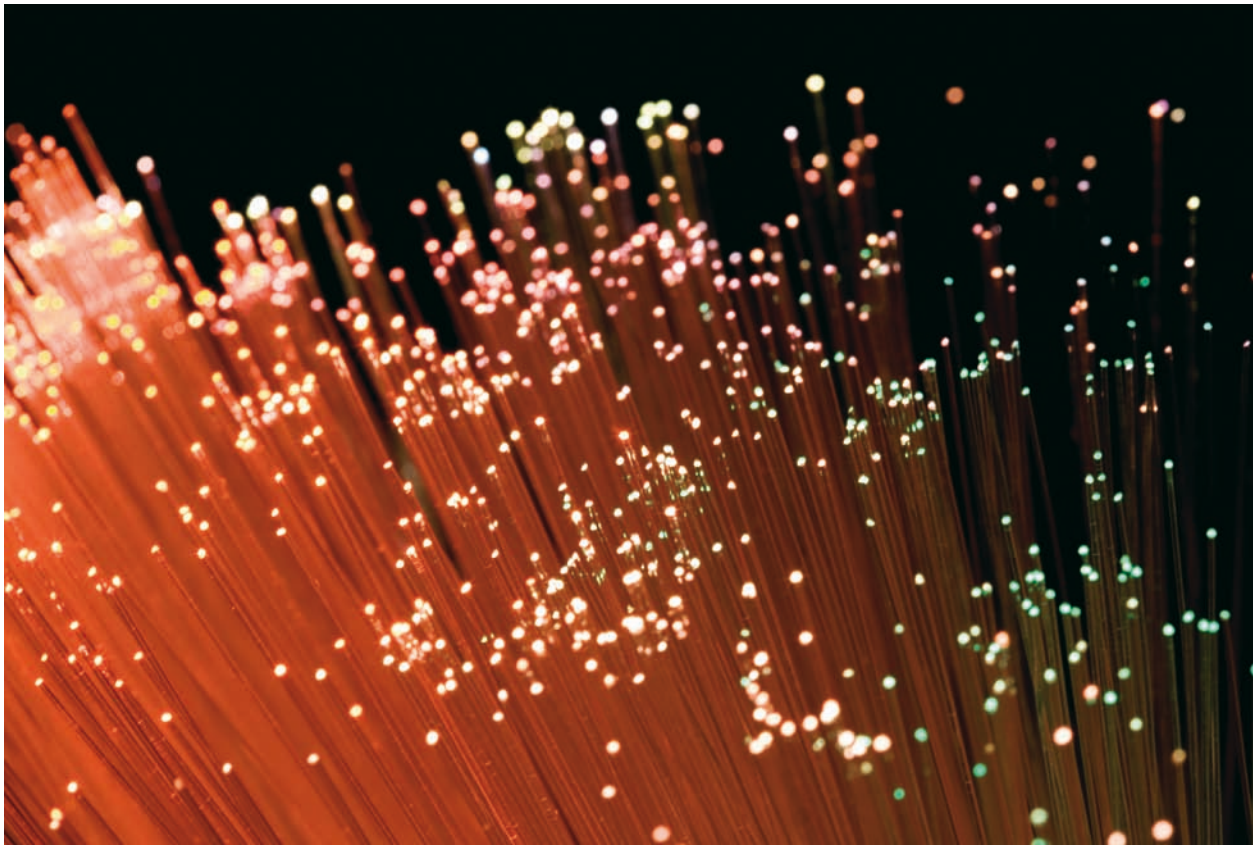
Consequently, Germany's political, business enterprise and science need to continue working together on the following central tasks: producing greater numbers of highly qualified persons, by improving education for everyone; and strengthening Germany's position as a centre for innovation by assuring the international competitiveness of Germany's science and research sectors.

At a "Qualification Summit" held in October 2008 in Dresden, the Federal Government and the Länder provided the basis for carrying out these key tasks. Both sides agree that expenditures for education and research in Germany need to reach a level of 10 percent of the country's gross domestic product by the year 2015. This goal for Germany's future is an unprecedented one. Working in cooperation, we can continue to modernise Germany's education and research systems, and enhance its international competitiveness and attractiveness, thereby creating the basis for future prosperity.

We need to act now, during the crisis, to build on the High-Tech Strategy's successes to date and to drive – and make use of – the major wave of innovation for the coming decade. This challenge is relevant for all stakeholders, and thus Germany's political, science and business enterprise sectors must all continue in their efforts to meet it.

We want to make Germany a world centre for innovation and position our nation accordingly internationally. With its focus on education, science, research and innovation, the Federal Government has been promoting innovative, new approaches, in the interest of Germany's citizens and business enterprise sector. These efforts are generating new, sustainable economic growth, while also enhancing our quality of life. We are called on to act together to ensure that such productive efforts continue.

2. The High-Tech Strategy for Germany – results and outlook



SUMMARY

- **The High-Tech Strategy is the right conceptual approach:** its innovation strategy, which is unprecedented in its overarching scope, a scope that cuts across all relevant policy and thematic areas, is bringing competencies together, in the interest of increasing innovation. Research and innovation activities are being combined across all departments. Relevant joint activities have been launched. The Strategy's concept is widely supported throughout the business enterprise, science and policy sectors.
- **Priorities have been set:** the High-Tech Strategy emphasises society's major requirement areas: health; climate protection and resources conservation; mobility; and security. In these areas, existing strengths are being reinforced, and new incentives created – and lead markets with international competitive advantages are emerging as a result. At the same time, Germany is contributing in its own special ways to the task of meeting global challenges via research and innovation.
- **The High-Tech Strategy is combining and mobilising resources:** numerous new instruments for promoting cooperation between industry and science have been launched, with a clear focus on network-building, clusters and SMEs (for example, Top Cluster Competition; the "KMU-innovativ" programme for funding cutting-edge research by SMEs; the Central Innovation Programme for SMEs (ZIM); the "Entrepreneurial Regions" programme). Strategic partnerships and innovation alliances between industry and science have been successfully established (for example, in the areas of energy efficiency and automotive electronics). The pathways leading from development to markets have become shorter and faster.
- **Framework conditions play a decisive role in successful innovation:** the High-Tech Strategy boasts an unprecedented combination of research support and framework conditions. It focuses especially on young, innovative companies and SMEs. Conditions for start-ups have been improved; financing opportunities for start-ups have been expanded; intellectual property protection has been reinforced; and innovation-oriented procurements have been promoted.
- **The High-Tech Strategy's successes are being systematically evaluated, and the strategy is being continuously improved:** the Expert Commission on Research and Innovation (EFI), and the Science and Industry Research Union (Forschungsunion Wirtschaft – Wissenschaft), provide the Federal Government with expert advice; both have confirmed the Strategy's positive impacts. Independent accompanying research on the Strategy's impacts provides a reliable scientific database for the High-Tech Strategy's systematic improvement.

The High-Tech Strategy is the right conceptual approach

Germany is one of the world's leading powerhouses in science, research and innovation. In addition to developing ideas, Germany also needs to translate ideas into successful products, however. That is why, in August 2006, the Federal Government launched the High-Tech Strategy for Germany. The Strategy is helping to create a new innovation climate in Germany in which ideas can "take off."

Functioning in an unprecedented overarching manner across all relevant policy and thematic areas, the national strategy combines a wide range of research and innovation activities, throughout all relevant departments. Pertinent joint activities have been launched, since today's global challenges can be met only through concerted efforts involving all resources.

The High-Tech Strategy's three central aims give Germany's research and development activities a clear strategic orientation:

AIMS OF THE HIGH-TECH STRATEGY

LEAD MARKETS

- Set new priorities – oriented to global challenges: health, climate protection / resources conservation / energy, mobility, security
- Consider all factors entering into successful innovation
- Use strategic partnerships to mobilise industrial research
- Rely on key technologies as a basis for innovation

Set new priorities and create lead markets

INDUSTRY / SCIENCE

- Encourage the growth of outstanding research and innovation clusters: the "Top Cluster competition"
- Expand and streamline innovation support for small and medium-sized enterprises (SMEs): the Central Innovation Programme for SMEs (ZIM); the "KMU-innovativ" programme for funding cutting-edge research by SMEs
- Strengthen top-quality research and innovation in the new Länder

Build bridges between industry and science

FRAMEWORK CONDITIONS

- Provide more attractive terms for innovation financing
- Improve conditions for start-ups
- Make R&D investments more attractive by enhancing intellectual property protection
- Make public procurement more innovative
- Pursue initiative for a "Freedom of Science Act" ("Wissenschaftsfreiheitsgesetz")

Improved framework for innovation in industry

- **Lead markets** in global requirement areas are being created and expanded; priorities are being oriented correctly, to global challenges: health, climate protection / resources conservation / energy, mobility and security.
- **New bridges** are being built **between industry and science**; this is combining, concentrating and mobilising resources. The important focuses include promotion of cooperation, networks and clusters, with special emphasis on SMEs.
- **The framework conditions** for innovation have been studied and improved.

The High-Tech Strategy is the right approach, as the 2009 report of the Expert Commission on Research and Innovation (EFI) notes:

"With the High-Tech Strategy, a promising form of cooperation, cutting across departments and policy areas, has been initiated."

"The Expert Commission has endorsed the concept behind the High-Tech Strategy – that concept continues to be an important step in enhancing the effectiveness of national research and innovation policy."

The High-Tech Strategy is being continually improved and refined

The Expert Commission on Research and Innovation (EFI) advises the Federal Government, drawing on its own excellent, internationally recognised scientific expertise. With the Commission's second report, which appeared in early March 2009, the Federal Government welcomes the independent judgements of experts. In connection with such annual reports, comprehensive analyses of the strengths and weaknesses of the German innovation system, carried out in a framework of international and chronological comparisons, are produced. The studies and reports are publicly available at www.e-fi.de.

The Expert Commission on Research and Innovation (EFI)

Members:

Prof. Dietmar Harhoff, Ph.D. (Chairman)

Prof. Dr. Hariolf Grupp †
(deputy chairman until 20 January 2009)

Prof. Dr. Dr. Ann-Kristin Achleitner

Prof. Jutta Allmendinger, Ph.D.

Prof. Dr. Patrick Llerena

Prof. em. Dr. Joachim Luther

The two reports presented in 2008 und 2009 have confirmed the usefulness of the overarching strategy, which spans all relevant departments and policy areas, as well as the strategy's effectiveness in mobilising relevant action. The Expert Commission supports the basic outlines of the Federal Government's research and innovation policy. The 2009 report shows that the Federal Government, by considerably increasing federal funding for research and development, and by carrying out its High-Tech Strategy, has provided an important basis, over the past few years, for new economic growth.

The Expert Commission also calls attention to the additional steps that will have to be taken to safeguard the German innovation system's competitiveness. The Commission calls for additional steps to reinforce research and innovation, to eliminate barriers and obstacles and to refine the overarching, interdepartmental and interdisciplinary innovation strategy. In particular, the Expert Commission sees a need for further action in the areas of innovation-oriented design of the relevant framework and of innovation financing. Key actions to those ends, say the experts, will include providing an innovation-friendly tax system and intensifying support for start-ups, which are an important avenue for knowledge transfer between science and industry. At the same time, the Expert Commission calls for intensified efforts to meet the growing demand for highly trained and specialised personnel and to improve the use of opportunities for growth in the services sector. The Federal Government has acted to meet some of these challenges, and the possibility of action on others is being reviewed (see the individual descriptions in the various chapters of the present report).

In the newly established **Science and Industry Research Union** (Forschungsunion Wirtschaft – Wissenschaft), the industry, science and political sectors are cooperating at a high level. The Union is providing both content-oriented and strategic support for the High-Tech Strategy.

The Science and Industry Research Union (Forschungsunion Wirtschaft – Wissenschaft)

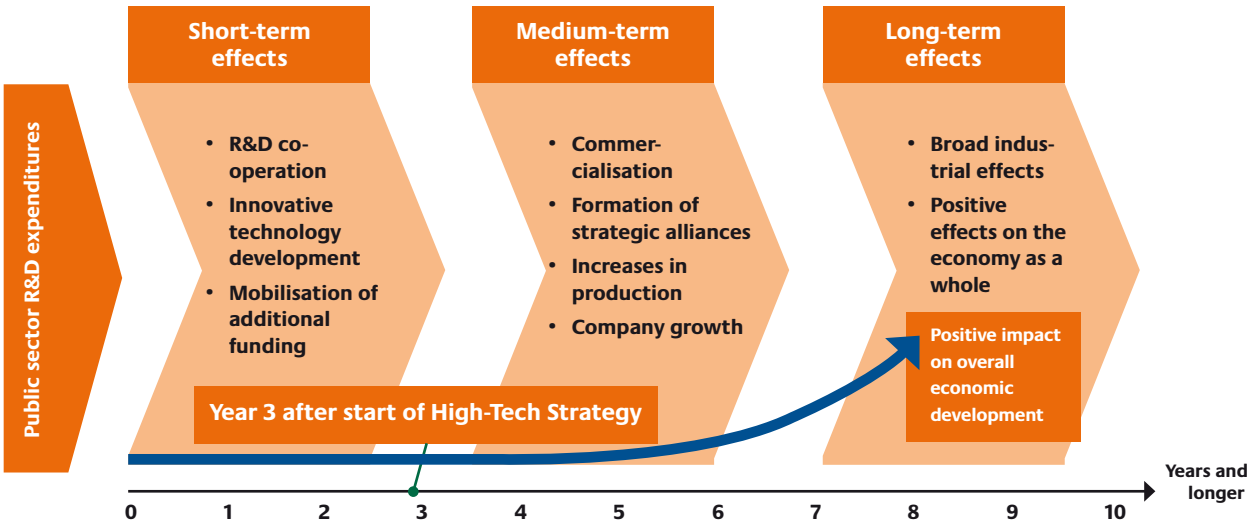
The Union comprises a total of 20 leading representatives of the areas of policy, industry and science. It is chaired by Prof. Dr. Hans-Jörg Bullinger (President of the Fraunhofer-Gesellschaft) and Dr. Arend Oetker (President of the Donors' Association for the Promotion of Sciences and Humanities in Germany)

www.hightech-strategie.de

In their own institutions and circles, the members of the Research Union function as "promoters" for individual fields of innovation and support pertinent implementation in those areas. Their efforts to these ends include participating in innovation alliances and serving as "ambassadors" for Germany's R&D sector.

The Research Union has initiated a number of measures: in January 2009, at the Research Union's recommendation, a Research and Technology

Research and innovation policy calls for patience; it develops its full impacts only over a period of years



VDI/VDE-IT 2009, drawing on Tassey 2003 and Ruegg 1999

Advisory Board for Bioeconomics (Forschungs- und Technologierat Bioökonomie) was established under the auspices of the German Academy of Science and Engineering (Acatech). That advisory board is charged with carrying out scientific analyses relative to the sustainable use of biomass and with making proposals for a pertinent national innovation strategy. Yet another example is the "Task Force on Services" ("Taskforce Dienstleistungen"), established by the Research Union. Furthermore, the "Research Union's Working Group on Tax-based R&D Support" ("Arbeitsgruppe der Forschungsunion zur steuerlichen FuE-Förderung") has prepared a report with a scientific analysis of this instrument (tax-based support) and made specific proposals for introducing and structuring it.

The impact of new initiatives must be reported clearly and honestly. For this reason, independent, **supporting research into such impact** is extensively required. From the very beginning, the Federal Government has sought to answer this need in connection with the High-Tech Strategy and has subjected all relevant new initiatives to evaluation and/or supporting research. Pertinent efforts initiated to date, for example, include system evaluation of the the "KMU-innovativ" programme for funding cutting-edge research by SMEs; international comparative analyses of the "Strategic Partnerships" instrument; and supporting evaluations of the Top Cluster Competition, the "Research Bonus" ("Forschungsprämie") funding line and the Central Innovation Programme for SMEs (ZIM). The relevant funding initiatives from specialised programmes are also evaluated and supported by research. In sum, the basis for solid scientific assessment is in place.

At the same time, it must be remembered that research and innovation have a complex impact that tends to appear in the long term. Systematic science and innovation policy, and the High-Tech Strategy itself, will require a number of years to produce specific successes. Research and innovation policy calls for patience, for a longer-term orientation. The Expert Commission has specifically highlighted this truth.

Similarly, it is just as important to look ahead, into the future, as it is to evaluate past results. The High-Tech Strategy is oriented to future technological developments, processes and challenges. With this in mind, in September 2007, the BMBF launched the **"Foresight Process"**, which aims to look 10 to 15 years – and even further – into the future (**www.bmbf.de/de/12673.php**).

2.1 Lead markets have developed – priorities have been set

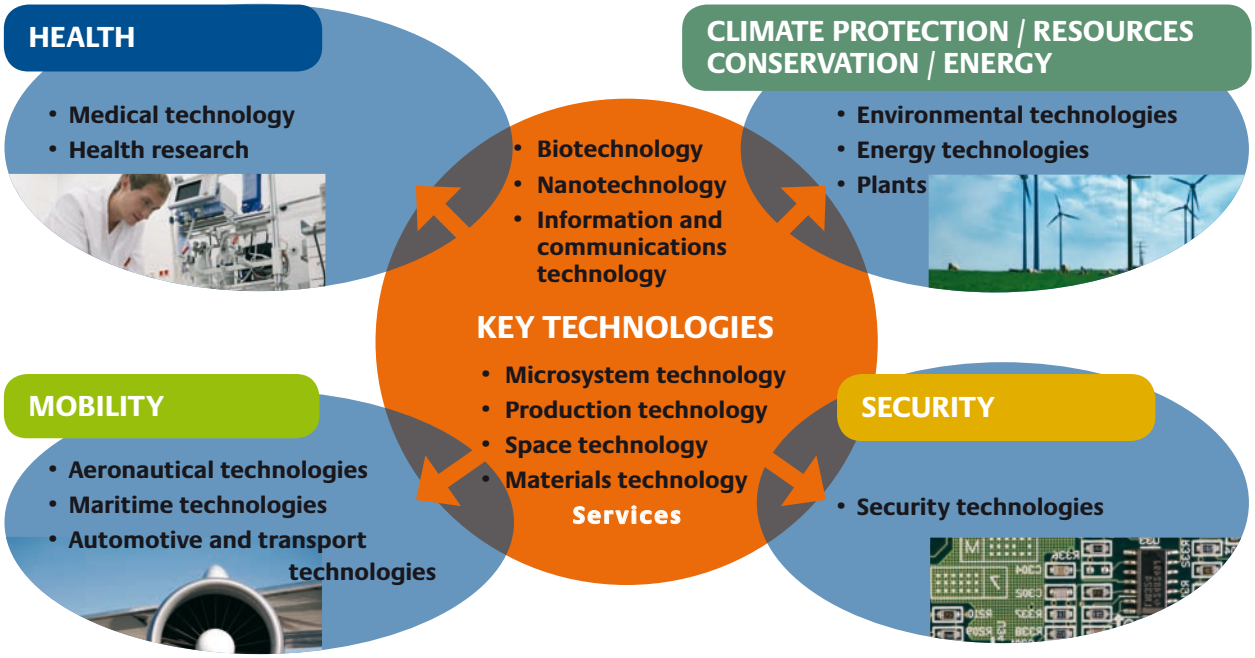
Via innovative products, technologies and services, Germany creates **lead markets** – markets that have major growth potential and in which international competitive advantages can be obtained via early development and introduction of innovations.

For this reason, the High-Tech Strategy includes priorities in areas in which such lead markets can emerge or are already in place – areas in which Germany is already carrying out cutting-edge research and in which it has an outstanding outset position, thanks to its excellent science and research sector and its technology leadership. With this approach, Germany is moving from strength to strength, as well as reinforcing and building on international, lasting demand for products and services. The High-Tech Strategy provides support in those areas in which added value is created!

At the same time, the relevant **priorities** have been defined in accordance with lead-market-oriented topic areas in which the state has special responsibilities and which are of special societal and global relevance: health, climate protection / resources conservation / energy, mobility and security.

The outstanding position enjoyed by Germany's **key technological sectors** (ICT, nanotechnology and biotechnology; optical technologies; microsystem technology, production technology and materials technology in combination with innovative services) supports the emergence of such lead markets. Key technologies have a broad impact, throughout entire economies. They thus drive technological development for new products and innovations.

The following sections present the various individual requirement areas and the pertinent initiatives and measures launched by the Federal Government.



The requirement areas relative to the High-Tech Strategy's 17 innovation areas and to key technologies are interrelated

Health

SUMMARY

Challenges and aims

Protecting and restoring health is a central human need. Health research and biotechnology play a significant role in meeting this need. The Federal Government is working to improve the quality of life for all people, including the very elderly; to protect society's ability to function effectively; and to ensure that the health care system remains affordable. As a result of the growing demand for health care services, and of medical technology innovations and the emergence of new applications for biotechnology, the health care sector also has considerable economic potential.

Results and outlook

Health research and biotechnology are among the High-Tech Strategy's central areas of action. Germany is an international leader in many sub-areas of these major sectors. The important emphases in this area include:

Improving understanding of disease:

- **Medical genome research** has led to new types of diagnostic and therapeutic procedures, and the Federal Government's support is helping to improve the basis for individualised medicine.
- New areas of research, such as **system biology**, **regenerative medicine** and **computational neuroscience**, have been successfully established, at an early point in their development, with the support of the Federal Government.
- The science and business enterprise sectors, with the support of the Federal Government, have been acting on the importance and the potential of **nutrition research** in the prevention and positive influencing of diseases.
- **Prevention research** has been established as a basis for a separate area of the health care system, along with the areas of treatment, care and rehabilitation.

Research findings are being translated into applications more quickly:

- **Health research** is developing new, integrative concepts for **prevention, diagnosis, therapy** and **rehabilitation** and **post care**. The basis on which such new concepts can enter quickly into clinical practice has been established.
- In contrast to pertinent trends in the 1980s and 1990s, Germany is now again the European leader in the area of **clinical studies**.
- **Care research** has been intensified, with a view to ensuring the continued availability of high quality, widely offered medical and nursing care, especially in light of the constraints of demographic change, limited financial resources and medical and technological progress.
- A **"Pharma Initiative"** and a **"Pharma Task Force"** are providing new impetus for Germany's biotechnology and pharmaceutical sectors; the relevant aim is to restore Germany's status as the "world's apothecary."
- In the area of **medical technology**, BMBF support is enables research ideas to be implemented more quickly in the form of marketable products.

Challenges and aims

Health is a central and universal need. Many basic questions pertaining to health in the broad, holistic sense remain unanswered, in spite of intensive research, or are having to be reformulated in keeping with changed societal conditions. In our ageing society, the prevalence of civilisation-related diseases such as diabetes, cardiovascular disorders and rheumatic diseases has been increasing. As a result of this trend, and of changes in living and environmental conditions, the number of chronically ill people, and of people requiring continual nursing care, has been growing.

Health and biotechnology research is expected to provide fundamental new insights relative to health maintenance, disease prevention and treatment, and to yield solutions to existing and future societal challenges in this area.

The important bases of any viable health care system future include an **understanding of the ways in which diseases arise and develop**. Only when we truly understand diseases i.e. the interrelationships between genetic disposition, environmental factors, diet, exercise and lifestyle can we recognise risk factors in time and take suitable precautionary and preventive measures. Relevant prevention options, for example, can include special diets and extra exercise, but they can also call for medications that reliably prevent the emergence of diseases. In the interest of effectiveness, prevention and treatment must be backed by suitable, evidence-based studies of the pertinent efficacy, benefits and risks.

On this basis, the **Federal Government** is working toward the **following aims**:

- Study of the **origins and development of diseases** is a key basis for **improved prevention, diagnosis and therapy**. Such study plays a central role in efforts to acquire the ability to adequately treat and combat the largest possible number of the 30,000 different diseases known to medical science.

- The impact of **diet and nutrition** on health need to be systematically studied. The development of functional foods, as well as of greater personalisation of dietary plans, could play a profound role in health maintenance.

- The enormous progress achieved in genome research is making **individualised medicine** a realistic possibility. An understanding of molecular factors in disease, as well as of specific, individual processes in pathogenesis, will make efficient, targeted prevention and treatment possible. To this end, further studies of relevant processes within the human body are needed – especially studies that document individual development and relate it to research findings. Such work must include systematic consideration of gender-specific differences.

- **Medical advancements must become rapidly available in the form of treatment and therapy**, in the interests of improving health care for the population – and of enhancing the German health care sector's competitiveness.

- **New ways of dealing with the impacts of demographic change** need to be developed, in the interests of ensuring that health care remains widely available; of enhancing prevention – also in older people; of treating patients with multiple disorders and with extensive nursing care needs; and of enabling older people to remain independent, with a high quality of life. At the same time, concepts for providing care and treatment of all needy persons are required, concepts that are viable in real, everyday care frameworks.

- It is absolutely necessary to **protect the quality, efficiency and cost-effectiveness of the health care system**. Useful efforts to this end include shortening of treatment periods, via innovative approaches in prevention, therapy, rehabilitation and post-care; use of affordably priced medical apparatus; and complete coverage networking of all stakeholders – also via a telematics infrastructure.

Health – major potential benefits for the economy

Excellent growth opportunities are forecast for the coming years for companies in the health care sector. Technical progress, and demographic change, will ensure that demand for health care services continues to grow.

The **health care sector** is already one of Germany's largest economic sectors, with over 4.4 million employees and a 10.6 percent share of the country's gross domestic product. In terms of its overall economic role, it is thus larger than the automotive sector. Provisional estimates indicate that up to 800,000 additional jobs could develop in the German health care sector by 2020.

The **German medical technology sector**, with a total of 170,000 employees in over 11,000 companies, most of them SMEs, is considered particularly innovative. It is a leader in the relevant international competition. From 2005 to 2008, the sector's total revenue increased by 21.4 percent, from EUR 14.7 billion to EUR 18.7 billion. Foreign trade is an especially strong driving force, now accounting for 64 percent of the sector's revenue.

Medications developed by biotechnology laboratories have earned a significant market position: in 2007, such medications accounted for EUR 4 billion, or 15 percent, of the pharmaceutical industry's total revenue in Germany.

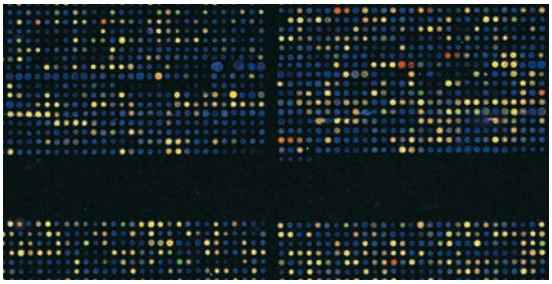
Results and outlook

Providing impetus for promising, new research fields

In 2001, the human genome was completely sequenced for the first time. That success, in which German scientists participated, in the framework of the German Human Genome Project (Deutsches Human Genom Projekt; DHGP), remains a milestone in life sciences research, even if not all expectations regarding rapid application of the sequence to the fight against disease were fulfilled. Now, support for **medical genome research**, in the framework of the National Genome Research Network (Nationales Genomforschungsnetzwerk; NGFN), an application-oriented programme succeeding the DHGP, is achieving successes, however. This effort has produced important findings relative to the causes and development of diseases, thereby strengthening the international competitiveness of German medical genome research. One indicator of the suc-

PRACTICAL EXAMPLE

Better diagnosis of prostate cancer



Analysis of gene signatures (patterns of gene activity) in prostate cancer

Prostate cancer is one of the most common cancers. To date, no satisfactory diagnosis options are available that can clearly differentiate between slow growing and aggressive tumors. For this reason, patients are often treated unnecessarily or incorrectly, often leading to serious side effects. Now a new diagnostic method may be able to eliminate such diagnostic uncertainties. The German Cancer Research Center (DKFZ) in Heidelberg, working in cooperation with partners, has developed a procedure for recognising gene activity patterns in prostate tissue. The procedure permits very early detection and assessment of cancer cells, with the help of a chip-stored database of gene activity samples. In the procedure, a prepared tissue sample is subjected to a chemical reaction. This yields colour-coded gene signatures that point to the activity of certain genes, thereby serving as a basis for more reliable diagnosis of prostate carcinomas. The new procedure is currently being studied for its usefulness in everyday clinical practice.

cess achieved consists of the major interest seen on the part of industry; industry participation has been increased by 60 percent compared to 2005.

In addition, system biology, a new and closely related research field, has now been established in Germany at an early point in its development. **System biology** seeks to understand the broad spectrum of regulatory processes in our cells by linking experimental approaches with mathematical methods. Thanks to key support from the Federal Government, Germany is now one of the international leaders in this research area. In cooperation with the Länder, new, interdisciplinary research structures have been established. Under the leadership of the BMBF, European strategies for the development of system biology have been outlined.

Regenerative medicine is another young, promising research field. It studies processes involved in the function and regeneration of cells, tissue and organs, with the aim of using the resulting findings to develop therapeutic procedures. To date, inadequacies in the availability of suitable donated organs persist, even as demand for replacement organs has increased. Transplant patients are subject to risks of organ rejection. With the support of the BMBF and the German Research Foundation (DFG), a good scientific – and translation-oriented – basis for regenerative medicine has been established in Germany. The translational centres for regenerative medicine now in place in Berlin and Leipzig function as crystallisation cores for the field.

With the help of Federal Government support, Germany is now among the international leaders in **computational neuroscience**, an internationally burgeoning research field. Computational neuroscience seeks to link experimental neurosciences with physics, mathematics and computer science, in efforts to study the brain's function in connection with the processes of disease, thought, learning and ageing. The National Bernstein Network Computational Neuroscience (**www.nncn.de**) has already earned an excellent international reputation. Other countries, including the U.S., are seeking to intensify their cooperation with Germany's science sector. To date, over 80 young international scientists have been attracted to the "National Bernstein Network."

Increasing knowledge about healthy diets

With the help of BMBF support for nutrition research, support which has been considerably extended since 2005, as well as departmental research by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV; Max Rubner-Institute (the Federal Research Institute of Nutrition and Food)), a foundation has been laid for a better understanding of the ways in which nutritional factors affect human metabolism. Such basic knowledge is needed for the tasks of making specifically targeted nutritional recommendations – taking account of specific life situations – and of developing foods that can help prevent and alleviate disease.

PRACTICAL EXAMPLE

Healthy coffee

In the project, "**Coffee prevention**: identification, testing and optimisation of the health-promoting properties of coffee", which is being carried out by a Hamburg-based company, in cooperation with four academic partners (spread throughout Germany), the health effects of coffee are being studied. In the process, coffee's most important active ingredients, with respect to cell defences, have been identified. One such substance, for example, is chlorogenic acid. Two studies involving humans found that test persons had considerably higher levels of antioxidant cellular defences in phases in which they drank test coffee than they did in phases in which they drank no coffee. These results have produced fundamental new findings concerning the antioxidant effects of coffee drinks, findings that can now be used in the development of new products.

PRACTICAL EXAMPLE

Better research for people with dementia

The numbers of people with dementia disorders grow as average life expectancy increases. Such disorders create major burdens for both patients and their families. The **lighthouse project "Dementia"**, initiated by the Federal Ministry of Health (BMG) and the **"German Centre for Neurodegenerative Diseases"**, established by the BMBF, are just two of the Federal Government's many efforts aimed at increasing our understanding of dementia disorders and promoting relevant research. Studies being carried out within the lighthouse project evaluate the benefits of non-pharmaceutical types of therapy and care for dementia patients; assess existing relevant health services structures; explore ways of providing care oriented to specific guidelines; and evaluate, and study ways of expanding qualification measures for specific groups of care providers and care-providing members of dementia patients' families.

In the framework of the High-Tech Strategy, a greater focus is being placed on the implementation of scientific findings in the form of products and procedures. This trend is being driven especially by the increasing participation of industrial partners in collaborative research projects of the BMBF. The BMELV, for example, supports food-industry projects working to give allergy sufferers wider food choices – and, thus, to improve their quality of life.

Building new structures and research cooperation

In recent decades, the prevalence of chronic disorders has increased considerably in Western societies. One of the keys to preventing the occurrence of chronic disorders, and to alleviating their development and impacts, is improved prevention. In this area, a diverse (and even confusing) group of disciplines, prevention services providers and practitioner partners has been brought together. Specialists in the resulting field, **prevention research**, are now able to develop prevention measures on an evidence basis and to evaluate them scientifically.

With the help of intensive support from the BMBF and the German Research Foundation (DFG), **clinical research** in this area has been developed to globally leading standards, and a powerful pertinent **research infrastructure** has been created. The central instruments in this area include medical competence networks oriented to specific diseases. Such networks bring together the basic research, clinical research and patient-oriented research being carried out nationwide, for specific disease areas, while integrating medical specialists and patients' associations in the process. To date, disease-oriented competence networks have been established for the areas of degenerative dementias, obesity, diabetes, multiple sclerosis and asthma/COPD.

Structural deficits in **university medicine** have been overcome in sample areas, via efforts that have included the establishment of a number of "Integrated Research and Treatment Centres" ("Integrierte Forschungs- und Behandlungszentren"; IFB). One such centre is the IFB for strokes, located in Berlin where all relevant disciplines for the study of strokes have been brought together under one roof. This interdisciplinary approach is enabling new research findings to enter into the realm of patient care more rapidly.

New research facilities, and expansions of existing institutes, are providing new impetus for research and interdisciplinary research cooperation. One relevant example is the **"German Centre for Neurogenerative Diseases"** (Deutsches Zentrum für Neurodegenerative Erkrankungen"; DZNE). In the interests of linking and networking research on neurodegenerative disorders such as Alzheimer's disease or dementia, the centre brings together a

Successful research cooperation – zoonosis research

One example of successful research cooperation within the framework of the High-Tech Strategy is provided by zoonosis research, or research into diseases that can be transmitted from animals to people (one such disease, for example, is **"avian influenza"**). Changes in lifestyle, increasing mobility, global population growth and climate change are all having an impact on the ways in which diseases spread. In one such impact, zoonoses have been increasingly occurring in industrialised countries. In the interest of furthering research and developing prevention strategies and care measures, the BMELV, BMBF and BMG have been combining relevant national competencies and resources with the aim of building interdisciplinary cooperation structures. In the **"National Research Platform for Zoonoses"** ("Nationale Forschungsplattform Zoonosen"), future-oriented cooperation between medical and veterinary researchers, and with the integration of government departmental research, is being established. This process is being supported by zoonoses research networks and by the "Immediate Action Programme for Influenza Research" ("Forschungs-Sofortprogramm Influenza", FSI). In the Immediate Action Programme for Influenza Research (FSI), for example, researchers are seeking to close gaps in our understanding of the highly pathogenic H5N1 avian influenza, and the related pandemic risks, and to develop pertinent new strategies for combatting it (including new detection techniques and new vaccines for cats). **www.zoonose.net**

broad range of internationally leading, interdisciplinary research into age-related neurodegenerative disorders under one roof. Study of the etiology of such disorders, along with the therapies development of preventive measures, targeted therapies and new research approaches relative to care and treatment, are expected to launch groundbreaking processes that will improve the quality of life for the aged. At the same time, the relevant social burdens on patients' relatives are to be reduced, and the pertinent costs contained within the health care system. The new centre is being established as a Helmholtz Centre with its main location in Bonn and branch locations in Munich, Tübingen, Göttingen, Magdeburg, Rostock/Greifswald and Witten. Furthermore, the centre's research will be promoted via extensive support for projects within the nationwide "Disease-oriented competence network on degenerative dementias" ("Krankheitsbezogenes Kompetenznetz Degenerative Demenzen"; KNDD).

Health services research provides the scientific basis for describing and studying changes in the health care sector and their impact. Policy-makers depend on findings from health services research in their efforts to deal with the great many issues that arise especially in connection with the "services"/ expenditures side of statutory health insurance and social nursing care insurance. For this reason, the Federal Ministry of Health (BMG) has long supported relevant measures in health services research – for example, in the framework of a model programme for quality assurance in medical care and a "lighthouse project" on dementia. Health services research has also been playing a larger and larger role in the Federal Government's health research programme.

Along with neurodegenerative disorders, diabetes and related complications and long-term health damage will become an increasingly significant societal problem. For this reason, diabetes research is to be intensified and developed into an internationally leading, interdisciplinary and holistic research area. Relevant plans call for the establishment of a **"German Diabetes Research Centre"** ("Deutsches Zentrums für Diabetesforschung e. V."), with a strategic network in which research establishments of the Helmoltz Association, the Gottfried Wilhelm Leibniz Science Association (WGL), universities and university hospitals will join in developing new prevention strategies and early detection mechanisms – and new therapy approaches and care concepts that will contribute vitally to overall care for diabetes patients. That measure is closely tied to the "Disease-oriented competence network on

diabetes" ("Krankheitsbezogenes Kompetenznetz Diabetes"), in the framework of which diabetes research projects are supported nationwide.

Translating medical progress into prevention and treatment

Germany has a highly diverse, internationally recognised life sciences research sector. In 2008, Prof. Dr. Harald zur Hausen was awarded the Nobel Prize for Medicine, an honour that highlights the sector's capabilities and the international reputation of German life sciences research. In addition to the country's universities and university hospitals, institutes of the Helmholtz Association of German Research Centres (HGF), the Fraunhofer-Gesellschaft, the Max Planck Society and the Gottfried Wilhelm Leibniz Science Association (WGL) are all involved in generating groundbreaking findings. The High-Tech Strategy is aimed at ensuring that researchers move quickly into promising, new research fields and that research findings are applied in Germany in economically useful ways. A survey readily reveals that the country's life sciences have already made use of such opportunities in several areas.

Germany is the European leader in clinical studies

Clinical studies function as a driving force for innovation in health research and in the health care sector. Before it can be approved as a medication, every new drug must successfully undergo various phases of clinical testing. Such testing provides findings on a drug's safety and effectiveness and on its usefulness in therapy with a statistically relevant number of test persons. Clinical studies thus play a key role in the translation of research findings into commercial applications and in patient care. Critical assessment of medical procedures, in the context of clinical studies, is aimed at ensuring that only those developments most suited for treatment actually become adopted in regular care. Gender-specific aspects play an important role in such testing.

Thanks to improvements in the structures, capacities and framework for clinical studies – for example, rules pertaining to the assumption of therapy costs in outpatient studies – since 2007, Germany has been the European leader in clinical studies. Measures such as the BMBF's and DFG's funding of clinical studies, and the funding of centres for clinical studies, have paved the way for this success.

Innovation alliance / strategic partnership	Focus
Molecular imaging	**Medical technology:** This innovation alliance links industrial and scientific activities in the interest of improving early detection and therapy.
BioPharma competition	**Development of medications:** The aim of this effort is to enhance the use of biotechnological procedures, by promoting cooperation between pharmaceutical and biotechnology companies, and to develop relevant joint implementation strategies.
Innovative Medicines Initiative	**Development of medications:** Public-private partnerships between companies and research institutions, aimed at optimising pharmaceutical development and at boosting ongoing value creation.
Health Regions of the Future	**Innovations in the health care sector:** Competition for regional clusters linking industry, science and health services, and aimed at enhancing the use of innovations in health care and improving health care for patients.
Translational Centres for Regenerative Medicine	**Regenerative medicine:** Research institutions, universities, clinics and industrial partners are working jointly on new scientific solutions in the development of procedures for replacement tissue cultivation and tissue regeneration.
National Bernstein Network for Computational Neuroscience	**Neurosciences:** Research centres, higher education institutions and industrial partners are cooperating interdisciplinarily in studying the functioning of the brain and in applying relevant new findings – for example, in treatment of diseases and in the development of efficient teaching and learning strategies.

Innovation via improved cooperation between science and industry

Germany's biotechnology and pharmaceuticals sectors feature close cooperation between industry and science: numerous start-up entrepreneurs and staff of biotechnology companies moved into such positions directly from universities and research institutes. Such connections enable findings to be transferred directly into companies. At the same time, pathways to the marketing of new findings are often extremely arduous and long.

In the framework of the High-Tech Strategy, cooperation between pharmaceutical and biotechnology companies and scientists is being specifically promoted in **innovation alliances and strategic partnerships**.

The High-Tech Strategy is thus especially supporting the translation of academic findings into industrial research and development. And it is doing so successfully: Cooperation between biotechnology and pharmaceutical companies – for example, cooperation aimed at developing new medications – has been increasing briskly.

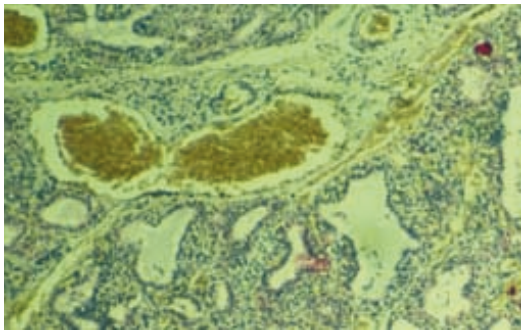
Success for the pharmaceutical sector

According to surveys of the Donors' Association for the Promotion of Sciences and Humanities in Germany, pharmaceutical companies increased their R&D expenditures from a level of EUR 4.580 billion in 2005 to EUR 5.240 billion in 2008. This increase amounts to nearly 13 percent. As a result, in 2007 five of a total of 31 new drugs developed in Germany were approved for medical use. Currently, German biotechnology and pharmaceutical companies are involved in a total of some 240 clinical development projects. In terms of absolute figures, they rank second in this category in Europe, behind UK companies.

Biotechnology is providing the basis for new medications

A great deal of hope is being placed in a new generation of medications, "biopharmaceuticals", for treatment of still incurable diseases such as certain cancers, Alzheimer's disease and Parkinson's disease. While to date most biotechnological pharmaceuticals have been developed in the U.S. and the UK, Germany's biotechnology sector is catching

PRACTICAL EXAMPLE



Successful pharmaceutical development by a start-up originating from a German research institution

The first antibody discovered and developed in Germany has cleared a major obstacle on the way to its approval for sale. This milestone has been achieved by Trion Pharma, a 1998 start-up originating from the Helmholtz-Zentrum München, working in partnership with Fresenius Biotech. In February 2009, the Committee for Medicinal Products for Human Use (CHMP), of the European Medicines Agency (EMEA), expressed its support for approval of Trion's "Removab" antibody. Formal approval is expected to be granted at the end of April 2009. While the antibody is currently intended solely for a relatively small group of patients – namely, patients in the late stages of cancer who develop abdominal dropsy – other indication areas are being studied in ongoing clinical studies of the treatment of ovarian cancer and gastric cancer.

PRACTICAL EXAMPLE

New medications are being produced in mosses

"Therapeutic proteins" have a great future ahead of them. Promising treatment successes have been achieved with them in cases of cancer, asthma and rheumatic disorders. At the same time, these therapeutically effective proteins present a complication: they cannot be chemically produced. Their molecules are too large and too multilayered for such production. As a result, they have to be obtained from animals or plants or grown in cell cultures. In the BMBF funding project **"Development and production of new biopharmaceuticals in moss"** ("Entwicklung und Produktion neuartiger Biopharmazeutika im Moos"), the firm of Greenovation GmbH (located in Heilbronn), working in cooperation with academic partners, has brought a procedure for developing and producing such proteins in mosses to commercial maturity. The proteins are obtained from genetically modified moss strains, via a procedure that yields the necessary similarity to relevant human proteins. Cultivation takes place in closed fermenter systems (photobioreactors). Light provides the energy for the necessary cell growth.

Prototype of a moss bioreactor from the company "greenovation Biotech Gmbh" in Freiburg

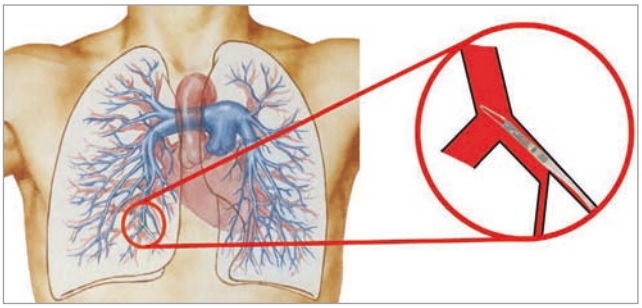
up. Indicators of this progress include a tripling of biotechnologically produced medications in the approval phase and a marked increase in the numbers of medical drugs in late clinical phases. A first therapeutic antibody developed and produced in Germany is slated to be approved in the near future (see the project example).

The **Pharmaceuticals Initiative for Germany** was launched by the BMBF in mid-2007. It is providing additional impetus for Germany's pharmaceutical and biotechnology sectors, with the aim of restoring Germany's seal of quality as the **"World's Apothecary"**. Today, as in the past, many pharmaceutical research findings originate in Germany. In many cases, the resulting medications are produced in other countries, however. Especially via the **"BioPharma" competition**, the Pharmaceuticals Initiative supports prompt, rapid networking of all stakeholders involved in studying and developing medications, with the aim of making such development more effective. To date, three consortia have been selected as competition winners and supported in the implementation of their concepts: The "Max Planck Drug Discovery & Development Center", located in Dortmund; "Neu2", a northern German consortium; and "Neuroallianz", based in Bonn. These strategic partnerships between biotechnology companies, pharmaceutical companies, research institutions, clinics and financial investors are seeking to promote the efficient development of medications.

The **"Pharmaceuticals" ("Pharma") Task Force**, sited within the Federal Ministry of Health (BMG), is working to improve the framework and innovation opportunities for the pharmaceutical industry in Germany, and to facilitate exchanges between pharmaceutical industry representatives and policy-makers. Since its establishment, the task force has prepared, and published, specific proposals and recommendations for improving the framework and conditions for the pharmaceutical industry. In addition, the "Interministerial working group for regulatory issues in biomedicine and bioethics" ("Interministerielle Arbeitskreis für regulatorische Fragen der Biomedizin und der Bioethik") brings together stakeholders from the science, industry and medical sectors for the purpose of developing recommendations for innovation strategies in biomedicine.

PRACTICAL EXAMPLE

Early warning system for cardiac insufficiency



Miniaturised telemetric measuring capsule (on right) for continuous monitoring of blood pressure data from the interior of the body

In spite of taking heart medications, many chronically ill heart patients also suffer from cardiovascular insufficiency. Ideally, such patients' blood pressure should be monitored continuously. For this reason, a tiny blood pressure measuring capsule has now been developed with BMBF support that can be implanted in these patients. The new heart capsule provides an early warning whenever a patient's heart's pumping strength drops. In future, the new device will thus enable patients' doctors to quickly detect any such cardial irregularities and address them with suitable medication. As a result, patients will receive fast assistance and avoid otherwise necessary hospital stays – and the costs of treating such conditions will be cut considerably. With such continuous monitoring, even patients with advanced cases of cardiac insufficiency will be able to lead largely independent lives, in their own homes. The heart capsule has been brought to market maturity in a collaborative research project involving four academic partners and the firm of BYTEC Medizintechnik GmbH, located in Stolberg.

The German medical technology sector: innovation strength a guarantee for growth

The High-Tech Strategy's aims include supporting and expanding medical technology, one of Germany's most innovative sectors. Medical technology integrates key technologies such as microsystem technology, information and communications technology, nanotechnology, molecular and cellular biology, regeneration technology and pharmaceutical technology. Central support measures in this area include an **innovation competition to promote medical technology**, which is funding selected research ideas with the aim of shortening the time to market for innovative medical products. This type of support is required in that the sector, which consists extensively of SMEs, has increasingly been encountering problems in financing its necessarily long development procedures, which can last more than ten years. One of the factors contributing to such long development, for example, is that new medications must undergo extensive clinical testing, in keeping with their classifications.

The aim of the **"Innovation Alliance for Molecular Imaging"** ("Innovationsallianz Molekulare Bildgebung") is to improve techniques for imaging living cells and to apply new methods in the early detection and therapy of diseases, especially cancer, cardiovascular disorders and dementia disorders. To these ends, engineers are cooperating closely with scientists, pharmaceutical specialists, clinical practitioners and software specialists. Along with the firms Siemens, Bayer-Schering Pharma, Boehringer Ingelheim, Carl Zeiss and Karl Storz, over 25 SMEs and some 25 research institutions are involved in the effort.

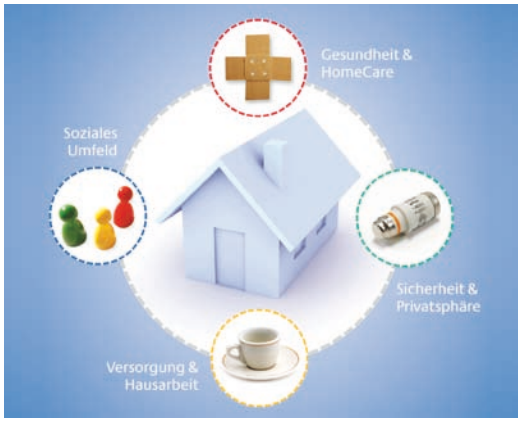
Interdisciplinary approaches in caring for aged and chronically ill persons

It is clear that care requirements for elderly and chronically ill patients – i.e. for medical care in addition to that provided in doctors' offices and hospitals – will increase. Such growing requirements will clash with staffing and financial constraints. For this reason, the Federal Government is supporting research projects for example, via the funding priority "Health in Old Age" ("Gesundheit im Alter") – aimed at helping elderly people, many of whom suffer from multiple disorders, to remain independent for as long as possible. In addition, new types of care and services, such as "ambient assisted living" concepts, will grow in importance. What is more, activation of a telematics infrastructure in the

PRACTICAL EXAMPLE

Assistance systems for the elderly – ambient assisted living

Two examples of new types of assistance systems include a) mobile pulse monitoring and EKG devices that report irregularities directly to doctors; and b) sensors that monitor patients' sleep, and detect any falls, sending alarms whenever any critical situations arise. Such assistance systems are being developed with the help of medical technology, microsystem technology, state-of-the-art information and communications technology (ICT) and innovative services. The aim of such efforts is to improve the quality of life for all people, in all phases of life. "Assistance



systems" include concepts, products and services that improve interaction between technical and social systems. Significantly, intelligent assistance systems can enable older, mobility-restricted people to stay independent for longer. Assistance systems call for the involvement of care providers, doctors and family members. Research and innovation provide the basis for technical systems that, in keeping with users' needs, facilitate – or even completely assume – everyday tasks, including even various types of medical care.
www.aal-deutschland.de

health care sector will create a broad technological basis for such new types of care and services (telemedicine, telemonitoring). Such advances will also help to improve care in rural areas.

International cooperation strengthened

In recent years, numerous international and multilateral cooperative efforts have been launched in the areas of health and biotechnology. In the framework of the EU's 6th and 7th Framework Programmes for Research and Technological Development (FP6 and FP7), and as the result of key initiative provided by Germany, a number of European competence networks, known as **"ERA Nets"**, have been established. For example, the ERA Net "ERA-SYSBIO" brings together European activities in the area of systems biology, and "E-RARE" has launched a joint funding announcement, involving several countries, relative to work on rare diseases. "EMIDA" concentrates European research on animal health, and "SAFEFOODERA" is focused on protecting consumers' health via food safety. Binational research cooperation – for example, with France, Poland and Israel – is yet another focus of relevant efforts in this area.

In addition, German researchers are playing a key role in the development of the European research sector – for example, via the **"ESFRI-Forum"** (European Strategy Forum on Research Infrastructures, http://cordis.europa.eu/esfri/). Germany is coordinating two of the six life sciences research infrastructures in this framework. The enhanced ESFRI "roadmap" for 2008 includes all four proposed life-sciences research infrastructures.

Climate protection, resources conservation, energy

SUMMARY

Challenges and aims

Adequate supplies of food, energy and natural resources, clean air and clean water are fundamental requirements worldwide. Sustainable business strategies that protect the climate and the environment are a vital basis for lasting economic success and social prosperity. Therefore, the Federal Government has formulated demanding climate protection aims (calling, inter alia, for a 40 percent reduction of CO2 emissions by 2020).

At the same time, many technologies, products and services that have been developed in Germany, in the interest of climate protection and resources conservation, are in demand worldwide. In many areas, they are the international leaders in their categories. In 2006, environmental protection goods worth a total of EUR 56 billion were exported from Germany. This figure represents a pertinent world-market share of 16 percent.

Results and outlook

In order to achieve its ambitious energy policy and climate protection aims, the Federal Government has launched the **Integrated Energy and Climate Programme,** the largest energy and climate programme Germany has ever had. The programme provides for a package of legal changes and major investments in state-of-the-art technological R&D.

The High-Tech Strategy also addresses this central area. Via numerous initiatives and measures, the Federal Government is helping to meet the challenges facing us:

- The **"High-Tech Strategy for Climate Protection"** combines strengths in the private business enterprise, science and policy sectors, with the aim of triggering needed progress and technological breakthroughs in climate protection. The core issues addressed by the Strategy are those pertaining to climate protection and efficient resources use.
- The Federal Government's **Energy Research Programme** combines measures for promoting modern, efficient energy technologies. In the framework of the High-Tech Strategy, this programme has been financially reinforced and given new emphases.
- **Strategic partnerships** for climate protection and resources conservation (including partnerships in the areas of organic photovoltaics, pilot CO2-storage systems, lithium-ion batteries) are focussing on energy-efficiency and resources-efficiency, and on developing new energy-generation and energy-storage technologies.
- An **Environmental Technologies Master Plan** is solidifying and expanding Germany's leading role in global trade in environmental goods. Initially, activities in this framework are concentrated on the areas of water, raw materials and climate protection (including renewable energies). The "German Water Partnership", a platform founded in April 2008 for innovation in the water-resources management sector, represents an important first step in this framework.
- **Improved climate research**, via a range of activities, including the "klimazwei" funding priority and intensified **climate-related advising**, provided by a "Climate Service Centre"
- The potential for plant science innovation relative to safeguarding the **global food supply** and simultaneously **increasing bioenergy production** is being tapped via research in agriculture and plant biotechnology.

Challenges and aims

Findings to date about the earth's climate trends leave no room for doubt: the earth's climate has already changed, and it will continue to do so. The signs of global warming include rising sea levels, melting glaciers and an increasing frequency of extreme weather events such as heat waves, droughts, torrential rainfall and storms. As we have repeatedly seen in recent years, the damage caused by extreme weather events is reason enough to take serious, carefully considered action. At the same time, climate researchers are now saying that the earth's climate will change even if drastic protection measures are taken. Germany is already taking the necessary precautions to prepare for such change.

The UN IPCC report – reliable findings on climate change

The Fourth Assessment Report of the UN Intergovernmental Panel on Climate Change (IPCC) concludes that the earth has warmed by an average of 0.74 degrees Celsius over the past 100 years. Eleven of the past twelve years (1995 through 2006) rank among the twelve warmest years in the instrumental record of the earth's global surface temperature (which dates from 1850). Current levels of greenhouse gases are considerably higher than the corresponding natural levels over the past 650,000 years. Measurement data unequivocally indicate that the earth's climate is changing and that the pace of global warming is accelerating.

www.ipcc.ch

Demand for natural resources has grown enormously since the beginning of the 21st century, driven especially by skyrocketing demand from threshold countries such as India and China. Even though the current global financial and economic situation has caused demand to diminish for the time being, demand is expected to begin climbing again in the medium term. Consequently, strategies for efficient use of raw materials including environmentally and socially compatible production, higher efficiency in use and substitution are needed more urgently than ever before. What is more, in light of growing global demand for agricultural products, massive productivity increases are needed in use of biomass for food and bioenergy production. The challenge of providing an energy supply that is affordable, safe and climate-friendly is a global challenge. Germany is seeking to be a leader in meeting this challenge, with a broad energy mix that includes both high efficiency conventional energy systems and new energy technologies. It is clear that technologies currently available will not be adequate to the task of shaping the future energy architecture in line with growing demand. In short, a paradigm shift toward sustainable economies will have to take place.

In the framework of its Integrated Energy and Climate Programme, as well as of its national sustainability strategy, the Federal Government has defined an ambitious **range of aims** in the areas of climate protection and resources conservation:

- Climate protection and adaptation to climate change: as Germany's contribution to international climate protection treaty for the period after 2012, the Federal Government is offering to reduce Germany's greenhouse gas emissions by 40 percent below their 1990 levels, by 2020. This offer is subject to the condition that the European Union must reduce its emissions by 30 percent below 1990 levels, and that other countries must adopt similarly ambitious aims.

- Thrifty, efficient use of natural resources: energy productivity in Germany is to be doubled by 2020, in comparison to its level in 1990. In addition, raw material productivity is also to be doubled by 2020, in comparison to its level in 1994.

- An energy supply that is sustainable and reliable, for the long term: plans for the period until 2020 call for renewable energies' share of primary energy consumption to be increased by 10 percent, and for their share of electricity consumption to be increased by 25 - 30 percent. By 2050, renewable energies are expected to be meeting about half of all energy demand.

Double benefits of innovations for climate protection and the environment

Sustainable economies, successful research into climate protection and innovative environmental technologies pay off in two ways. Firstly, they protect our earth for future generations. The economic costs of "business as usual" would be astronomical. The "Stern Review on the Economics of Climate Change", for example, estimated the costs resulting from failure to enact climate protection at about 5 to 20 percent of global gross domestic product. In a worst-case scenario, that would amount to some EUR 6 billion per year.

Secondly, investments in climate protection and the environment can have enormous economic effects. Demand for environmentally friendly and resources-conserving products, processes and services is expected to be strong in the medium and long terms. A study by Roland Berger, for example, found that the global market for environmental technologies had reached a volume of about EUR 1 trillion in 2005. The study also predicted that that market would grow by over five percent annually, and reach a size of about EUR 2.2 trillion in 2020 (the forecast was made prior to the financial and economic crisis). The largest growth in absolute terms is expected to take place in the lead markets of energy efficiency and sustainable water-resources management. The global market for renewable energies (including bioenergy, wind power and solar energy) is expected to increase by a factor of three to six in the next 15 years.

With its traditional strengths in areas such as wastewater management, air quality control and waste management technologies, renewable energies, plants and machinery, Germany has excellent opportunities, even in the current economic framework, to be a leader in these promising lead markets. Investments in such technologies will thus create and protect jobs and economic growth in Germany, throughout the long term.

- German exports of goods for environmental protection have been increasing sharply. All areas of Germany's environmental industry have registered large workforce increases. Currently, a total of some 1.8 million people work in the sector. Especially large increases have occurred in recent years in the areas of environmentally friendly energy production / renewable energies and energy efficiency.
- As of 2007, the area of renewable energies accounted for some 250,000 jobs in Germany. Furthermore, according to forecasts, that sector could well be employing 400,000 to 500,000 by 2020.
- The significant bases for such success include success in international markets. Exports in the German renewable energies industry rose from EUR 0.5 billion in 2000 to EUR 9 billion in 2007.

Results and outlook

Germany's innovation strength, and its capability for technological progress, are being harnessed to the task of meeting the country's ambitious aims and simultaneously further reinforcing growth and prosperity. The Federal Government views sustainable economic strategies, improved energy and raw materials efficiency, new fuels produced with the help of alternative energy sources, and improved energy storage systems as necessary elements of the strategy for protecting our vital resources and our prosperity in the long term. Significantly, there are no contradictions between a focus on the environment and a focus on the economy. Sustainable business strategies that protect the climate and the environment are a vital basis for lasting economic success and social prosperity.

The Federal Government is thus applying a coordinated package of measures, with new concepts and initiatives. More strongly than before, innovation policy is now a joint strategy of all federal departments, a strategy characterised by a systematic orientation, by attention to the applicable framework conditions and by a focus on priority areas and on radical innovation:

Far-sighted overarching energy and climate policies

With its **Integrated Energy and Climate Programme**, the Federal Government has taken important steps toward a state-of-the-art, safe,

reliable and climate-friendly energy supply for Germany. At the same time, it has defined measures for ambitious, intelligent and efficient climate protection. The package comprises a total of 29 measures, aimed especially at greater energy efficiency and greater use of renewable energies. **The package combines changes in the legal framework with investments in research and development. Examples include:** Amendment of the Act on the Preservation, Modernisation and Development of Combined Heat and Power Generation (Combined Heat & Power Act; KWKG); amendment of the Act on Energy Saving (Energieeinsparungsgesetz) and of the Energy Saving Ordinance (Energieeinsparverordnung; EnEV); amendment of the Renewable Energy Sources Act (EEG); the Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmG); measures for facilitating the sale of biogas to the gas grid; expansion of the use of biofuels; the Act for acceleration of expansion of the high-voltage network (Gesetz zur Beschleunigung des Ausbaus des Höchstspannungsnetz); and conversion of motor-vehicle taxation to an emissions / CO2 basis.

The real keys to the aims of the Integrated Energy and Climate Programme (IECP) are innovative energy technologies – both on the supply side, where energy is produced, and on the demand side, where it is consumed. The Federal Government has thus made research and innovation a central priority of the IECP.

The **High-Tech Strategy on Climate Protection** focuses on selected aspects of the Integrated Energy and Climate Programme and, via an overarching, interdisciplinary approach, brings together various measures and stakeholders in the area of climate research. An integrative part of the High-Tech Strategy for Germany, it has the effect, in cooperation with partners in the areas of science, industry and policy, of launching the right steps toward state-of-the-art energy-saving and resources-conserving technologies:

- Expansion of the knowledge base for climate protection and adaptation to climate change (for example, via reliable climate forecasting and improved short-term weather forecasting, especially with regard to extreme weather events; via the establishment of the Climate Data Center, the largest German climate data centre, within the sphere of the Deutsche Wetterdienst (German meteorology service)),
- R&D and demonstration projects that improve the technological outlook for climate protection and help strengthen German industry in this important international market of the future,
- Improved availability of knowledge about climate change and its impacts, for decision-making in the industrial and political realms,
- Via international dialogue and cooperation, assumption of global responsibility. In view of the global challenges facing us, research activities, especially in the areas of climate protection and resources conservation, adaptation to climate change and environmental protection, need a strong international orientation. As a result, pertinent research agendas should be coordinated internationally.

State-of-the-art, efficient energy technologies via research and innovation

The Federal Government's central focuses include expanding support for research and development for state-of-the-art, efficient **energy technologies**. The Federal Government has thus made such support a priority of its Integrated Energy and Climate Programme. Research and development are the strategic key to safeguarding a sustainable, long-term energy supply for Germany. A number of different government departments are involved in relevant implementation, each within the framework of its own competencies. The Federal Government's support policy is coordinated via a **"Coordination Platform for Energy Research Policy"** ("Koordinierungsplattform Energieforschungspolitik"), established within the Federal Ministry of Economics and Technology (BMWi).

The centrepiece of activities in this framework is the Federal Government's 5th **Energy Research Programme**. It will serve as the basis for the Federal Government's support policies in the coming years. The aim of the programme is to advance the transition, via innovation and technical resources, to a sustainable energy supply. In order to address the growing energy policy and climate policy challenges, the 5th Energy Research Programme, "Innovation and new Energy Technologies", has been extended by two years, so that it now runs until 31 December 2010. In addition, the programme

has been financially reinforced (2009/2010 budget: about EUR 1.15 billion), and its priorities have been redefined, as follows:

- **Climate protection and energy efficiency:** Under the technology programme, the BMWi is recombining its funding measures within the area of non-nuclear energy research, and it is increasing relevant funding. The primary pertinent aims are to achieve short-term to medium-term success, via concentration on applied R&D and demonstration projects. The programme includes the following priorities: "Power-station technologies (COORETEC)", "CHP, district heat", "fuel cell, hydrogen", "efficient electricity use, storage systems", "energy-optimised construction" and "energy efficiency in industry, commerce, trade and services". The programme also includes measures for supporting research into safety and final storage for the nuclear sector.

- **Renewable energies:** The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has expanded its research support in the area of renewable energies and it has set relevant new priorities. In keeping with offshore wind energy's relevance to the Federal Government's aims for the expansion of renewable energies, funding for wind energy research has been greatly increased. The research initiative "Research at alpha ventus", through which comprehensive R&D activities in the first German offshore wind farm are being supported, plays a central role in this connection. In addition, a new priority has been defined, "Optimisation of power supply systems with regard to the expansion of renewable energies". This effort is focussed on projects involving the integration of growing amounts of fluctuating power inputs from wind energy and photovoltaic systems within the electricity grid.

- **"Bioenergy":** The aims of "Renewable raw materials" ("Nachwachsende Rohstoffe"), a funding programme of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), are to provide a sustainable supply of raw materials and to study alternative sources of raw materials. With innovative technologies for converting biomass for the purpose of energy and substance recovery, in biorefineries and "white" biotechnology systems, the potential for the industrial use of renewable raw materials is being further increased. The bioenergy research sector has been reinforced by the German Biomass Research Centre (Deutsches Biomasseforschungszentrum; DBFZ), established by the BMELV in 2008 in Leipzig. The new centre is studying technical, economic and ecological issues related to biomass use in energy production. In a "National action plan for substance recovery from renewable raw materials" ("Nationaler Aktionsplan für die stoffliche Nutzung nachwachsender Rohstoffe"), which the BMELV is planning for 2009, relevant measures will be combined and refined.

- **"Basic Energy Research 2020+" ("Grundlagenforschung Energie 2020+"):** using a broad in-

PRACTICAL EXAMPLE

Less yields more: thinner, more efficient solar cells

The production of solar cells and modules needs to be efficient and cost-effective, if solar energy systems are to become widely adopted. In the "SiThinSolar" project, research is underway for the development and optimisation of more cost-effective silicon-based solar cells. The project's research emphases are not limited to the use of new materials; the partners in

Silicon solar cells are becoming thinner and more efficient.

the project, based in the Halle region, are working especially to enhance knowledge about silicon's microstructures. Such knowledge will make it possible to develop more efficient solar cells. In addition, work is aimed at minimising production waste and at improving long-term reliability.

terdisciplinary approach, this new BMBF funding concept is supporting basic research, with a long-term orientation, relative to new technological options. This effort is focussed on highly efficient processes for producing, transforming, storing, transporting and using energy. Examples of its priorities include the development of next-generation renewable energies technologies – for example, in the area of thin-film photovoltaics; biomass conversion for energy production; solar-powered, biomimetic production of hydrogen; and the development of technologies for storing CO2 from coal-fired power stations. Energy research conducted by the Helmholtz Association plays an important role in this effort. The BMBF's funding priority "Bioenergy 2021 – Research for the Use of Plant Biomass", part of Basic Energy Research 2020+, is oriented to pertinent central recommendations made by the German Advisory Council on Global Change (WBGU).

Innovation alliances and strategic partnerships are joining forces in the interest of innovative energy production and use

How can the efficiency of solar cells be improved? How can batteries and lighting systems be made more energy efficient? How can CO2 emissions from power stations be reduced? Such questions – and others as well – are being explored in strategic partnerships and innovation alliances. Such cooperative efforts are mobilising considerable investments by business enterprises. The following innovation alliances and strategic partnerships have been launched in the area of climate protection and resources conservation:

Innovation alliance / strategic partnership	Focus
Organic photovoltaics (OPV)	**Energy production / photovoltaics:** This project is focussed on improving the efficiency and durability of solar cells made from organic materials. Such solar cells are a cost-effective alternative to today's solar cells.
OLED Initiative	**Energy efficiency / lighting:** Organic light-emitting diodes convert electricity into light extremely efficiently, and they can be produced as thin, flexible layers.
CarbonNanoTubes (CNT)	**Climate / chemistry:** This project is working to harness the amazing properties of carbon nanotubes (CNT). In particular, CNT applications in the areas of energy technologies (such as fuel cells, energy-storage systems, wind power, solar cells) and environmental technologies (such as water desalination) are being explored.
COORETEC research programme	**CO_2 reduction / efficiency improvement:** The aims here are to further improve the efficiency of gas-fired and coal-fired power stations and to develop technologies for separating carbon dioxide produced in combustion processes. Improvements in the efficiency of power stations fired with fossil fuels enhance both the plants' cost-effectiveness and their environmental compatibility.
Pilot systems for CO_2 storage	**CO_2 reduction / geological storage:** This project is focussed on demonstrating the safe storage of carbon dioxide in deep underground layers. In the process, suitable technologies for safe, long-term CO_2 storage, and for permanent, reliable monitoring of storage locations, are to be developed and tested.
Lithium-ion battery (LIB 2015)	**Energy storage / automotive, renewable energies:** This project is working to develop a new generation of powerful batteries for use in electric or hybrid vehicles, as well as for energy storage in connection with renewable energies.
E-Energy	**Energy supply:** This project is aimed at an "Energy Internet", i.e. extensive digital networking and computer-based optimisation of the nationwide energy system.
Earth observation	**Geodata:** This project is focussed on making high-quality earth observation data available with the help of space research for commercial use, in the context of a sustainable business field.

Sustainability drives innovation

The concept of sustainability in business and industry has become a significant competitive factor. Moreover, this is an area in which Germany has an excellent basis and options for developing technologies and services for the global market. The Expert Commission on Research and Innovation (EFI) emphasised this again in its second report.

Germany is already a leader in environmental technologies. Now it is seeking to build on and expand this position. This is why, in November 2008, in improving the High-Tech Strategy, the Federal Government launched the **Environmental Technologies Master Plan** (the initiative for this interlocking environmental and innovation policy was put forward jointly by the BMU and the BMBF). The aim of the overall effort is to enhance the development of emerging markets in three particularly promising areas, and to further improve the framework for innovation. In a first step, the Master Plan is focussed on the areas of water, raw materials and climate protection (including renewable energies). In a second phase, additional activities will be added, and jointly developed by the Federal Government's departments. The bases for this approach are provided by the BMBF's Foresight process, especially the results of the "Roadmap Environmental Technologies 2020" ("Roadmap Umwelttechnologien 2020") technology forecast of the Karlsruhe Research Centre. The Roadmap's "State-of-the-art Report" highlights the great potential for innovation available in a number of areas – for example, resources efficiency. In 2009, The Roadmap will be completed, and funding policy options will be derived from it.

The "German Water Partnership" (GWP) platform is a first visible success of the Environmental Technologies Master Plan. In a result initiated jointly by the BMBF and the BMU, the GWP brings together a range of different stakeholders from the research, business enterprise and association sectors. The platform is designed to promote German industry's position, in the export market for "water technologies", via concerted efforts.

Sustainability strategies will become vitally important in the building sector as time passes. The **"Future of Building"** ("Zukunft Bau") research initiative of the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) is aimed at strengthening the German construction sector's competitiveness in the European Single Market and coordinating knowledge growth and innovation in the building sector, with regard to technical, cultural and organisational aspects. A key aim is to link scientific and technological developments in construction of energy-efficient housing (the

PRACTICAL EXAMPLE

German Water Partnership

The "German Water Partnership" has already profited from the fact that long-term commitments, reliability and solid partnerships pay off in international efforts: an order for planning of a sewage-sludge incineration facility in Shanghai, a city with many millions of inhabitants, was recently awarded to a consortium that includes CONSULAQUA Hamburg, a GWP member company. Along with the consortium members' expertise, trust and confidence in the German partners involved was a factor in the award. Both this expertise and trust were built in the BMBF project "Study of sewage-sludge treatment and management technology in wastewater treatment plants in Shanghai/China" ("Erforschung der Schlammbehandlungs- und -beseitigungstechnologie auf den Klärwerken in Shanghai/China"), which was carried out by project partners of TU Darmstadt. This project developed initial relevant contacts in China that were then successively enhanced in the framework of German-Chinese scientific-technological cooperation. The basic principles applied by the German Water Partnership include making individual GWP members' contacts and networks available for joint use by all members, as well as sharing pertinent information and experience. In short, the GWP is concentrating the German water sector's resources and activities and making German water sector expertise known worldwide.
www.germanwaterpartnership.de

"low-energy house" ("Niedrigenergiehaus") sector), throughout a spectrum that even includes buildings that produce more energy than they use ("plus energy" buildings), with improved raw materials productivity – for example, via resources-efficient waste management / recycling, durability improvements and greater use of recycled materials. At the same time, efforts are being made to reduce relevant land consumption and to take account of pertinent aspects of demographic change. The "Future of Building" research initiative is also developing amendments of construction sector regulations, with such aspects in mind, and is introducing advanced technologies into building procedures.

Research for a better climate

By means of research, development and innovative new approaches in climate protection, the key factors affecting the earth's climate are being studied and addressed, and strategies for protection against the impacts of climate change are being developed. The BMBF funding priority **"klimazwei – research for climate protection and for protection against climate impacts"** is building a practical orientation by linking basic climate-system and atmospheric research with pertinent application-oriented aspects. This project is focussed especially on reducing greenhouse gas emissions, on developing detailed climate models and on developing strategies for adapting to climate change and extreme weather events (www.klimazwei.de).
The special impact that climate change could have on waterways and navigation, via higher sea levels or through changes in river regions, are being studied in the BMVBS research programme **"KLIWAS – Impacts of climate change on waterways and navigation in Germany, and development of adaptation strategies"**. In this framework, the government's departmental research institutions are working in collaboration to develop scientific foundations for research into the impacts of climate change and to study adaptation strategies for ensuring that inland navigation, an environmentally friendly mode of transport, retains its functionality in future. Significantly, the results of this work will be of relevance for other areas of action and policy pertaining to water bodies (**www.kliwas.de**).

On 1 January 2009, a new information and advising platform for policy-makers, decision-makers

PRACTICAL EXAMPLE

Clean energy: Using intelligent power station technologies to lower CO2 emissions

The low-CO2-emissions pilot facility at the Schwarze Pumpe power station in Germany's Lusatia (Lausitz) region

Intelligent power station technologies play a decisive role in reducing CO2 emissions, without also reducing fossil-based energy production.

The aim of the **"Innovative Power Station Technologies"** ("Innovative Kraftwerkstechnologien") project is to develop a clear, cost-effective overall concept for state-of-the-art lignite-fired power stations. To this end, researchers at BTU Cottbus, working in cooperation with industry partners, are engaged in a range of individual projects. These cover development areas such as technologies for reducing CO2 emissions; new types of filters; methods for drying lignite; and processes for long-term power station maintenance.

PRACTICAL EXAMPLE

Beech and oak instead of tropical hardwoods

Can any native/local wood species serve as satisfactory substitutes for teak and mahagony? Yes, respond scientists working in the BMBF's "Sustainable forest management" ("Nachhaltige Waldwirtschaft") funding priority. And the answer has to do with "wood modification", a process being used by the Göttingen-based "Innovative modified beech-wood products" ("Innovative modifizierte Buchenholzprodukte") collaborative research project, and by Holzindustrie Templin GmbH, in the "OakChain" project. The specific processes involved in the two projects differ. The "beech side" is changing beechwood's properties at the cellular level, by using special coatings; the "oak side" is changing the basic composition of oak with the help of a thermal chamber. In both cases, the wood takes on key characteristics of tropical hardwoods: long life, structural stability, rotting-resistance and weather-resistance. Wood modified via the new processes, which are ecologically safe, can be used for such products as skateboards, sauna chairs, garden furniture and wood decks. And the new native-broadleaf substitutes for tropical hardwoods provide an added benefit: products made from them will bind additional CO_2 for long periods of time, thereby helping to protect the climate.

and investors was established at the GKSS Research Centre in Geesthacht: the **"Climate Service Centre"**. The new Centre gives climate-data users hands-on access to climate system research by efficiently combining, evaluating and providing reliable information about the climate's current status and its expected future development. In the CSC framework, a network of research institutions, climate-advising organisations and industry stakeholders is being created set up to cooperation between data users and scientists, a clear focus on pertinent demand chains and on useful products. And such products include now routinely produced global and regional climate scenarios and forecasts.

Climate Change Finance Forum: One of the emphases of the Federal Government's climate policy is to develop financing options and investment strategies for creating climate protection technologies and for tapping into potential markets. The Climate Change Finance Forum was founded at a climate research summit in Berlin, at the BMBF's initiative, by a number of banks, re-insurers and investors in Germany. A dialogue partner of the Federal Government, the Forum is working, in cooperation with the "Sustainable Business Institute" at the European Business School (EBS), on a programme for developing and supporting pertinent research-policy dialogue between policy-makers, financial services providers and real economy players. The overall aim of the effort is to support the financial services industry in contributing to strategies for climate protection and adaptation to climate change, especially by financing needed technical innovation. One specific idea that has resulted from this framework is a concept for a "climate protection-innovation fund" that, working via public-private partnership, would provide venture capital to help speed the introduction of climate protection technologies to the market.

Institute for Advanced Sustainability Studies (IASS): In response to recommendations made at "Global Sustainability – a Nobel Cause", a Nobel laureates' symposium held in Potsdam, and to the results of the Federal Government's Climate Research Summit, as set forth in the High-Tech Strategy, the BMBF and the State of Brandenburg are supporting

the establishment of an interdisciplinary, advanced institute in Potsdam for research into the areas of climate, the earth system and sustainability. The founding director of the new institute is Prof. Klaus Töpfer. At the IASS, up to 50 visiting scientists (fellows), from up-and-coming young scientists to Nobel laureates, will have the opportunity to conduct research, on topics of their own choosing, for limited periods. The Institute ("IASS" is a working name at present) will build bridges between the science, policy and industry sectors, and between those sectors and society, and it will promote societal consensus regarding the possibilities and necessary measures for managing processes of global change.

Safeguarding the global food supply via research and innovation

As a result of population growth, changes in eating patterns, climate change and limits on available arable land, the task of securing the world's food and feed supply is a growing global challenge. Enormous productivity increases are needed, throughout the spectrum from basic agricultural production to the food industry and to sellers and distributors. This is why the High-Tech Strategy is supporting research and innovation in plant science, aimed at helping significantly to safeguard our food supply and defuse the growing conflict between biomass use for food production and biomass use for energy production:

In cooperation with the Länder and the BMELV, the BMBF launched the competition **"Competence networks in agricultural and food research"** ("Kompetenznetze in der Agrar- und Ernährungsforschung"), which is designed to link Germany's leading agricultural science institutes with each other and with industry. The purpose of the project is to develop an internationally competitive infrastructure for cutting-edge agricultural research and to ensure that resulting research findings are translated quickly into applications. The competence networks are to be oriented to the entire value chain of agricultural production, from the production of natural resources to provision of high quality raw materials such as biomass and feeds, and high quality food for consumers.

In the area of **plant biotechnology**, all available options for plant production and use – including genome research, systems biology and biological safety research – are being studied and developed. In the process, public dialogue is being conducted about the opportunities provided by state-of-the-art biotechnology. Such opportunities include techniques for increasing yields, producing new active substances via crops and adapting crops to climate change.

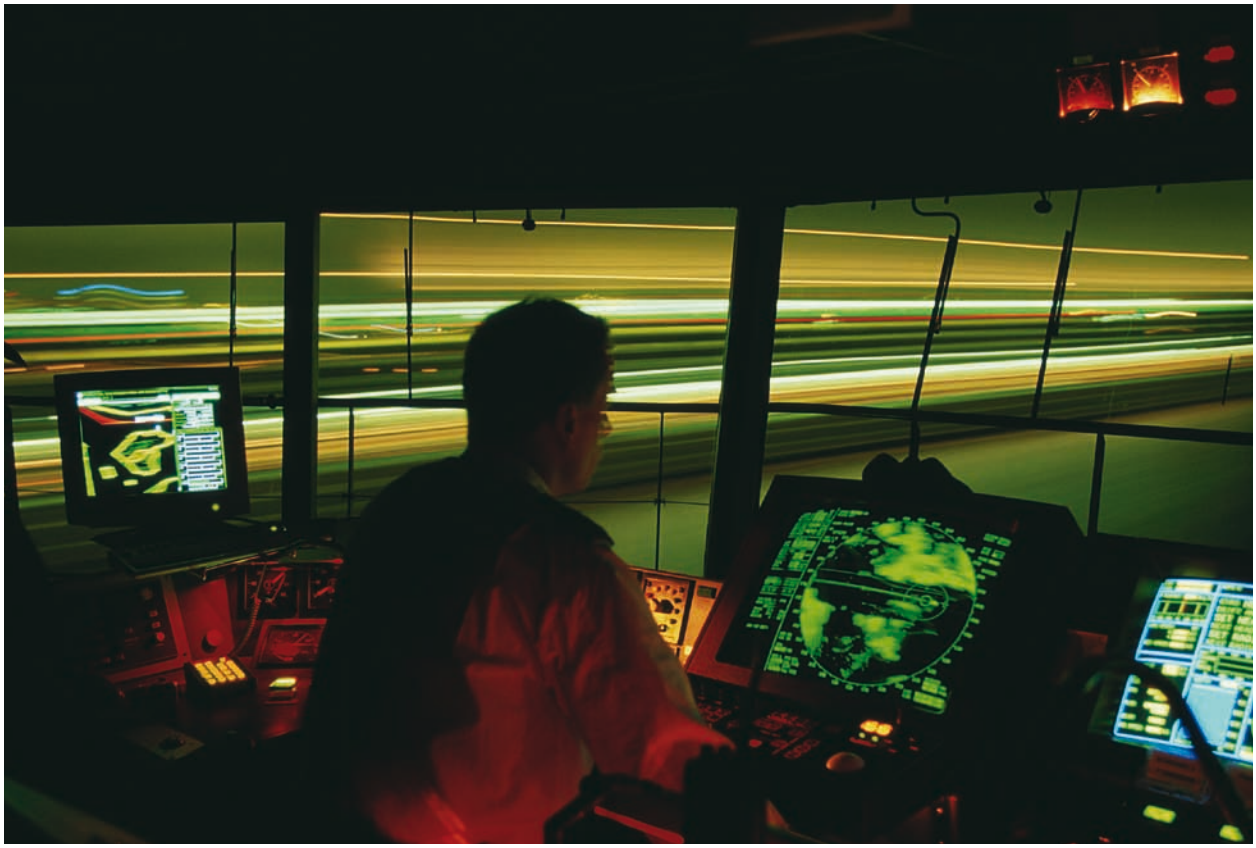
With an **innovation-support programme**, the BMELV is supporting new technologies and processes in the agricultural and food industries, including technologies and processes for enhancing consumer protection. Wireless communications systems for agricultural machinery; weed detection systems for efficient control of pesticide and fertiliser use; and research into the cultivation of resistant crops and the breeding of high-yield, healthy farm animals are just a few examples of research focuses oriented at enhancing sustainability and increasing productivity in resource-conserving ways. Innovative food industry procedures that may help improve food quality and safety are also being promoted.

PRACTICAL EXAMPLE

Communication in the field

In a cooperative project, TU Berlin, the University of Karlsruhe and the firms of SimPlan, Logic Way GmbH and John Deere are jointly developing a new communications system designed to enhance agricultural productivity. With the new system, data collected in farm fields, during transports, as well as data gathered in processing facilities, are transmitted wirelessly to a central control station. The project, which is supported by the BMELV, will thus make it possible, for example, for combine operators to exchange harvest yield and grain-quality data with other operators, for the purpose of optimising machinery settings. Harvest machinery equipped with such systems can also be remotely diagnosed for any problems; can be remotely serviced; and even (at some time in the future) remotely controlled.

Security



SUMMARY

Challenges and aims

Worldwide, terrorism and organised crime have increased, and more and more natural and environmental disasters have occurred. Our modern society, globally mobile, and with extensive electricity, gas and communications networks, has to meet such growing safety and security requirements via research and innovative technologies and processes. The Federal Government is working to intensify security research, with the aim of providing ethically acceptable protection, especially for supply and infrastructure networks.

Significantly, the German market for security-relevant products and services alone generates over EUR 10 billion, and it is growing at annual rates of up to eight percent.

Results and outlook

New security risks call for innovative ways of dealing with hazards and crises. The High-Tech Strategy is unprecedented in including civil security research as a central research area. Its priorities in this area include:

- A **research programme for civil security**, providing for close cooperation between all stakeholders (federal and Länder authorities, the science and industry sectors, the EU and relevant international organisations), is developing innovative ways of protecting against threats and hazards. Its specific emphases include scenario-oriented security research (such as research into ways of rescuing large crowds of people and protecting supply infrastructures).
- A **Conference on the social dimensions of security research**, held in Berlin in November 2008, helped build relevant interdisciplinary cooperation by facilitating intensive exchanges with experts, in the areas of the humanities, cultural and social sciences, regarding the social issues involved in democratically acceptable security research.
- EU cooperation in civil security research has been launched on the basis of the new programme. Close **links with the European security research programme**, and with the EU's relevant policy areas, highlight Germany's strong role in the building of a European security architecture.
- **International government-to-government agreements** are strengthening Germany's political weight in security cooperation (one pertinent example is an agreement with the U.S. on transatlantic research cooperation).

Challenges and aims

Events and developments such as terrorism and extremist attacks, the spread of weapons of mass destruction, regional conflicts, the collapse of states, organised crime, natural and environmental disasters present a broad range of threats – also for Germany. Dangers and threats may vary widely in terms of their impact. They can affect either individual persons or a society as a whole. Even relatively small factors, completely unrelated to terrorism, can lead to major negative impact. Well known examples include the storm "Kyrill", which paralysed traffic throughout Germany, and the accidental severing of a cable along the Ems river, which caused electricity blackouts throughout Europe.

Germany's highly efficient, automated and interlinked infrastructures react very sensitively to interventions. Greater security needs to be provided for such structures. For example, it has to be ensured

that no containers with hazardous materials, bombs or counterfeit/pirated products are smuggled into the country via the Port of Hamburg, or that no hazardous radiological, biological or chemical agents find their way into foods and the public water supply.

The Federal Government's aim in this area is to identify the many different types of security challenges confronting a modern, networked society, and to protect the open civil society's vital areas. Such areas especially include infrastructure, energy, supply and utility systems, information technology systems, telecommunications, transport, health care and the financial system. At the same time, these projects are linking technological and societal issues, and considering pertinent legal, ethical and sociological aspects.

With civil security research, the Federal Government is seeking to help develop key solutions – for example, to prevent environmental disasters or major accidents and to minimise the impact of such incidents. And passengers must be able to travel safely and securely, without fear, by plane or train. New security approaches, concepts and technologies must be found to ensure that Germany continues to be among the world's safest countries.

Results and outlook

Today's new and changed security risks call for new solutions and approaches. In its High-Tech Strategy, therefore, the Federal Government has recognised and developed the issue of civil security as a central requirement area. Research and development provide the basis for new, carefully tailored security solutions.

New programmatic approach

In the interests of enhancing protection for the country's citizens, the Federal Government has launched the **Programme "Research for Civil Security"**. For the first time, the new security research programme links the humanities and social sciences in pertinent ways, with the natural and technological sciences, with the aim of drawing on both major areas to develop innovative security solutions (**www.sicherheitsforschungsprogramm.de**).

To ensure that research is always oriented to actual requirements, and that research findings can be translated into practical applications, authorities with security responsibility are integrated in projects (for example, Federal Criminal Police Office (BKA), Federal Office for Information Security (BSI), the THW technical assistance organisation, Federal Police, Federal Office of Civil Protection and Disaster Assistance (BBK) and the Federal Highway Research Institute (BASt)). With this orientation, the High-Tech Strategy's interdepartmental approach is especially effective. The security research programme brings together all responsible policy areas throughout all relevant departments under the leadership of the BMBF, thereby facilitating interdisciplinary cooperation.

Civil security research: Twin benefits

In addition to protecting against dangers, and creating safe conditions and environments, security products and services provide great economic opportunities. In 2005, security products and solutions accounted for EUR 10 billion in Germany alone, with fully EUR 3.6 billion related directly to IT security. And the pertinent growth rates are high. According to the OECD, annual growth rates of up to eight percent are possible in the global market. As a result, security technologies are an area in which international competitive advantages can be gained – i.e. they are a true lead market.

With its security research programme, in the framework of the High-Tech Strategy, the Federal Government is seeking to develop opportunities for success in these future markets. Demand for security-relevant products and services generates value and jobs, and it strengthens German industrial competitiveness. What is more, by generating demand in the area of security solutions, the state can create new market opportunities and thereby facilitate the introduction of new technologies.

The security research programme focusses especially on research with regard to complex security scenarios. Examples of the sorts of questions relevant to such **"scenario-oriented security research"** include: What are the best ways of protecting large events? How can security for public transport systems (railway, local public transportation) be expanded and improved? How can cascading effects (for example, electricity blackouts leading to telecommunications failures, etc.) be prevented? Work on such scenarios involves a great deal more than simply the development of technological security solutions. It has a central application-oriented focus that takes account of the entire pertinent innovation chain, throughout a spectrum from research to industry and to end users. The end users within the meaning of the security research programme include infrastructure operators, authorities (along with their own facilities) and security and emergency-response forces (police, fire departments, the THW technical assistance organisation and other assistance organisations).

In addition, research into the **"social dimension"** of civil security is being supported, in projects for the development of society's security awareness and the institutional security architecture. Such projects conduct interdisciplinary studies of the necessary societal basis for innovation security solutions, the possible impact of such solutions and the manner in which such solutions these be integrated within the societal framework. In such interdisciplinary work, the projects are searching for solutions that are ethically acceptable and transparent in the public eye. Germany is an international leader in this area.

Targeted initiatives

The security research programme has already registered initial successes. The response to the programme has been strong, and, as of March 2009, in the context of 42 collaborative research projects, the programme has mobilised some EUR 41 million in industrial funding (i.e. over and above the government support being provided).

The initial research focuses include the development of portable detectors (portable analysis units or "mini-laboratories") that can identify and locate explosives, poisons and pathogens such as anthrax quickly and locally. Already, "terahertz devices" are available for detecting explosives and weapons.

PRACTICAL EXAMPLE

Evacuation from a subway train – innovations for fire departments and emergency response services

An emergency in a subway network. What has happened? Will fire department and rescue services be able to reach the site of the emergency quickly, or are poisonous gases in the subway tunnel and neighbouring subway stations blocking access? In subway rescue operations, it can be an enormous challenge simply to reach the site of the emergency. With current systems, little real-time information is normally available during rescue operations, about the possible release of hazardous substances in connection with accidents or terrorist attacks.

In the **"OrGaMIR"** project, being carried out under the direction of the University of Paderborn, and in cooperation with scientific and industrial partners, subway operators and fire departments, new methods are being analysed of obtaining such important information more quickly. The availability of such information would facilitate faster, safer evacuations. The project is aimed at making possible near-real-time measurements of any poisonous contaminants in local public transportation systems, as well as near-real-time calculations of the spreading of such contaminants. The project results will provide a basis for deriving potentially life-saving instructions and information for passengers, emergency response crews and operator organisations.

A body of experts advises the Federal Government in civil security research

In improving the security research programme, the Federal Government relies heavily on available expertise. This is why an independent body of experts has been established in this area. The "Scientific programme committee on security research" ("Wissenschaftlicher Programmausschuss zur Sicherheitsforschung") includes personages from the areas of research, science, government authorities and business enterprises. The committee's interdisciplinary expertise, covering subjects as diverse as sensors and ethics, helps to ensure that the security research programme is balanced in its content and aims. The committee is also helping to link German activities with European activities in this area.

In addition, researchers are studying relevant scenarios – for example, orderly, panic-free rescues of large numbers of people from stadiums or from subway networks (following incidents). Solutions are also being developed with the help of computer simulations, behaviour analyses and field tests – for example, solutions for automatic early warning and evacuation systems.

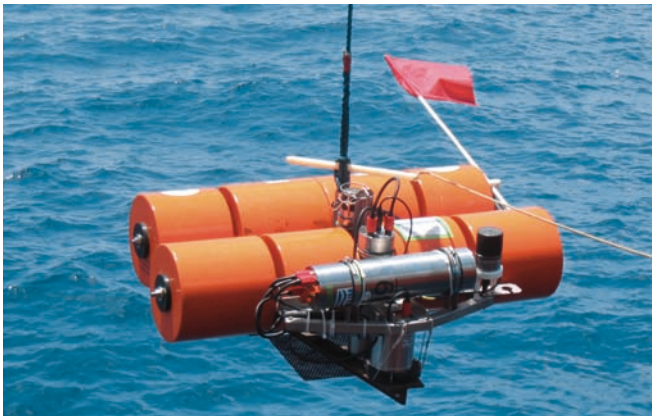
A programme on **"Protecting commodity chains"** is currently being prepared. Comprehensive protection of the free movements of goods must not lead to additional burdens on such movements; it must not slow the movement of goods nor make goods more expensive. The twin aims of cost-effectiveness and security are now being linked with the help of research and innovation. German know-how is facilitating the movement of goods. In a pertinent example, the U.S. Congress has issued regulations calling for x-ray inspection, as of 2012, in all ports of departure, of all shipping containers destined for the U.S.. The new regulations have led to controversy between the EU and the U.S., as well as in the U.S. itself, since no suitable technologies for such inspections are yet available. Furthermore, a lack of suitable technologies would have a negative impact on the flow of goods. The security research programme is addressing this

PRACTICAL EXAMPLE

Tsunami early warning system – a milestone in international disaster prevention

Now, Indonesia's people are better protected against natural disasters: in November 2008, a new tsunami early warning system went into operation that was developed under the leadership of the Helmholtz Centre Potsdam / Deutsches GeoForschungsZentrum (GFZ) and with key involvement of the German Aerospace Center (DLR). The Federal Government provided funding totaling EUR 51 million for the project. Final handover of the system to Indonesia is slated for 2010.

The system comprises numerous components, including seismometers, GPS stations, water-level sensors, seabed sensors and measuring buoys. When an earthquake occurs, data gathered by the system's sensors are transmitted, via satellite, to a control centre, where computers calculate the potential hazards within minutes. The information yielded by the system thus provides a basis on which authorities can warn the public quickly and reliably. In future, similar components may also be used in Mediterranean and North Atlantic regions with earthquake risks.



issue in its support area "Protecting commodity chains" ("Sicherung der Warenketten"), which is also part of the "Freight Transport and Logistics Master Plan" ("Masterplan für Güterverkehr und Logistik"; cf. the Chapter on "Mobility").

Functional networks, linking end users, industry and science, play a key role in any successful translation of research findings into practical, marketable products and processes. For this reason, a relevant new instrument, **"innovation platforms"**, is being established within the civil security research programme. Such platforms offer all stakeholders within the security research sector a forum for dialogue, and they are conducive to the formation of networks linking research, industry and authorities. Examples of issues to be discussed in this context include: the framework conditions for future implementation, the requirements applying to the future market and the ways in which new solutions can be integrated within society. A first innovation platform, **"Protection of transport infrastructures"** ("Schutz von Verkehrsinfrastrukturen"), was established in September 2008. Other innovation platforms are currently being prepared.

Security is also an **international issue**. This is why the security research programme's priorities include forging international research alliances and helping to shape the European security architecture. The EU's Seventh Research Framework Programme (FP7) provides an unprecedented range of options for such priorities. A total of EUR 1.4 billion has been provided throughout Europe, for the period 2007 to 2013, for research funding in the area of "Security". In January 2007, in the interest of facilitating access to European collaborative research projects, a **National Contact Point (NCP) for Security Research** was established, charged with providing advising regarding EU research funding opportunities.

On 16 March, the Federal Government signed a **first government-to-government agreement with the new U.S. administration** regarding transatlantic cooperation in security research. The agreement calls for close scientific and technological cooperation serving the two countries' common transatlantic security interests. Examples of relevant topics include air transport security, IT security and development of state-of-the-art technologies for the x-ray inspection of shipping containers.

Mobility

SUMMARY

Challenges and aims

Transports keep growing, and yet the available space and land for transport infrastructure are limited. Technological solutions to this dilemma are thus urgently needed – along with solutions for reducing transport-related environmental burdens and enhancing safety for all persons involved in transports. The Federal Government is aiming to use innovative approaches to protect environmentally friendly, resource-conserving and energy-efficient mobility options for Germany's modern society and to position Germany as Europe's most modern logistics hub.

At the same time, industrial competitiveness in this area can easily continue to grow. Germany is an international leader in the areas of automotive, traffic control and transport technologies. The international financial crisis notwithstanding, Germany's automobile industry remains among the country's revenue leaders. The automobile industry accounts for about one out of every five euros of industrial revenue generated in Germany. Other major value-creating and strongly growing sectors include the aerospace and maritime technologies sectors, which together employ some 170,000 people.

Results and outlook

The High-Tech Strategy is places emphasis on resource-conserving technologies and innovative, environmentally friendly transport concepts. At the same time, the "Freight Transport and Logistics Master Plan" serves as a strategic concept for transport policy, as well as a central step toward a highly capable freight-transport infrastructure and toward a suitable orientation in freight transports.

Mobility – safe, energy-efficient and climate-friendly

- **Motor vehicle taxation** is being oriented to CO_2 emissions
- A **National Electromobility Development Plan** focusses on the development of new electric drive systems and storage systems (fuel-cell, hybrid and electric vehicles)
- A **"Mobility and Transport Technologies" transport research programme** gives priority to intelligent logistics and infrastructure, as well as to modern, safe and environmentally friendly mobility.
- **Strategic partnerships** – including such partnerships oriented to automotive electronics, hydrogen and fuel-cell technology and to innovative vehicle communications systems – are concentrating resources in the interests of innovative mobility.

Maritime High-tech

- The programme **"Shipping and Maritime Technologies for the 21st Century"** provides the necessary basis for state-of-the-art blue-water, inland and coastal navigation; for environmentally friendly technologies for offshore oil and gas production; for maritime environmental technologies; and for the economic use of polar waters.

Safe, clean air travel

- An **Aviation Research Programme** is developing the technology basis for dealing with environmental and flight-safety issues arising in connection with the growth in air travel.

Challenges and aims

Transport growth, both individual transport and transport of freight and goods, is creating major challenges for transport infrastructures, logistics systems and transport technologies. A range of studies predict that freight transport volumes will increase by some 70 percent from 2004 to 2025. At the same time, the space available for roads, railway lines and freight-handling centres is limited. What is more, traffic jams cause considerable economic damage – damage that could be alleviated by intelligent traffic management concepts. Moreover, improved safety technology in vehicles can reduce and prevent traffic accidents, nine out of ten of which occur as a result of human error.

Demographic change will affect transport and infrastructure systems. While reductions in transport volumes are expected in some regions, freight transport will increase dramatically in large population centres. In addition, individual mobility patterns in urban areas will change radically.

As transport grows, the relevant environmental-policy and climate-policy challenges grow as well: already transports is responsible for about 20 percent of Europe's CO2 emissions and accounts for about 70 percent of its oil consumption. What is more, transport generates noise that can have negative impacts on health.

The Federal Government's climate protection aims are thus oriented directly to transport: lower greenhouse gas emissions, greater energy efficiency and greater reliance on renewable energies. Technological solutions, innovative approaches and creative adjustments are needed to manage continuing transport growth, while also meeting the need for safer, faster – and greener – passenger and freight transport. At the same time, the Federal Government aims to develop Germany into Europe's most modern logistics hub.

Vehicles and transport – a market of great importance and with a great future

Logistics, the automobile industry and sales are Germany's largest sectors in terms of revenue. The following figures highlight the importance of mobility and transport for the German economy:

- One out every seven jobs in Germany depends, either directly or indirectly, on the automobile industry. In 2007, this sector had revenue of nearly EUR 300 billion and employed some 750,000 people.
- Prior to the financial and economic crisis, German logistics companies generated revenue of EUR 180 billion per year. Logistics is Germany's leading sector when it comes to providing training, and it has room to absorb an additional workforce of about 20 percent (i.e. of current levels). Some 2.6 million people – taking all relevant sectors into account – are employed in logistics-related job areas.
- In the tourism sector, some 3.4 billion day trips and single-day business trips are made per year. Such trips generate gross annual revenue of EUR 156 billion.
- The railway industry generates 53 percent of its total revenue, which amounts to EUR 9.1 billion, in exports.
- Each year, railways and local public transportation systems transport about 9.3 billion passengers.
- In 2007, the German shipbuilding industry generated revenue of EUR 5.5 billion.
- The German shipbuilding and offshore-supply industry is the world's leading exporter in its category. With a total of 76,000 employees, and revenue of EUR 12 billion, it ranks second worldwide, after Japan.
- The German aerospace industry spends an average of about 20 percent of its revenue on research and development; it is thus one of Germany's most research-intensive and innovative sectors.

Results and outlook

In its High-Tech Strategy, the Federal Government is relying on innovative concepts and technologies in its efforts to ensure that the **growing transport sector (both passenger and and freight transport) remains safe and sustainable**, while also fulfilling its key role in the German economy.

Mobility – safe, energy-efficient and climate-friendly

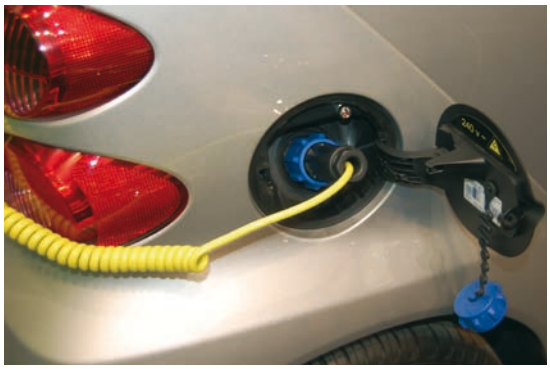
The Federal Government's climate-protection aims are also triggering efforts in the area of mobility. With its High-Tech Strategy, and the Federal Government's comprehensive package of measures within the Integrated Energy and Climate Programme, Germany has taken the necessary steps to reduce its greenhouse gas emissions by 40 percent by 2020. The human stress generated by automobile traffic is to be sharply reduced. Relevant efforts will apply especially to that sector's resources and land consumption, its noise and its carcinogenic emissions. In the framework of the Integrated Energy and Climate Programme, therefore, and with effect as of 1 July 2009, **motor vehicle taxes** for new automobiles will be based on CO2 emissions. With this move, the Federal Government is providing an incentive for the purchase of vehicles with low fuel consumption (which are also cheaper to operate).

At the same time, the government's economic-stimulus packages provide important impetus for the purchase of modern, "greener" automobiles. Those who purchase a new car by 30 June 2009 are exempted from motor vehicle taxation. In addition, all those who purchase vehicles meeting the "Euro 5" or "Euro 6" emissions standards will be exempted from motor vehicle taxes until the end of 2010.

In the interests of the long-term future of mobility, alternatives to the conventional internal combustion engine, powered by fossil fuels (petrol, diesel fuel, natural gas), must be found. The future belongs to electrically powered vehicles, i.e. hybrid, electric and fuel-cell vehicles. Such vehicles help reduce dependence on oil imports, and they contribute significantly to reductions of emissions of CO2 and other pollutants. For this reason, the Federal Government intends to make Germany a lead market for electromobility. Research and development will play a central role in the achievement of this aim. In its second economic stimulus package (Konjunkturpaket II), the Federal Government is providing EUR 500 million for application-oriented research in the area of mobility. The relevant areas that are supported include competence-building in electrochemistry, development of technologies for the industrial production of lithium-ion batteries, development of new drive-system concepts and the establishment of relevant model regions. As a result, this project is both strengthens Germany's competitive-

PRACTICAL EXAMPLE

Electric cars



The Federal Government has been investing heavily in development of electric cars. Now, in addition to the pertinent activities already underway, the Federal Government is intensifying its efforts in the area of "electromobility". Funding for research and development in the area of electromobility is concentrated on relevant competence-building, on fuel-cell and battery development for mobile applications, on energy and drive-system management, and on network integration and electric circuits. Such developments are aimed at achieving extensive standardisation and modularisation of the overall system. Regional and sectoral field tests play an important role in this project. In cooperation with industry, such tests are expected to lead to particularly efficient, cost-effective solutions. The Federal Government's current aim in this regard calls for one million electric cars to be on Germany's roads by 2020.

PRACTICAL EXAMPLE

Intelligent traffic lights

A team of researchers from industry and university institutes has developed an intelligent traffic light that reacts to the current traffic situation. The new system thus helps to save time and protect the climate. The project is part of the BMWi-supported research initiative Adaptive and Cooperative Technologies for Intelligent Traffic (**AKTIV**; Adaptive und kooperative Technologien für den intelligenten Verkehr). In this project, a total of 29 partners from the automotive and related supply industries are working together on optimal ways of guiding and managing traffic flows and grids, and on developing driver-assistance systems that individually aid drivers in dangerous traffic situations.

ness and boosts climate protection. The second economic stimulus package (Konjunkturpaket II) complements the Federal Government's ongoing activities in this research area, activities such as the National Hydrogen and Fuel Cell Technology Innovation Programme (NIP), and the "LIB 2015" and "Automotive Electronics" Innovation Programmes.

The additional measures in the area of electromobility that are now possible under the second economic stimulus package (Konjunkturpaket II) are to enter into an interdepartmental, intersectoral action framework, the **National Development Plan for Electromobility**. On this basis, science, industry and policy-makers will develop a pertinent joint approach, covering the entire spectrum from basic research to market introduction. In addition, attention will be given to the entire relevant value-creation chain – including materials, components, fuel cells, batteries, as well as the entire system and its applications. Key relevant facts and figures were discussed with industrial and scientific stakeholders at a national strategy conference on electromobility that was held in November 2008 in Berlin.

It is also important for today's traffic and transport systems to be adapted to the growing needs and requirements of people and markets. This task calls for innovations that can improve transport and mobility quickly and in lasting ways. The **transport research programme "Mobility and Transport Technologies"**, which is being carried out under the direction of the Federal Ministry of Economics and Technology (BMWi), has translated these aims into three priorities: intelligent logistics, intelligent infrastructures and mobility for people in the 21st century. Projects in this framework will include developing innovative traffic management systems and making both local public transportation and railways (both passenger and freight transport) more attractive and efficient. Since mobility is often a transborder affair, international cooperation aimed at solving problems on roads and railways is being supported.

In order to meet the challenges arising in the area of freight transports, in 2008 the Federal Government launched a **"Freight Transport and Logistics Master Plan"**, a strategic concept, with specific measures, for the future design of freight transport. The Master Plan takes the necessary steps to prepare for the transport of tomorrow. A strategic guide for transport policy, it describes the ways in which the infrastructure's function and performance can be safeguarded and how transports can become more energy-efficient, more generally efficient, cleaner and quieter. The Master Plan is the result of a two-year discussion process, under the direction of the Federal Ministry of Transport, Building and Urban Affairs (BMVBS), involving a total of over 700 experts representing business enterprises, unions, the policy sector, economic and ecological associations and the science sector.

Innovation alliance / strategic partnership	Focus
Automotive electronics (IAE)	**CO_2 reduction, automotive safety:** Innovative automotive electronics systems are to be used to make automobiles more environmentally compatible and to enhance safety for all drivers and passengers.
National Hydrogen and Fuel Cell Technology Innovation Programme (NIP)	**Innovative drive-system technologies:** Mobile, stationary and portable applications of hydrogen and fuel-cell technologies are to be developed and brought to market maturity.
Safe, Intelligent Mobility – Test Field Germany (Deutschland) (SIM-TD)	**Traffic safety and management:** The aim of this project is to use innovative vehicle-borne communications systems (that link vehicles with each other and with traffic control stations) in order to make traffic safer and reduce traffic jams.
"Door-to-door" ticket (eTicketing)	**Simple and convenient mobility:** This project aims to develop of an interoperable fare-management system for local public transportation, in order to prepare the way for a standardised ticket for all of Germany.

Innovation alliances and strategic partnerships

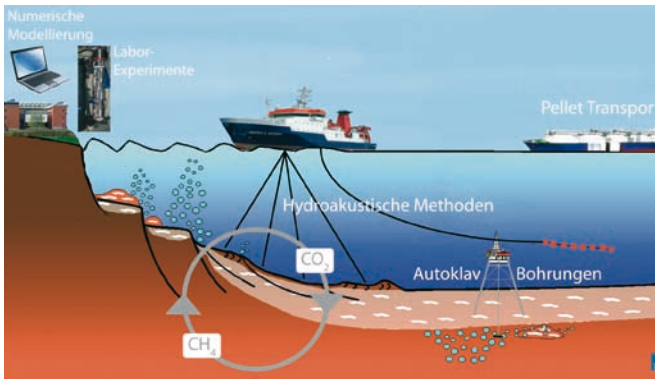
In the area of mobility, the following innovation alliances and strategic partnerships have been launched, in order to concentrate pertinent political, scientific and industrial resources:

Maritime High-tech

In the interest of making Germany a centre for maritime high-technology, with its research programme **"Shipping and Maritime Technologies for the 21st Century"**, the Federal Government is relying especially on research and innovation. The aims of the programme, which is being managed by the Federal Ministry of Economics and Technology (BMWi), include improving ships' energy efficiency,

PRACTICAL EXAMPLE

Energy sources on the ocean floor



The collaborative research project **"SUGAR - Submarine Gas Hydrate Deposits: Exploration, Exploitation and Transport"**, which is being jointly supported by the BMWi and the BMBF, and directed by the Kiel-based Leibniz Institute of Marine Sciences (IFM-GEOMAR), is pursuing the aim, in cooperation with 30 industrial and scientific partners, of developing a safe, environmentally compatible process for combining submarine methane exploitation with carbon dioxide storage. By successfully combining two such complex research fields, Germany – even though it lacks gas-hydrate deposits of its own – could acquire technological leadership in this area and make important contributions to meeting energy requirements and protecting the earth's climate. Methane hydrates, also known as "frozen natural gas", are found in large quantities under the ocean floor. They are seen as an energy source of the future.

enhancing flexibility in series production of ships and developing innovative freight-handling technologies. In collaborative research projects, most of them industry-led, business enterprises are working in cooperation with higher education institutions and research institutes, toward joint development goals.

The field of maritime technologies includes more than just shipbuilding. Industrial use of the seas also includes extraction and processing of natural resources (marine mining), production of fossil fuels and renewable energies (offshore technologies for oil and gas production, and technologies for using wind, wave and tidal energy) and use of maritime control and safety technologies. In addition, the sea, long a traditional source of food (for fishing and aquaculture), is now also an increasingly important source of materials for medicines and cosmetics.

The offshore sector is expanding worldwide. Technologies for extracting raw materials and energy from the high seas are a growing market. In this field, the Federal Government is relying on innovation. The emphases of the government's offshore research include an **Offshore Test Field**, supported by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), in the North Sea. If the seas are to be used sustainably, constant and careful attention must be given to development of technologies for preventing and combating ocean pollution (marine environmental protection technologies). Surveying technologies (hydrography), hydrologic engineering and coastal zone management play similarly important roles. The most important trends in the international offshore market include development of deep-water oil and gas fields, resources extraction and transports in polar waters and extraction of minerals and gas hydrates. Water depths of more than 1,500 metres present extreme challenges for equipment, systems and services, and a **Lighthouse Project, "Integrated Systems for Underwater Production of Hydrocarbons"** (ISUP), is working to meet such challenges.

Safer, "greener" air travel

For years, the **aviation industry** has enjoyed above-average rates of growth. In 2007, its total revenue passed the EUR 20 billion mark. Eurocontrol, the European Organisation for the Safety of Air Navigation, is predicting double the amount of of air traffic by 2025, with respect to the corresponding level in 2003, for Germany alone. Such growth will create new jobs at airports, with aircraft manufacturers and with aircraft industry suppliers. All in all, some one million jobs now depend, either directly or indirectly, on the aviation industry.

Growth in air traffic will have an impact on the environment and could affect flight safety. The European **research agenda "ACARE-Vision 2020"** is focussed on such challenges. In addition, Germany's current **fourth aviation research programme** (Luftfahrtforschungsprogramm IV; LuFo IV) supports the German aviation industry, in cooperation with researchers, in providing the necessary technological basis for meeting such challenges. Relevant research activities are focussed, inter alia, on the following areas:

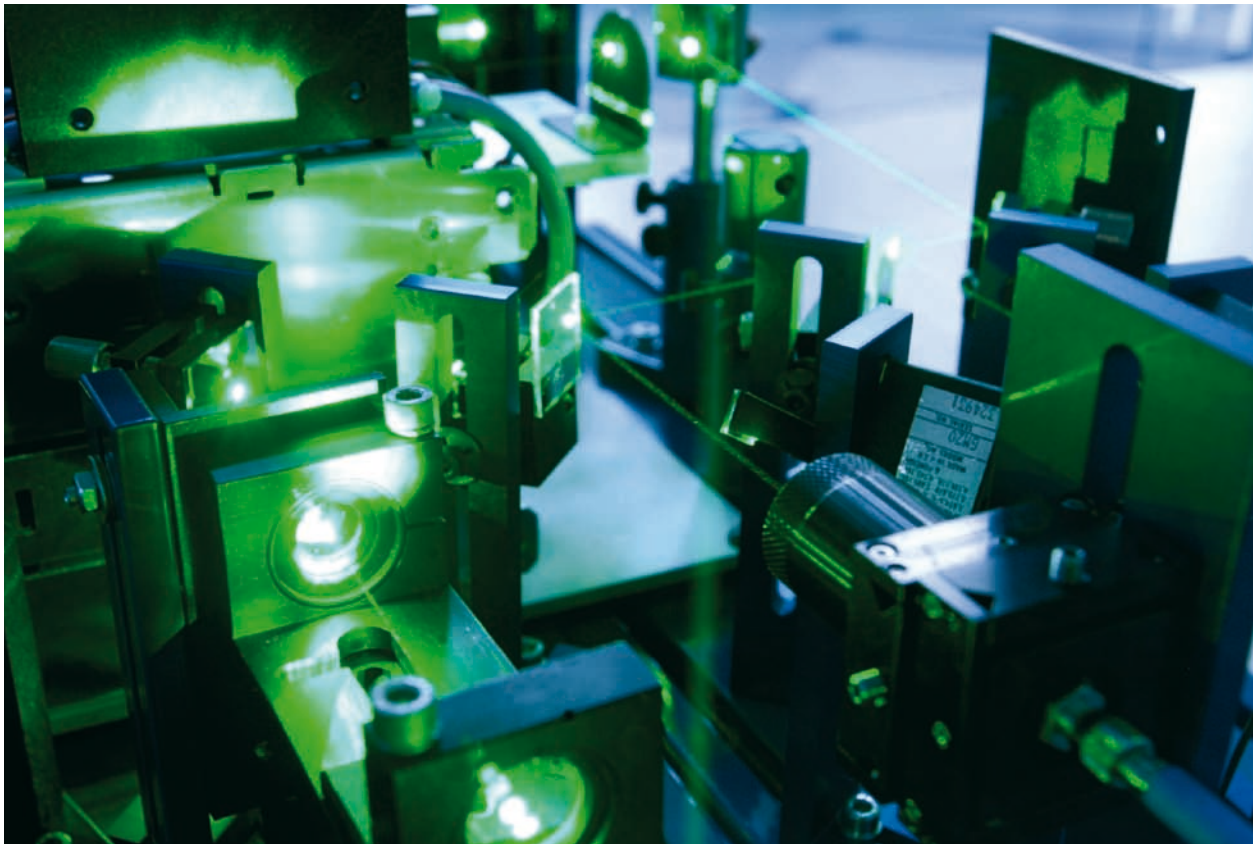
- **Increasing transport performance:** Aviation infrastructures and processes must be coordinated and integrated in such a manner that the expected growth in transports can take place safely, reliably and flexibly, and the air accident rate can be reduced by 80 percent.

- **Environmentally compatible air transports:** By means of technological measures in the areas of aircraft engines and aviation physics, external noise levels are to be cut in half, and fuel consumption – and, thus CO2 emissions – are also to be reduced by about 50 percent. Such efforts are focussed especially on innovative lightweight structures, engines and on-board systems. In the longer term, new aircraft concepts (such as flying wings) are to be studied.

- **Safety and convenience for passengers:** Innovative solutions are expected to enhance passenger comfort in flight, to improve reliability and punctuality and to enhance safety in spite of the growth in air traffic.

The aviation research programme is being closely coordinated with relevant European activities, especially the "CleanSky" and "SESAR" research initiatives. The primary tasks of the European research framework programme include considering individual national technological developments within the overall context of the European aviation industry.

Key technologies



SUMMARY

Challenges and aims

Key technologies drive innovation and thus serve as the basis for new products, processes and services – including products, processes and services that can meet specific societal challenges, such as developing new medicines or protecting earth's climate. The Federal Government aims to reinforce and build on Germany's technological leadership in the area of key technologies, to promote the translation of research findings, to develop new application areas and to advance the (further) development of lead markets. Key technologies are making key contributions in the priority areas of health, climate protection / resource conservation / energy, security and mobility.

The **pertinent economic opportunities** are immense: Germany's competitiveness as a centre for production and jobs – and, thus, Germany's economic future in a knowledge-based society – will depend decisively on the degree to which key technologies' opportunities are used and transferred into commercial applications. Examples:

Information and communications technology (ICT): This sector's 800,000 jobs in Germany generate revenue of about EUR 145 billion. The phasing-in of broadband Internet is expected to create some 100,000 additional jobs per year throughout Europe.

The area of **microsystems technology** alone has registered growth of about 15 percent per year over the past three years.

Optical technologies: Germany is the world market leader in many areas of laser technology (for example, it has a 40-percent share of the world market for high performance lasers for materials processing, a market worth some EUR 2.5 billion). In the area of the "light of the future" – LEDs – Germany already has a 12-percent world market share, thereby ranking second internationally.

Production technologies: In 2007, a total of 6,000 companies, with a total workforce of more than 900,000, generated revenue of EUR 190 billion. Germany's machine tools producers, with a world market share of over 19 percent, are the world market leaders.

Materials technologies: Some five million people in Germany work in areas in which materials technologies play a key role.

Biotechnology: Considerable revenue growth is expected in medical and industrial biotechnology; in industrial biotechnology alone, global revenue is expected to increase from US$ 50 billion to about US$ 300 billion, in the space of only ten years.

Nanotechnology: The world market is expected to reach a total volume of over EUR one trillion by 2015.

Services: The sector, with a workforce of over 27 million, is the largest value-creation sector in Germany, and it is growing rapidly. Value creation accounts for about 70 percent of revenue.

Results and outlook

In the framework of the High-Tech Strategy, key technologies are being promoted via numerous initiatives and measures. Examples:

- Successful establishment of **innovation alliances and strategic partnerships**, such as "Organic Light-Emitting Diodes (OLED 2015)"; "Organic Photovoltaics (OPV)"; "CarbonNanoTubes"; "Semantic Product Memory (SemProM)"; "Applied Virtual Technologies in Products and Production (AVILUS)"; "100 Gbit/s Carrier-Grade Ethernet Transport Technologies – 100 GET" (transport services for the future Internet); "Safe Intelligent Mobility – Test Area Germany (SIM-TD)"; standards for 4th generation (4G) mobile communication systems; the "BioPharma" competition; and "BioIndustry 2021" ("BioIndustrie 2021").
- Under the programme **"ICT 2020 – Research for Innovation"**, research funding has been oriented to leading application areas in Germany in which innovation is highly ICT driven.
- The research initiative **"Innovation against Product Piracy"**, operating in the framework of the programme "Research for the Production of Tomorrow", is advancing the battle against product piracy and counterfeiting.
- The funding programme **"WING – Materials Innovations for Industry and Society"** promotes research aimed at producing better, more efficient and lower-cost customised materials.
- With the **framework programme "Biotechnology** – Using and Shaping its Opportunities", funding is focussed on innovation in industrial, medical and plant biotechnology.
- In the **"Nano-Initiative – Action Plan 2010"**, an interdepartmental action framework has been created to facilitate faster translation of research findings into products and to enhance relevant framework conditions (including those in such areas as work safety, environmental protection and consumer protection).
- In the **"Ambient Assisted Living – AAL"** project, microsystem technology, ICT, medical technology and innovative services are used to provide the basis for assisted living systems that can help senior citizens lead healthy and independent lives.
- **Space technologies** are producing state-of-the-art satellite systems for space-based climate and earth monitoring.
- **"Innovation with Services"** is promoting vigorous and (especially) systematic development of innovative services.

Challenges and aims

Key technologies drive innovation in leading application areas in Germany, including such areas as automotive technology, medical technology, mechanical engineering and logistics. In today's world, new products, processes and services can hardly emerge without the help of key technologies, which now provide the basis for a multitude of applications throughout a broad range of sectors. Germany's economic future thus depends decisively on its commitment to using the opportunities inherent in key technologies and to translating such technologies into commercial applications.

Research and development in the area of key technologies make essential contributions to the solution of society's challenges, especially in the focus areas of health, climate protection / resources conservation / energy, security and mobility. Without key technology-driven innovation, for example, neither modern pharmaceutical development nor reductions in CO2 emissions from road traffic would be conceivable.

For this reason, the Federal Government aims to reinforce Germany's technological leadership in the area of key technologies and promote the implementation of relevant research findings. At the same time, it is promoting the development of new application areas and the (further) development of lead markets. In addition, it is focussing on innovative services that can enhance the market's acceptance of technological innovation and open up new

markets and employment opportunities. Promotion of key technologies and innovative services is expected to build on Germany's strength as a provider of system solutions.

Results and outlook

The Federal Government's High-Tech Strategy is emphasising the enhancement of bridges between a) relevant scientific fields and b) technologies and application areas. It also places emphasis on synergies that enable key technologies and innovative services to contribute significantly to the development of solutions for climate protection, greater energy-efficiency, higher health standards and innovative mobility and security.

The examples below represent only a small selection of ongoing and planned initiatives in the following key technologies:

- Information and communications technologies
- Optical technologies
- Production technologies
- Materials technologies
- Biotechnology
- Nanotechnologies
- Microsystem engineering
- Innovative services

It will be important to continue developing customised measures in the interest of key technologies, and to continue adapting existing measures as necessary. As in requirement areas, such efforts will have to focus on identifying key thematic priorities, with the aim of providing the best possible basis for the translation of research findings into applications. Needless to say, it will also be necessary to continue monitoring the framework conditions for each individual innovation field.

Information and communications technologies

Information and communications technologies (ICT) have been increasingly pervading and influencing virtually all of society's various areas of life and work. They provide the technological basis for new multimedia applications and other services in the areas of industry and business (eBusiness, eCommerce), public administration (eGovernment), health care (eHealth), transport and private life. What is more, ICT drive growth in many other sectors. Over 90 percent of all computer processors are found not in our office computers, but in hidden parts of ABS systems, machine-control units and medical equipment. The High-Tech Strategy has enhanced the driving role of ICT development.

Information and communications technologies – changing markets, and new markets, have enormous growth potential

ICT are a growth market. Globally, according to analyses of the European Information Technology Observatory (EITO), this market grew by 6.3 percent from 2006 to 2007. And the market is growing especially dynamically in the threshold countries India and China. The 800,000 employees in Germany's ICT sector generate revenue of about EUR 145 billion. The BITKOM industry association expects revenue and employment to stay at about the previous year's level, in spite of the uncertain economic situation. On an average for all European Union Member States, the sector accounts for some 6 percent of gross domestic product. In Europe, ICT have been contributing 40 percent of productivity growth.

The BMBF programme **"ICT 2020 – Research for Innovation"**, which was first presented at the CeBIT 2007 exhibition, is implementing the High-Tech Strategy in exemplary fashion for the ICT sector: research funding (totalling EUR 1.5 billion for five years) has been oriented to leading application areas in Germany in which innovation is highly ICT driven. Apart from the ICT sector itself, such areas include the automotive industry, mechanical engineering, medicine, logistics and energy. ICT thus contribute significantly to the solution of societal challenges, such as enhancing road traffic safety, reducing motor vehicle fuel consumption, reducing resources consumption in freight transports, enhancing medical care and developing ambient assisted living systems (AAL) for senior citizens.

In the automobile industry (in areas such as ABS systems, machine control systems), logistics and medical technology, over 80 percent of innovation is now ICT driven. In support efforts, a special focus is being placed on small and medium-sized enterpriservices (SMEs), especially via the "SME

Innovation alliance / strategic partnership	Focus
Semantic Product Memory (SemProM)	**"Intelligent products":** This project is aimed at developing the next generation of mobile, embedded and radio-based elements for Internet communications between everyday objects, and between such objects and their environment. The project is thus contributing significantly to the **Internet of things**.
Applied Virtual Technologies (AVILUS)	**Virtual and augmented reality:** This project is aimed at developing powerful technologies for virtual and augmented reality applications. The resulting applications are oriented to automotive development and production, to services and training, and further training.
THESEUS	**"The Internet of services":** THESEUS is aimed at creating an Internet-based knowledge infrastructure that will facilitate Internet users' access to, and productive use of, global knowledge resources, which are growing rapidly in all areas.
100 Gbit/s Carrier-Grade Ethernet Transport Technologies – 100 GET (transport services for the future Internet)	**Data transmission:** The aim of this European innovation alliance, in which Germans are collaborating with partners from Finland, France, Sweden and Spain, is to define basic aspects of technical standards that will enable the Internet to deal with the enormous growth in data traffic expected in the future.

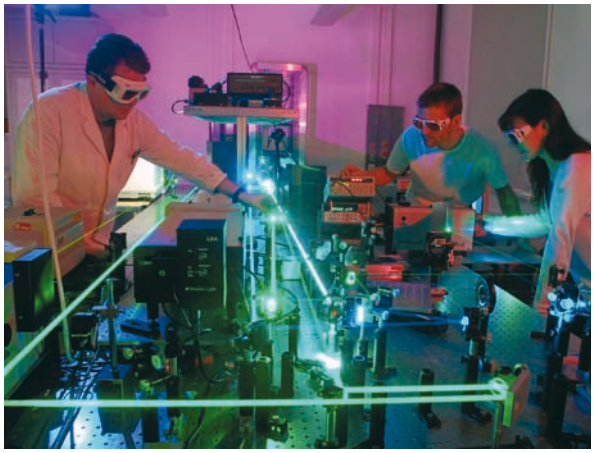
Innovation Campaign for Information and Communications Technology" (which is not topic restricted) and the "KMU-innovativ" programme for funding cutting-edge research by SMEs in ICT. In the second of these, a total of 878 project proposals had been submitted by SMEs as of the end of 2008. Of the submitting group, 460 SMEs were seeking to participate in funding programmes for the first time.

In the **Information Society Germany 2010 action programme**, proposed legislation and funding programmes are being coordinated with a view to the information society's further development. In addition to improving the relevant legal framework (via actions including the amendment of the Telecommunications Act; telecommunications regulation; the Telemedia Act; the Second Act to Regulate Copyright Law in the Information Society, known as the "second basket" of amendments to copyright law), the programme combines the technology-support projects of the various relevant government departments. Other priorities include initiatives for promoting broadband networks and digital media, for a network for electronic business communications and for complete coverage electronic administrative services. Such services include the electronic health-data card and efforts to enhance ICT security. In 2008, in the framework of the Federal Government's "eGovernment" programme, research contracts were awarded in the areas of the electronic personal ID card; secure communications via the "De-Mail" system; the "115" central phone number for government agencies and authorities; the EU Services Directive; public participation via online media; and digital public services via "eGovernment".

New **innovation alliances and strategic partnerships** in the area of ICT are linking industry and science and helping to create lead markets.

Optical technologies

Optical technologies play key roles in many sectors – from electronics to mechanical engineering to medicine. Coherent light, the laser has become a vitally



important precision instrument, especially in industrial production, communications technology and medicine. At the same time, incoherent light (lamps, lighting, LEDs, photovoltaics) is being used to new success with German technology. German business enterprises and research institutions are globally successful in these markets. Optical technologies are key technologies in innovation alliances of the High-Tech Strategy – for example, "Organic Light-Emitting Diodes (OLED 2015)", "Organic Photovoltaics (OPV)" and "Molecular Imaging". Such innovation alliances are focussing on new markets by drawing systematically on existing strengths. With the aid of research funding, optical technologies have become a globally prominent field for German excellence – optical technologies "made in Germany"!

Optical technologies – creating jobs and growth

Optical technologies have become an impressive industrial sector, with a total of 101,000 employees in Germany. Companies in the optical technologies sector together spend some EUR 1.6 billion annually on R&D (and their R&D expenditures amount to 9.7 percent of their revenue). Already, this technological sector in Germany affects about 16 percent of all jobs in the manufacturing sector. Since the end of the 1980s, Germany has become a global market leader in many areas of laser technology. Its share of the world market for high-performance lasers for materials processing amounts to 40 percent, or a volume of EUR 2.5 billion. In the area of the "new light", or "light of the future" – LEDs – Germany now has a global market share of 12 percent. Furthermore, Germany holds the efficiency record for LEDs: 150 lm/W. Especially strong growth rates are forecast for the LED and OLED sector.

Production technologies

Automobiles, machines and industrial plants made in Germany are in demand around the world. One of the most important trends in the area of production technologies has to do with the sustainability principle. The reason for this is that manufacturing companies are increasingly having to produce in an environment of scarce, expensive raw materials. Sustainable production technologies are thus growing in importance worldwide. German companies are leaders in this area. Numerous research projects in Germany are now working to enhance resource efficiency – in areas such as lightweight construction techniques, mobile energy sources or resource-conserving production processes.

World champion exporter, thanks to its manufacturing sector

Manufacturing is the basic reason why Germany holds the title of "world champion exporter". The country's mechanical engineering sector (machine tools), for example, with a total of 6,000 companies, and more than 900,000 employees, generated revenue of EUR 190 billion in 2007. Germany's machine tool manufacturers are the world market

leaders, with a market share of over 19 percent. And although the financial crisis certainly has not failed to affect the real economy in this area, the sector thus is still superbly positioned to emerge even stronger from the crisis.

Also in the context of climate change, sustainable technologies will have to be developed in the area of production. To that end, the Federal Government, via a new funding priority, is promoting the development of innovative approaches **for enhancing resource efficiency and energy efficiency in production**. Moreover, the measure is being complemented by an innovation alliance in the area of energy- / resource-efficiency in key areas of automotive production technology.

In addition, research and innovation are also being used to combat product piracy. The research

initiative "Innovation against Product Piracy" is aimed at developing effective protection for producing companies against product piracy. Since 2008, the BMBF, via the programme "Research for the Production of Tomorrow" has been promoting efforts to develop built-in copy protection that, in future, will make it virtually impossible to counterfeit machines, services and replacement parts.

Materials technologies

The success of new developments often depends decisively on the use of materials with just the right properties. For example, implanted heart pacemakers need to be safe and comfortable for wearers, and automotive components have to be highly robust. Innovations in materials are found in virtually all technology sectors. Examples of such innovations include highly scratch-resistant paints; metal alloys designed to withstand high temperatures; and ultra-light, yet ultra-tough plastics for aircraft (for example). Materials are also playing key roles in the framework of the innovation alliances "Molecular Imaging" and "Lithium-Ion Battery" and in the "CarbonNanoTubes" initiative.

In manufacturing sectors, material costs account for nearly half of all production costs. At the same time, development of new materials is expensive, and something that few companies or organisations can manage completely on their own. For this reason, materials research is thus being given targeted support, via the framework programme **"WING – Materials Innovations for Industry and Society"**. WING integrates materials research, chemistry and nanotechnology, all key elements in materials innovation for products and processes.

The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) is also supporting materials research, in the framework of its **"Renewable Resources" programme**. In one example of efforts within that programme, natural fibres are being used to produce reinforced automobile parts. Similarly, bio-glues can be made from corn and

International leadership in innovative materials

Nearly five million people in Germany now work in materials-based sectors. Such sectors include automotive and machine tools production, the chemical industry, ICT, energy, electrical engineering / electronics and metals production and processing. Such sectors also account for a significant share of Germany's foreign trade surplus, and they contribute significantly to Germany's strength as an exporter. In the current economic crisis, innovation in the area of new materials can play a significant role in boosting the international competitiveness of German companies.

PRACTICAL EXAMPLE

Efficient processing of water from oilfields, using ceramic membranes

Oil extraction operations tend to strike large quantities of water. Since many oilfields are located in areas with growing water scarcity, such "production water" must increasingly be seen as a valuable resource. But this water has to be purified before it can be used for irrigation, and before it has a chance to contaminate existing water reserviors. Existing filtration processes use membranes that retain emulgated hydrocarbons, salts and other, often highly poisonous, substances. Such membranes then have to be cleaned of such deposits. Previously, such cleaning has been anything but simple or efficient, since it calls for the use of a range of different cleaning techniques.

Now, a research project involving the Gießen-Friedberg University of Applied Sciences, in cooperation with RWTH Aachen University, Colorado State University and industrial partners, is modifying newly developed ceramic membranes for the cleaning of "production water". The group is also developing a concept for the efficient cleaning of membranes. Ultimately, the new procedure is to be integrated in an overall cleaning concept for water processing in oilfields.

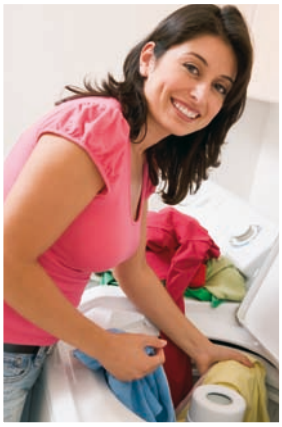
potatoes. Sugar from sugar beets can be used as a raw material for production of organic plastics. The renewable-resources spectrum is being significantly expanded via the use of biotechnological methods in plant breeding, in the framework of the BMBF funding priorities "Genome Analysis in the Biological System of Plants (GABI)" and "Transnational Plant Alliance for Novel Technologies – towards implementing the Knowledge-Based Bio-Economy in Europe (PLANT-KBBE)".

Biotechnology

Biotechnology has become both the basis and the impetus for numerous applications in medicine, the food and feed industries and the chemical industry. Biotechnology plays roles, for example, in the production of medicines, in new diagnosis and therapy concepts, in the production of fine chemicals in wastewater treatment processes and in processes for producing energy from biomass.

PRACTICAL EXAMPLE

A cold wash, and yet the laundry is clean



Innovative industrial biotechnology is providing new, naturally based active substances for industrial production, thereby easing stresses on the environment. One example involves enzymes for laundry detergents.

In the framework of a BMBF funded project, BRAIN AG, located in Zwingenberg (near Darmstadt) identified new types of enzymes that, when used in laundry detergents, function at 40 °C, instead of at 60 °C. In Germany alone, this advance could reduce carbon dioxide emissions by about one million tonnes per year. Dr. Holger Zinke, founder and managing director of BRAIN AG, received the "Umweltpreis 2008" environmental award for his work on "white" biotechnology.

The biotechnology industry – Germany is the European leader

In a development triggered by the BMBF's "BioRegio" competition in 1995, Germany has become the European leader in biotechnology within the space of just a few years. It now has nearly 600 biotechnology companies (of which about 500 are biotechnology-only companies and about 100 are companies that are involved in other fields as well). In 2007, this group of companies had a total of over 29,500 employees, or a 24-percent larger workforce than they had in 2005.

In the sector as it stands today, many companies have attained the maturity necessary for long-term international success. Revenue growth provides an indication of this trend: in 2007, the biotechnology sector reached the EUR 2 billion revenue mark for the first time. By comparison to the corresponding figure for 2005, that revenue milestone represents a growth of 30 percent. What is more, the sector's R&D expenditures reached EUR 1 billion for the first time. As of 2007, a total of 21 German biotechnology companies were publicly listed on stock exchanges. In this category, Germany ranks second in Europe, behind the UK.

Over 40 percent of these companies are involved with health products ("red biotechnology"). A relatively small number – nearly 8 percent – are involved in industrial biotechnology. It is estimated that biotechnological processes now account for about 5 percent of the chemical industry's total revenue, and about 15 percent of the pharmaceutical industry's total revenue. The pace of conversion of industrial processes to a biotechnological basis is expected to pick up markedly in the next few years. In addition, total worldwide revenue for industrial biotechnology is expected to increase from about US$ 50 billion today to about US$ 300 billion in ten years. Industrial biotechnology is seen to have enormous potential for establishing processes that are environmentally compatible, i.e. are energy-efficient and conserve resources.

www.biotechnologie.de

A number of initiatives launched during the course of the High-Tech Strategy are expected to turn research findings into innovations. These biotechnology initiatives are providing new impetus for innovation especially in the following three key application areas: the biotechnological production of basic chemicals and of end products (**"white" or industrial biotechnology**); the use of biotechnological processes in medical applications, such as development of new medications (**"red" biotechnology**; see above, in the chapter on health); and the production of high-yield crops and plants suitable for use as renewable resources (**"green" or plant biotechnology**). Other application areas are coming soon; for example, the potential for "black biotechnology", i.e. for the use of microorganisms as energy sources, is already being discussed (here, "black" refers to oil and coal, still dominant fossil fuels).

In Germany, an especially promising future is seen for the branch of industrial biotechnology that deals with the production of useful substances with the help of living organisms, enzymes or other organic production systems. Such production supplants traditional chemical processes. In some cases, it makes it possible to produce substances that cannot yet be synthesised. Among such substances are basic substances for the pharmaceutical, chemical and food industries, as well as for the production of textile, leather and paper.

The **"BioIndustry 2021"** initiative provides targeted support for strategic partnerships between science and industry, with the aim of speeding the translation of ideas and research findings from industrial biotechnology into marketable products. BMBF funding in this area, totalling EUR 60 million through 2011, is mobilising an additional EUR 90 million from industry, as well as complementary measures in the Länder in which relevant companies and organisations are located. Already, five start-ups have emerged from the BMBF funded BioIndustry 2021 clusters, and additional start-ups in this context are expected to follow.

With its "KMU-innovativ: Biotechnology – BioChance" initiative for biotechnology SMEs; the "GO-Bio" competition, which is oriented to proofs of concept and start-ups; and the "BioPharma" competition, the BMBF is contributing decisively to the continued success of the German biotechnology sector.

A centre for chemical-biotechnological processes is to be established in Leuna (CBP Leuna), with the joint support of the Federal Government, the state of Saxony-Anhalt and the Fraunhofer-Gesellschaft, for the promotion of holistic research approaches, emphasising state-of-the-art biotechnology and renewable resources, in basic research and application-oriented R&D projects. The new centre is expected to help improve the basis for the transfer of new process technologies, for the conversion of biological raw materials into chemical ingredients, into industrial applications.

PRACTICAL EXAMPLE

Modern plant breeding produces drought-resistant barley

The BMBF funded **project GABI-GRAIN** (GABI = Genome Analysis in the Biological System of Plants) is aimed at breeding new strains of barley that boast increased yields and improved grain quality even under drought stress. Increasingly frequent droughts have become an enormous problem in crop cultivation. Moreover, climate change will exacerbate

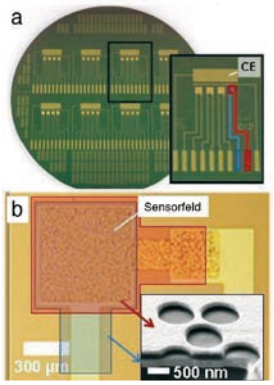
water scarcities and accelerate regional desertification. As a result, farmers will find themselves having to make do with less and less water.

In the project, research institutions and Martin Luther University Halle-Wittenberg are working in cooperation with two seed companies.

PRACTICAL EXAMPLE

Nanotechnology for highly sensitive medical diagnostics

In the **"NanoBioPore"** research project, the universities of Heidelberg and Bochum are working, with industry partners to use nanotechnology in the development of faster, more precise diagnostic procedures and faster, more precise ways of finding new active agents. Key disease markers often occur in extremely small concentrations, meaning they can be detected only with extremely sensitive sensors. Via thin-film and nanostructure technologies, nanoporous electrode systems are being developed into special "NanoBioPore" sensors that can detect pathogens and signal molecules that previously have been either highly difficult or impossible to detect. This advance will improve treatments for patients and, because it yields low-cost diagnostic procedures, will reduce treatment costs.



Plant biotechnology has a long tradition in Germany. Basic discoveries in the discipline were made here in the early 1980s. The central focus of R&D activities in plant biotechnology is on breeding plants with new or improved characteristics. Plant-biotechnology researchers work, always mindful of biosafety ("biological safety research"), to develop plants that, thanks to their special substances, are particularly valuable human foods or animal feeds; show heightened tolerance of unfavourable climate conditions; can be used, as renewable resources, in industrial or bioenergetic production cycles; or themselves produce pharmaceutical agents ("pharming"). Thanks in part to the BMBF's intensive support, and now to sharply increased industrial participation in pertinent research projects, Germany's plant biotechnology sector is among the European leaders in this area.

Use of genetically modified organisms (GMO), such as plants with engineered resistance to pests, is regulated by law throughout the EU. With a focus on retaining the current high level of protection, the Federal Government supports designing pertinent regulations and processes in keeping with criteria for innovative research. Special attention is paid to having independent scientific assessments remain the key basis for approval decisions.

Nanotechnology

Nanotechnology reveals the world of the very small. One nanometer is one millionth of a millimetre.

Nanotechnologies are unique in their cross-cutting aspects. They have applications and potential applications throughout a broad range of fields, fields such as energy technology (fuel cells and solar cells), environmental technology (material life cycles and waste management), information technology (new types of storage systems and processors) and health care.

Emerging technology with a great future

Nanotechnology has great technological and economic potential for Germany. Already, some 740 innovative companies in Germany are involved in developing, using and selling nanotechnological products. Some 50,000 industrial jobs are tied to such efforts and the sector's workforce is growing. Industry experts estimate that the world market for nanotechnology, throughout all relevant sectors, will reach a volume of over EUR 1 trillion by 2015.

Germany is the European leader in nanotechnology. Systematic funding policies have contributed decisively to this achievement. With some EUR 370 million in federal funding for this area, Germany is far and away also the European funding leader in nanotechnology.

An interdepartmental action framework, concentrating aims and approaches in nanotechnology, is seen as an important part of the necessary funding structures. This is why the BMBF, in

cooperation with the Federal Ministry of Economics and Technology (BMWi), the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), the Federal Ministry of Health (BMG), the Federal Ministry of Defence (BMVg), the Federal Ministry of Labour and Social Affairs (BMAS) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), has launched the **"Nano-Initiative – Action Plan 2010"**. The aims of this project are to speed the translation of nanotechnological research findings into products and markets, and to enhance the relevant framework conditions including conditions for work safety, environmental protection and consumer protection. At the same time, public dialogue on this area is being pursued in the interest of transparency and a responsible approach to nanotechnology. A total of seven funding priorities have been defined: the automotive industry, the optical technology industry, pharmaceuticals and medical technology, electronics, the chemical industry, the construction industry and the textile industry.

Technological development of nanomaterials is accompanied by active discussion of safety issues. In addition to its ongoing support for risk research, in the context of ancillary research in support of nanotechnology, the Federal Government, under the BMU's direction, conducted a **"Nano-Dialogue 2006–2008"** that considered the opportunities and risks inherent in nanomaterials. This dialogue is to be continued in the 2009-2010 period, taking account of relevant experience to date. At the same time, the Federal Institute for Risk Assessment (BfR) is working, via several initiatives, to promote objective communication of the relevant risks.

To speed up the pace with which innovative products and processes using nanotechnologies can emerge, the BMBF, via its "KMU-innovativ Nanotechnology – NanoChance" (the "KMU-innovativ" programme funds cutting-edge research by SMEs), particulary supports research-intensive SMEs and their innovation in cutting-edge research.

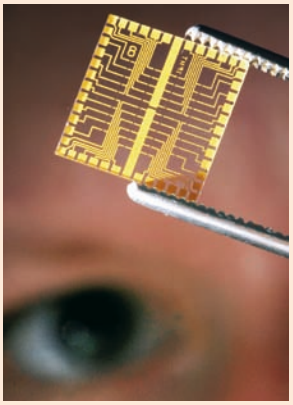
The **"nanoTruck"** is the Federal Government's rolling nanotechnology information centre. Since 2008, it has been touring through Germany, informing the public about the scientific foundations for, and applications of, nanotechnology and providing a forum for discussion and information exchanges.

Microsystem technology

A clumsy movement, and your laptop computer falls off your desk. Just a few years ago, that would have meant the end of your hard drive, and the data on it would have been lost, with no chance of recovery. Today, a sensor in your computer monitors the computer's movement, and it can tell if the computer is falling. When a fall occurs, the sensor shuts off the hard drive in mid-air. It is all possible thanks to microsystem technology. Microsystems are now found in innumerable everyday objects and devices. In most cases, they are present as tiny, invisible helpers. Microsystems typically combine different technologies – for example, their structures and connections often incorporate different technologies. By means of microsystem technology, biotechnology and nanotechnology systems can be integrated in micro- and macro-environments in order to make such environments "connectable", and thus available for use in the development of new products.

By providing funding via the **"Microsystem Technology" framework programme**, and by making microsystem technology an important part of the "ICT 2020" funding programme, the BMBF has highlighted this technology's importance, while also giving priority to supporting small and medium-sized enterprises (SMEs). In keeping with

Microsystem technology – great economic potential, thanks to widespread use



With a global market revenue of EUR 277 billion, microsystem technology has become a major economic factor. The microsystem technology sector boasts an annual growth of 15 percent. Some 680,000 jobs in Germany are closely tied to microsystem technology. Furthermore, the dynamic development of microsystem technology has generated a demand for experts that can hardly now be met: a total of 84 percent of graduates from university MST programmes find jobs within three months after they complete their studies (the comparable figure for engineers is 52 percent).

the cross-cutting nature of microsystem technology, such funding is linked in numerous ways with other funding areas – for example, in genomics and biotechnology, nanotechnology, materials and production processes and communications technologies. One important field of innovation in microsystem technology consists of ambient assisted-living systems (AAL) that help senior citizens to continue leading independent lives.

PRACTICAL EXAMPLE

A single cable does it all

Hydrogen, a secondary, storable energy source, has been figuring prominently in the current discussion about our energy future. To date, no suitable answer to the challenge of storing and transporting hydrogen has been found, however. Now the "IceFuel" research project, conducted by the Evonik AG (located in Hanau), in cooperation with the Karlsruhe Research Centre, the TÜV Süd service organisation and other partners, is aimed at using microprocess engineering to develop new types of pipeline systems that can simultaneously transport electricity, data and cryogenic media (such as liquid hydrogen at a temperature of -253°C). Such systems will be an important contribution to the development of future infrastructures.

Space technologies

Space technologies are central to the modern industrialised information society. A diverse range of vital applications depend on them, including communications and worldwide TV broadcasting, satellite-based navigation systems for automobiles, precise climate and weather forecasts and emergency maps.

In 2007, the space technologies sector, many of whose firms are SMEs, generated revenue of EUR 1.46 billion. In the framework of its High-Tech Strategy, Germany plans to invest a total of some EUR 3.6 billion in space research from 2006 through 2009. Such research thus accounts for the largest individual category within the Strategy.

Due to their complexity and high costs, space projects are often only feasible in the framework of international cooperation. This is why Germany is an important partner in the European Space Agency (ESA). ESA finances scientific missions for space exploration and study, and it awards contracts to space companies in connection with major projects such as Europe's participation in the International Space Station (ISS) or the Ariane launch vehicle.

German space technology – a leader in the areas of climate protection, earth observation and navigation

Innovative space technologies facilitate monitoring of compliance with environmental protection agreements, forecasting the impacts of climate change and managing natural disasters. Today, Germany is already the European leader in participation in space-based climate research and earth observation (examples: the GOCE satellite, the TerraSar-X German radar satellite and the RapidEye optical satellite system).

Now, a new ESA initiative, the Climate Change Monitoring Initiative (CCI), is expected to make it possible to standardise global climate data. In addition, the **Meteosat** European satellite system, under Franco-German management, is entering its third generation (MTG).

Furthermore, Germany has a important role in the **GMES/Copernicus** project, in which the EU is building a comprehensive space-based earth observation system.

By 2014, a total of 30 satellites are to be launched for the **Galileo global satellite navigation system**. This project, which is the EU's largest technology project, will then provide a highly precise position-locating service for all points on the globe. Initial progress has already been made: the first two test satellites are already in orbit.

On 1 December 2007, the **Act on Satellite Data Security** (Satellitendatensicherheitsgesetz; SatDSiG) came into force. SatDSiG provides a suitable framework for the commercial success of such innovative business areas and products, and it safeguards German security interests. The Act's legal framework is expected to enable German companies to establish themselves in the relevant international market, with legally founded planning certainty.

Automation and robotics for a future with a future

Not only are automated systems and intelligent robots keys to future space technologies, they are also "springboard technologies" for earth-based

applications. In order to build on Germany's expertise in these areas, expertise which is already recognised worldwide, the Federal Government has included a new "robotics" priority in its national space programme.

New space programmes approved at the ESA Ministers Conference in November 2008:

- **Germany assumes leadership in satellite communications:** In the framework of the European Data Relay Satellite System (EDRS), a system of satellites in geostationary orbit that ESA is developing, Germany provides globally unique high technologies for optical high-speed inter-satellite communications. Germany is a leading partner in this ESA programme.
- **Autonomous access to space assured:** Germany has a share of about 25 percent in the "Ariane 5" programme and its further development. The aim of the development programme is to enhance the system's versatility by adding a restartable cryogenic upper stage – to be provided by Germany – and to increase the system's payload capacity. The upgrade is expected to enable the "Ariane" to transport two commercial satellites into space simultaneously.
- **More science in space, with German support:** ESA's science programme is designed to ensure that space research remains the centrepiece of the European space programme. The Cosmic Vision 2015-2025 programme, for example, in which Germany has a prominent role, focusses on the study of the universe, our solar system and the origins of life. Germany has been able to ensure that the International Space Station (ISS), humanity's largest cooperative scientific and technological project, will remain available in future for demanding scientific projects. ISS will play a valuable role in enlarging the scientific understanding of human physiology, biology, materials sciences and physics (via the European Programme for Life and Physical Sciences and Applications in Space (ELIPS)).

Innovative services

Along with the demand for technological development, demand is growing for products that can be individually tailored to customers via product-supporting services. Such products are especially attractive, and thus customisable complete product/services packages are increasingly being offered. By offering such packages, companies can set themselves apart from others, gaining unique positions that confer significant advantages in global competition. Innovative services thus play a key role in economic and innovation policy.

Innovative services play an especially important role in the area of key preliminary services for R&D-intensive industry. Growth in promising markets such as logistics, multimedia and health will thus be closely tied to such services. This trend stands out especially clearly in the U.S., where services are growing robustly as a result of structural changes. As part of the trend, production of research-intensive products has been decreasing, while specialisation in knowledge-intensive services has been growing.

The Federal Government is addressing this trend with its **"Innovation with Services"** programme. In this project, the BMBF is supporting research into the factors that drive, and hinder, innovation in services. The programme's aim is thus to facilitate the use of the innovation potential inherent in modern services. Focussed on key issues in the services industry, the programme is working to develop methods and instruments for optimising existing services and developing new ones.

The economic importance of services is not yet being adequately reflected in education and research. A comparison with the U.S. reveals that the European services sector's R&D intensity is lagging considerably. Such deficits, therefore, need to be addressed via joint action by industry, science and policy-makers. The Science and Industry Research Union (Forschungsunion Wirtschaft – Wissenschaft) has issued a number of recommendations in this regard. For example, the Research Union has called for the establishment of endowed academic chairs, with a focus on services, and for the development of a seal of quality for "Services made in Germany". In addition, it has established a **"Services Task Force"** ("Taskforce Dienstleistungen"), charged with supporting the implementation of pertinent recommendations. With a total of 35 participating companies and institutes, the "Services Task Force"

has a scope unique among comparable efforts in other innovation fields. Moreover, it has already triggered major impetus for services innovation and for relevant industry-science cooperation.

The Federal Government has acted on the recommendations provided to it by the Research Union, calling for stronger links between services research and technological research, and between services research and other research areas: with its **"Health Regions of the Future"** and **"Energy-Efficient City"** competitions, it has launched pilot projects in which services research contributes significantly to the solution of societal challenges. Health and health care logistics, for example, has emerged as an area of major future importance. In addition the funding priorities for the programme "Technology and Services in an Era of Demographic Change" ("Technologie und Dienstleistungen im demographischen Wandel") and the programme "Ambient Assisted Living" (AAL), which is aimed at helping senior citizens remain independent for longer, feature close connections between a) services and b) ICT and microsystem technology. Additional relevant measures are to follow in the framework of the "Services 2020" ("Dienstleistungen 2020") action plan.

Services – the largest value-creation area, and growing rapidly

A total of 35 percent of all dependently employed persons in Germany (over 27 million), and the majority of the country's self-employed persons, work in the area of knowledge-intensive services. This makes that services area – one in which services account for some 70 percent of value creation – Germany's largest value-creation sector. As the Expert Commission on Research and Innovation (EFI) has confirmed, knowledge-intensive services account for about 37 percent of all value creation in Germany, thereby clearly surpassing R&D-intensive products in this regard, which account for nearly 14 percent of value creation. Many types of services have been weathering the current economic crisis to considerable success. In fact, it is now forecast that only services sectors will make positive contributions to growth in the country's national accounts for 2009. In forecasts for 2010, services account for the top seven entries in the list of areas with the highest growth contributions.

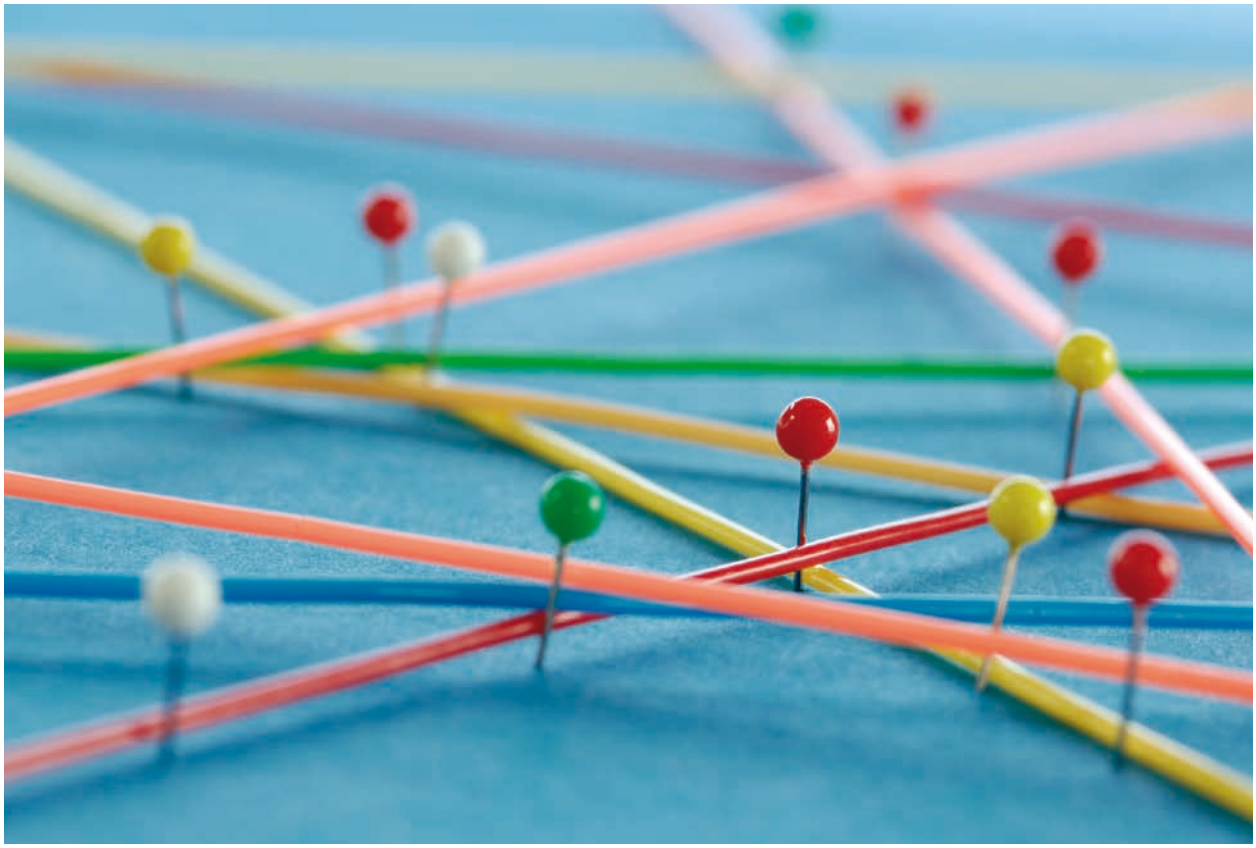
www.dl2100.de

PRACTICAL EXAMPLE

Personal Health Manager

Sedentary lifestyles and poor diets are widely responsible for many types of disorders. Health insurers and employers have been struggling to deal with the high costs resulting from such disorders, including cardiovascular diseases, back problems and diabetes. While prevention and fitness regimens with individual coaching are effective, they tend to be expensive, and thus available only to a relatively small group of people. On the other hand, competitive pressures have been forcing fitness services providers to reduce the amounts of time-intensive services they grant individual customers. Here is where the "Personal Health Manager" comes in, a result of the research project **"Sprint"** ("Systematic design for integration of products and services – hybrid value creation in the health sector" ("Systematisches Design zur Integration von Produkt und Dienstleistung hybride Wertschöpfung in der Gesundheitswirtschaft")). A combination of products (training equipment, pulse monitors, mobile devices, etc.) and services (coaching, training plans, etc.), the Personal Health Manager enables trainers to serve considerably larger numbers of persons than they would be able to serve without the system. The system is designed to automate, or support, repetitive processes and routine tasks, thereby saving the trainer time that he or she can use to offer regular personal advice and coaching. Via the Personal Health Manager, persons in training can receive training assistance, and suitably document their own progress, regardless of their location. The project, which is interdisciplinary, links the resources of leading experts in German and industry in relevant areas of business administration, information technology, services design, innovation and technology management and sports medicine. www.projekt-sprint.de

2.2 Concentrating and mobilising resources – bringing industry and science together



SUMMARY

Challenges and aims

Innovations need to be translated, quickly and efficiently, from research into products. This can succeed only through concerted efforts, interdisciplinary and intersectoral approaches and the use of synergies. The Federal Government is promoting close links between industry and science and the intensified use of SMEs' potential.

Results and outlook

The High-Tech Strategy has been helping to mobilise and concentrate resources, by promoting close links between industry and science:

- More funding for innovative small and medium-sized enterprises (SMEs).
- Accelerated access to funding programmes, via the "KMU-innovativ" programme for funding cutting-edge research by SMEs (a programme in which 50 percent of all participating SMEs are completely new to such funding programmes).
- SME funding via the Central Innovation Programme for SMEs (ZIM) has been consolidated and expanded, and pertinent funding has nearly doubled as of 2009.
- A total of nine innovation alliances have mobilised EUR 3 billion in private resources.
- The "Top Cluster" competition: the first five winners have been chosen; a second round has been launched.
- Support for clusters and networks, with a focus on SMEs and the new Länder, has been intensified (via efforts such as "Cutting-edge Research and Innovation in the New Länder", "Entrepreneurial Regions", "Innovation Competence East (INNO-Kom-Ost)").
- Closing the gaps between research and commercialisation: a new measure for promoting validation (proof of concept) is being launched in 2009.
- The Federal Government's "Research and Innovation" central funding advisory service, which facilitates simple, transparent funding access.

Challenges and aims

It is vitally important for industry to act on developments emerging from research and to introduce them to markets. Not only does Germany need innovation, it also needs to translate innovations into marketable products and production. Our country has to learn to profit more quickly from innovations. The Federal Government is thus aiming to marshal relevant industrial and scientific resources, and mobilise new resources, to this end.

Results and outlook

The High-Tech Strategy's priorities include building bridges between industry and science, and strengthening innovative SMEs. Targeted incentives are helping to bring industry and science closer together, and to concentrate resources via cooperation, partnerships and innovation alliances. A clear focus has been placed on building clusters and networks that integrate SMEs in key ways. The resulting strengthened transfer of knowledge and technologies between science and industry can lead, in centrally significant ways, to commercially successful innovation.

The Federal Government's support for clusters and networks (1995-2008)

Source: VDI/VDE-IT

More funding for SME innovation

Germany's small and medium-sized enterprises (SMEs) play a decisive role in driving innovation. SMEs can develop markets in especially quick and flexible ways. And this applies especially to new research areas, in which success depends centrally on innovation process speed. For this reason, the Federal Government has been giving high priority to promoting innovative SMEs within the context of its economic stimulus packages.

With its High-Tech Strategy, the Federal Government is giving priority to funding for innovative SMEs, with the aim of capitalising more intensively on the potential inherent in SMEs. Technology funding of the BMWi and the BMBF, for SMEs, amounted to a total of some EUR 725 million in 2007. Moreover, plans call for such funding to be increased to over EUR 950 million in 2009. Current budget figures indicate that the trend toward such disproportionate increases will continue. Other departments have also increased their SME funding. What is more, the Federal Government's second economic stimulus package (Konjunkturpaket II) provides additional, term-limited funding for research and development by SMEs in 2009 and 2010.

Cooperation between the research sector and SMEs – fast, convenient support

The **Central Innovation Programme for SMEs (ZIM)** is aimed at encouraging SMEs to intensify their efforts in the areas of research, development and innovation. In mid-2008, within the ZIM programme, the BMWi's thematically unspecified cooperation and networking programmes were consolidated, restructured and partly expanded. The pertinent application procedures have been streamlined and are convenient. ZIM is a nationwide, technologically and sectorally unrestricted funding programme for SMEs, including the industry-related research institutions with which they cooperate.

With ZIM, the BMWi now maintains only a single programme for funding R&D projects by SMEs. The former PRO INNO II, InnoNet and NEMO cooperation and networking programmes have been combined. In early 2009, the INNOWATT programme, which provided single-company-based R&D support for eastern German companies, was also integrated within the new format. The demand for ZIM has been growing steadily.

In January 2009, with a view to addressing SMEs' crisis-related growing requirements for financing for R&D projects, the Federal Government decided to add an additional EUR 900 million to the ZIM programme, in the context of the Konjunkturpaket II second economic stimulus package, in order to make the following changes: in 2009 and 2010,

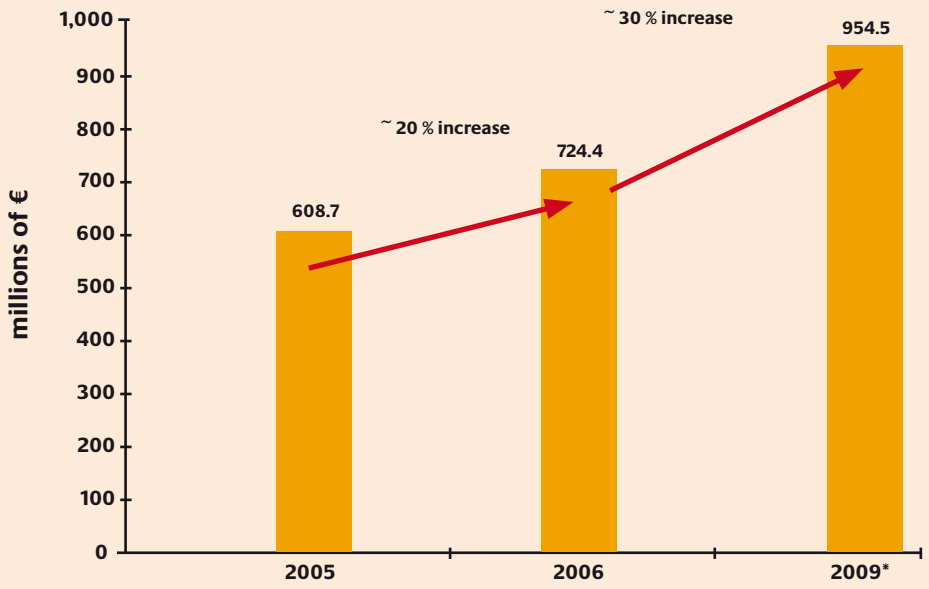


Figure: Technology funding by the BMWi and the BMBF for SMEs (not including additional relevant funding in the second economic stimulus package (Konjunkturpaket II)) Source: The "profi" project-funding database; budget plans * Extrapolation

support will also be available for R&D projects of individual western German companies, and the overall programme will also be available for companies with up to 1,000 employees, in both western and eastern Germany. With this move, the Konjunkturpaket II economic stimulus package is providing strong impetus for research and innovation.

The **"KMU-innovativ" programme** gives priority to cutting-edge research by SMEs and enhances SMEs' participation in innovation. This BMBF funding initiative is aimed at giving SMEs streamlined, fast access to technology-specific funding and, thus, to facilitate their access to the collaborative research networks operating within specialised programmes.

The funding initiative applies SME-friendly criteria, including opportunities for a simplified creditworthiness review and, in cases of equity shortages, for the setting of milestones in project scheduling. In addition, use of regular key dates and binding application processing periods gives applicants planning certainty.

The advantages of "KMU-innovativ" include:

- Provisions for faster goal attainment: advising by a central "guide service" ("Lotsendienst"; www.kmu-innovativ.de, Tel: 0800-2623 009)
- Speedy procedure: outlines and applications are processed within two months.
- Simplified credit worthiness review: even small, young companies have a chance.
- Definition of milestones: even companies with small equity resources are eligible for funding.

"KMU-innovativ" has been launched in technology areas that are of particular importance with regard to Germany's growth and prosperity:

- "KMU-innovativ: Biotechnologie-BioChance" (for biotechnology)
- "KMU-innovativ: Information and Communications technology"
- "KMU-innovativ: Nanotechnologie-NanoChance" (for nanotechnology)
- "KMU-innovativ: Optical Technologies"
- "KMU-innovativ: Production Research"
- "KMU-innovativ: Resources and Energy Efficiency"

The current evaluation of "KMU-innovativ" already shows that the calls for proposals conducted since early 2007 have met with an extraordinarily positive response. Use of the programme is well distributed throughout Germany. In each case,

some 50 percent of participating companies are "funding newcomers", i.e. are applying for BMBF funding for the first time. In selection rounds held since the programme's start in 2007, the project outlines recommended for support have called for funding totalling nearly EUR 200 million, and the pertinent projects' corresponding total financial volume has amounted to over EUR 320 million.

The Federal Government's new "Research and Innovation" funding-advisory service, which facilitates simple, transparent funding access

The Federal Government has established a point of initial contact for questions related to research and innovation funding. The Federal Government's "Research and Innovation" central funding-advisory service is aimed at all potential funding partners – including higher education institutions, research institutions and business enterprises. The service's comprehensive advice regarding the procedures and terms for all relevant R&D programmes of the Federal Government, the Länder and the European Commission enhances transparency and facilitates access to research funding. The service also provides support for the application process, and it especially welcomes "funding newcomers", especially small and medium-sized enterprises (SMEs). **www.foerderinfo.bund.de**

More ideas need to be successfully translated into products, processes and services. The **"Research Bonus"** ("Forschungsprämie") funding instrument to strengthen the abilities of higher education institutions and research institutions to cooperate with industry, and the **"Research Bonus Two"** ("ForschungsprämieZwei") for non-profit research institutions, provide additional incentives for cooperation with SMEs. Research and development orders of SMEs are eligible for bonuses amounting to 25 percent of the order volume, up to a maximum of EUR 100,000.

In 2009, and in keeping with the High-Tech Strategy's central aim of accelerating the closure of gaps between research and commercialisation, the BMBF is launching a measure for **supporting validation**, i.e. proofs of concept. This effort is designed to support scientists at higher education institutions and non-university research institutions in providing proof of the technical feasibility and economic potential of research findings (validation), with the aim of enabling such findings to be introduced to markets more quickly and successfully. Scientists often lack the resources or funding necessary to provide proof of the technical feasibility of ideas developed in the laboratory - i.e. they lack the resources necessary to move their research findings toward commercialisation. Validation funding plays a key role in enhanced knowledge and technology transfer between higher education institutions, research institutions and business enterprises.

In connection with its participation in the European **Eurostars** programme, which was launched in 2008, the Federal Government has introduced an additional funding instrument for SMEs that, in the framework of the EUREKA European research initiative, carry out research and development projects in cooperation with partners in other Member States. The programme, which is thematically unspecified, is a success: for the first time, SMEs are being given incentives to internationalise, via transborder cooperation. The great demand for the programme proves that the programme is having such an impact.

The **CORNET** programme supports international collaborative research projects that are carried out by networks of SMEs and that thus benefit numerous companies. **ERA-SME** supports European projects for cooperation between SMEs and R&D institutions, with the aim of improving transborder technology transfer between the research and industry sectors.

Innovation alliances and strategic partnerships are mobilising private capital

"Innovation alliances", a new instrument in research and innovation policy, was created in the framework of the High-Tech Strategy. Each instance of such strategic industry-science cooperation is oriented to a specific application area or emerging market. Innovation alliances have special economic leverage effects. The target leverage relationship is: one euro from the Federal Government to five euros from industry. In cooperation with the BMBF, the science and industry sectors established a total of six innovation alliances in 2007. In 2008, three more were added. As a result, some EUR 600 million in federal funding has leveraged over EUR 3 billion from industry. At the same time, it is important to set the right priorities. The example of climate protection / energy provides a good illustration: the innovation alliances are making significant contributions to energy-efficient lighting

(the OLED Initiative), to the use of renewable energies (Organic Photovoltaics) and to breakthroughs in energy storage (Lithium-Ion Battery).

In an unprecedented approach, innovation alliances require the industry side, at the board-of-management level, to enter into commitments regarding the additional financial investments to be made. This approach yields a completely new level of binding commitment. This result is of central importance for SMEs: armed with knowledge regarding future technological developments, and with pertinent commitments from large companies, SMEs are better able to plan around the high risks involved in R&D investment decisions.

Along with innovation alliances, the Federal Government also supports other types of strategic partnerships between policy-makers, business enterprises and the science sector. Increasingly, the need arises to combine elements of research funding with elements of departmental research, in order to link efforts toward the aims of promoting the science, research and industry sectors with efforts toward key specialised policy aims (such as energy-efficient construction, energy-saving and affordable mobility, attractive local public transportation).

The combination of resources, in the framework of innovation alliances and strategic partnerships, builds and concentrates existing strengths, thereby producing specific results –and, in turn, strengthening Germany's innovation leadership in the areas concerned.

Top Cluster Competition highlights Germany as a centre for innovation

In summer 2007, working under the motto "Germany's top clusters – more innovation. More growth. More employment", the BMBF launched the "Top Cluster Competition". This new competition is aimed at supporting the most capable of Germany's industry science clusters involved in strategic partnerships as they work toward international excellence. A total of three rounds of the competition are to be held, at intervals of about 1.5 years. In each of the three competition rounds, up to EUR 200 million will be provided, for up to five top clusters, and over a period of up to five years. The competition also provides for an implementation approach in which industry and private investors participate at comparable financial levels.

Winners of the first round of the Top Cluster competition

www.spitzencluster.de

Support for top clusters is based on a joint strategy that focuses on each cluster's specific strengths and is oriented to the definition of future development goals. In addition, projects are expected to run the full course of innovation, from idea to full commercialisation.

In September 2008, the five winners in the first round of competition were selected by an independent jury. The five winning top clusters fulfill the competition's basic ideals in particularly suitable ways. The first round of competition immediately generated a great deal of excitement and mobilising energy. In mid-January 2009, the BMBF then launched the second round of the competition. Now, new applicants, as well as clusters that were not selected in the first round, are working with great determination and commitment toward the next rounds.

Top quality research and innovation in the new Länder

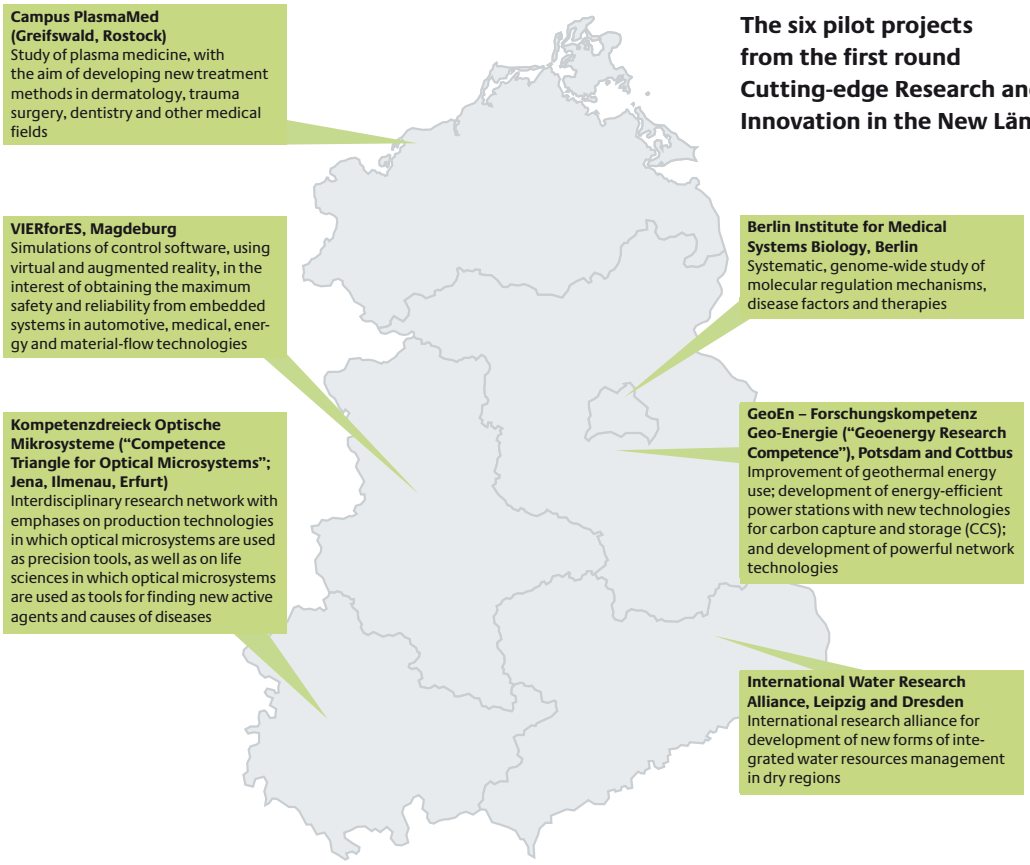
In 2008, working in cooperation with the east German Länder, the BMBF launched the programme "Cutting-edge Research and Innovation in the New Länder". This programme is aimed at meeting the challenges, in eastern Germany, of demographic change, persisting structural weaknesses and a lack of major companies. This orientation is expected to strengthen innovation and scientific excellence in the new Länder. To that end, scientific and industrial resources in eastern Germany's regions are being concentrated. In the process, support is being provided for inter-organisational, topic-oriented networks involving higher education institutions, research institutions and business enterprises. A special focus is being placed on higher education institutions in the new Länder, which stand to enhance their visibility and attractiveness by engaging in strategic cooperation with partners.

In summer 2008, in the first round, six selected pilot projects for cutting-edge research were successfully started. In May 2009, in a second round of support, additional cooperation networks will be selected, via a competitive procedure.

"Entrepreneurial Regions" is mobilising market-oriented innovation processes in the new Länder

Innovation is the key to the "Aufbau Ost" effort for economic development in the new Länder. With the "Entrepreneurial Regions" innovation initiative, the BMBF is supporting regional cooperation alliances in developing and implementing strategies for success with their own innovative, promising technological approaches. In the project, each relevant region's specific strengths and promise are to be tapped and developed, in the interest of efficiently promoting transfer of innovations to markets. Under "Entrepreneurial Regions", highly capable innovation centres, attractive for science and industry alike, are emerging that, in the longer term, will become known beyond their own regions as economic clusters. The pertinent funding is thus serving as start-up capital and investments for entrepreneurially active regions.

The six pilot projects from the first round Cutting-edge Research and Innovation in the New Länder



Over 200 "Entrepreneurial Regions" initiatives, involving over 2,000 individual projects – covering a spectrum from excellent basic research to specific, market-relevant development – are working, day in and day out, to help build the eastern German economy. The Federal Government's 2008 annual report on the state of German unification clearly shows that the economy in the new Länder developed positively in 2007, with a growth of 2.2 percent. It thus grew considerably more than it had in previous years. At the same time, unemployment dropped to its lowest level since 1991. Trends have been especially positive in the industrial sector – in which the new Länder grew even more rapidly than did the western German Länder – and in the area of future technologies. This welcome trend is partly a result of the systematic support for innovation and pertinent commercialisation provided via the "Entrepreneurial Regions" funding programmes.

Programmes in the "Entrepreneurial Regions" framework

- InnoRegio (1999 to 2006)
- Innovative Regional Growth Centres, with the module "Growth Centre Potential"
- Innovation Forums
- Centres for Innovation Competence
- InnoProfile
- ForMaT

www.unternehmen-region.de

"Innovation Competence East (INNO-Kom-Ost)" is strengthening the research infrastructure for SMEs in the new Länder

Non-profit extramural industrial research institutions are a key part of the eastern German research sector. In light of the lack of large companies in the new Länder, such institutions play an important role as liaisons between science and industry, and as initiators and moderators of regional and supra-regional R&D cooperation carried out by innovative SMEs. They provide requirement-oriented research and development services for SMEs, thereby strengthening eastern Germany's innovation resources. Under the "Innovation Competence East (INNO-Kom-Ost)" programme, which was restructured in early 2009, the Federal Ministry of Economics and Technology (BMWi) supports non-profit extramural industrial research institutions in developing new products and processes. Such support is aimed especially at speeding up the translation of such products and processes into markets and at helping such institutions to build their R&D competencies. The model project "Investment subsidy for technical infrastructure" ("Investitionszuschuss technische Infrastruktur") complements investment-promoting measures under the second economic stimulus package (Konjunkturpaket II).

Developing international opportunities for SMEs and clusters

While German companies – especially SMEs have to make special efforts to network internationally, such networking provides enormous opportunities for the development of emerging international markets. The Federal Government is thus working to stimulate internationalisation, by providing relevant information, advice and support. For example, SME-specific advisory services, staffed by a total of five cooperation advisors, have been established at the international chambers of commerce located in Moscow, Kiev, Minsk, Beijing and Shanghai. In addition, the available information regarding international clusters has been expanded, and the Federal Government promotes exploratory and preparatory measures relative to international cooperation.
www.kooperation-international.de

"Industry meets Science" is promoting new approaches in technology and innovation transfer in the new Länder

In the "Industry meets Science" innovation competition, a project launched in January 2007 by the Federal Ministry of Transport, Building and Urban Affairs (BMVBS), the Federal Government Commissioner for the New Länder is inviting eastern Germany's higher education institutions and research institutions to contribute and test new ideas for the development and application of innovative forms of communication and cooperation between science and industry. This effort is aimed at improving technology transfer and at enhancing awareness of the economic opportunities involved in developing each relevant region, as well as at strengthening the public role in such development. One of the competition aims, for example, is to strengthen the position of higher education institutions, in the new Länder, as "regional anchors" in innovation processes.

2.3 Improving framework conditions

SUMMARY

Challenges and aims

Only under suitable, innovation-promoting framework conditions can good ideas become economically successful products, processes and services. The Federal Government is aiming to structure the applicable framework conditions – which are a fundamental part of its innovation policy – in positive ways.

Results and outlook

In an unprecedented approach, the High-Tech Strategy combines research funding with innovation-oriented structuring of development processes and framework conditions. This approach needs to be continued and intensified. The successful improvements in framework conditions to date include:

- **Financing improved:** Corporate tax reform provides additional financial latitude; the "Help for Helpers" ("Hilfen für Helfer") Act has increased incentives for placing private capital in foundations.
- Improved conditions for start-ups: **Amendment of law on limited liability companies (GmbHG)** is facilitating start-ups; the **High-Tech Start-ups Fund** provides venture capital for young, innovative companies; the EXIST and "Power for Women Entrepreneurs" programmes support those seeking to start their own businesses.
- Innovation support via **public procurement**: In its procurement awards, the Federal Government consistently emphasises the use of new products and technologies.
- Improved protection for intellectual property: The initiative **"SIGNO – Protection of Ideas for Commercial Use"** advises and supports higher education institutions and start-up entrepreneurs in connection with patent law issues.
- Standards as a driving force for innovation: The project **"Innovation with Norms and Standards"** supports companies – especially SMEs – in connection with standardisation processes, which are often complex and expensive.
- Successful **reduction of "red tape"**: A current relevant status report notes that a total of 330 legal simplifications have already led to over EUR 7 billion in annual savings for industry.
- **More venture capital:** An attractive framework for innovation financing is all the more necessary during periods of financial and economic crisis, such as the present period.

Challenges and aims

For law-makers, a comprehensive research and innovation policy focus includes providing effective impetus and incentives for growth and innovation; eliminating barriers to innovation; and providing the freedoms that facilitate and power innovation.

The Federal Government thus aims to take account of all the conditions needed for innovation, and to link research funding inseparably with such necessary framework conditions. Such linkage provides a basis for functioning value-creation chains – extending from idea to product and to marketing – and thus supports the development of lead markets.

In the interest of international competitiveness, existing factors that hinder innovation need to be eliminated, while regulations that stimulate innovation need to be enacted.

Results and outlook

The Federal Government's High-Tech Strategy is unprecedented in applying an overarching approach, spanning all relevant policy fields, in treating innovation-oriented structuring of development processes and framework conditions as a fundamental part of a successful innovation policy. Important improvements have already resulted from this approach.

Financing improved

Adequate financing is an indispensable basis for innovation. Young, highly innovative and motivated start-ups, in particular, often lack adequate financing. In most cases, a lack of collateral leaves them unable to obtain bank financing. The central problem in this area, according to the Expert Commission on Research and Innovation (EFI), is that innovative SMEs tend to lack the necessary equity and that Germany's venture-capital market offers them too little assistance. Moreover, this situation is likely to worsen in the current crisis.

Corporate tax reform has improved the basis for private R&D investments. Reduction of the corporate tax rate to below 30 percent frees financial resources that can be applied to investments in research and development. In light of a number of existing measures for counter-financing (shifting of functions, license taxation, shell-company acquisitions), and of the flat-rate withholding tax (Abgeltungssteuer), restrictive impact on the R&D intensity of companies cannot be ruled out, however.

On 27 June 2008, in the interests of improving the conditions for the German venture capital market, the German Parliament (Bundestag) approved the Act on the Modernisation of Framework Conditions for Venture Capital and Equity Investments (Gesetz zur Modernisierung der Rahmenbedingungen für Kapitalbeteiligungsgesellschaften; **MoRaKG**). Parts of the Act, which came into force on 1 January 2008, are still being reviewed by the EU Commission in light of laws on subsidies (for example, the the Act's provisions on the use of losses). The Act's impacts on the venture capital market will have to be studied carefully.

Technology-oriented start-ups and young, innovative companies tend to find it particularly difficult to obtain financing. Both venture-capital companies and "Business Angels" have not shown adequate commitment in this area. This is where the Federal Government's **High-Tech Start-ups Fund** comes in. This fund, with a volume of some EUR 272 million, invests venture capital in young, promising technology companies making entrepreneurial use of promising research findings. With the help of seed financing of up to EUR 500,000, start-ups are given the opportunity to advance their R&D projects to the point at which they can provide a completed prototype, proof of concept or marketable product. The fund is a successful public-private partnership involving the Federal Ministry of Economics and Technology (BMWi), KfW Bank Group and the firms of BASF, Deutsche Telekom, Siemens, Robert Bosch, Daimler and Carl Zeiss.

Getting foundations involved

Foundations are important partners for the Federal Government; it is important to continue applying their resources in the interest of education and research. The group of organisations that benefit from the **"Act for further strengthening of civic involvement"** (Gesetz zur weiteren Stärkung des bürgerschaftlichen Engagements; "Help for Helpers"), which came into force in 2007, especially includes non-profit foundations involved in the area of education and research. By considerably increasing the maximum deductions for contributions, expanding support for donations and permitting the unrestricted carrying forward of remaining donation amounts, the Act has significantly enhanced the incentives for contributions in the area of education and research. For this reason, the Act has met with broad acceptance, and it has contributed to the positive development of Germany's foundation sector over the past two years.

Improved conditions for start-ups

Young, knowledge-based companies close the "innovation gap" between academic research and industrial applications. They translate ideas into innovations quickly and efficiently. Start-ups are often key exponents of radically new forms of value creation, and thus they often help assure larger economic success. This is why the High-Tech Strategy provides powerful support for the establishment and growth of new, innovative companies.

The conditions for start-ups have been improved through the **amendment of law on limited liability companies (GmbHG)**. In particular, facilitated

provisions for the raising of capital, and options for accelerated electronic registration, have enhanced the attractiveness of the "GmbH" legal framework for limited liability companies. With this move, the Federal Government has provided a competitive model and a highly successful legal form for companies, in line with European trends.

The **EXIST** start-up programme ("Existenzgründungen aus der Wissenschaft" = "Start-ups from Science") has been a success in providing advice and support for start-ups. This is evident in that nearly all universities, and many universities of applied sciences, now offer special training and support programmes for would-be start-up entrepreneurs. At universities and research institutions, EXIST has enhanced interest in entrepreneurship. In fact, it has triggered the development of a culture of entrepreneurship (**www.existenzgruender.de; www.exist.de**).

The great entrepreneurial potential of highly trained and skilled women is being promoted via the **"Power for Women Entrepreneurs"** action plan. On a model basis, the programme develops and tests innovative ways of creating a favourable climate for women entrepreneurs. It thus provides efficient support for women interested in going into business for themselves.

Start-up assistance for life scientists

Start-ups play a key role in the development of young sectors, especially highly innovative sectors such as biotechnology. In the framework of the High-Tech Strategy, the **"GO-Bio" campaign for start-ups** is providing additional impetus for the development of young scientists and start-ups. This project gives young scientists the opportunity to work in Germany with research groups of their own, to develop and validate innovative research ideas and to move their research findings into the technology-transfer phase via a start-up of their own. The first start-ups in this framework, supported by adequate assistance capital, have already emerged: of the projects of 22 teams receiving support, five have already led to spin-offs, and additional start-ups are pending.

In the interest of facilitating start-ups emerging from non-university **research institutions**, the "BMBF-EEF model project" (EEF = "Erleichterung von Existenzgründungen aus Forschungseinrichtungen", or "Facilitation of Spin-offs from Research Institutions") is being continued by the Helmholtz Association of German Research Centres ("Helmholtz Enterprise Fund") and by the Fraunhofer-Gesellschaft ("Fraunhofer fördert Existenzgründungen"; "Fraunhofer supports start-ups"). In addition, the "Entrepreneurial Regions" programme supports start-up concepts especially for eastern German research institutions, under the project "Team research for markets" ("Forschung für den Markt im Team [ForMaT]").

More innovation in public procurement

With a purchasing volume amounting to about twelve percent of the country's gross domestic product (GDP), the state is an enormous source of procurement orders. In light of the relevant great potential for selection of innovative products, several Federal Government departments with large procurement volumes have stated their intention in a joint declaration to emphasise new, resource-efficient products and technologies in their administrative purchases and invitations to tender. To this end, they are making thorough use of the available options under applicable procurement law (such as functional specifications for tenders, admission of alternative tenders and the use of competitive dialogue). This orientation is providing impetus for innovation and new technologies. In addition, the Federal Government plans to amend Art. 97 (4) of the **Act Against Restraints on Competition** (Gesetz gegen Wettbewerbsbeschränkungen) so that the Act will explicitly permit imposition of additional requirements on contractors – including requirements calling for innovative solutions.

Protection for intellectual property is being improved

Ideas and knowledge are among innovative companies' most important assets. Too little success is still being achieved in translating new ideas and research findings quickly into products – and, thus, into value creation in markets. It is true that German higher education institutions have been highly successful with patent applications. In 2007, for example, some 620 applications were filed. Yet patents are still being inadequately pursued in many cases. Such failure has negative consequences: the resulting earnings fall far short of a pertinent patented invention's likely real commercial potential.

The Federal Government has addressed this problem via its **"SIGNO"** umbrella brand (SIGNO = "Protection of Ideas for Commercial Use"). Since April 2008, SIGNO has been supporting higher education institutions, SMEs, start-up entrepreneurs and inventors in legally protecting and commercialising their innovative ideas. Furthermore, this is promoting technology transfer between science and industry. SIGNO continues the Federal Government's commercialisation campaign, which has already been extremely successful. This campaign supported a total of 24 patent and commercialisation agencies at higher education institutions, especially in the selection of patentable inventions, and in pertinent legal protection and commercialisation. To date, the "SIGNO SME patent campaign" ("SIGNO-KMU-Patentaktion") has provided support for some 6,800 companies and start-up entrepreneurs. A total of 75 percent of the inventions reported by companies in this framework have been patented. The impact on employment has been considerable: some 1,400 jobs have been created by the supported entrepreneurs (**www.signo-deutschland.de**).

On 30 May 2008, at Germany's initiative, the European Charter for the management of intellectual property from public research institutions and universities (known as the **"IP Charter"**) was unanimously approved as a Council resolution. The Charter is an important step toward improvement of technology transfer from science to industry and toward enhancement of Europe's competitiveness. With the Charter, a framework for treatment of intellectual property is now in place at the European level, a framework to which both public research institutions and companies can refer in their own organisational development and in negotiations on the commercialisation of intellectual property. Relevant measures for implementation have already been commenced.

In September 2007, **model agreements on research and development cooperation** were published. These agreements play a useful role in the preparation of joint projects of companies and higher education institutions or research institutions. They thus help minimise the legal and administrative expenses involved in cooperation. At the same time, they provide incentive for smaller companies to overcome any hesitancy to enter into necessary cooperation.

The **Act on Better Enforcement of Intellectual Property Rights** (Gesetz zur Verbesserung der Durchsetzung von Rechten des geistigen Eigentums), which came into force on 1 September 2008, facilitates action against product piracy and the enforcement of intellectual property rights. The economic damage caused by product and brand piracy has reached highly significant levels. The OECD estimates that product counterfeiting causes EUR 150 billion in annual economic losses worldwide. The corresponding estimates for Germany cite a figure

PRACTICAL EXAMPLE

Electronic certificates of genuineness protect against medication counterfeiters

In addition to causing economic damage for manufacturers of original medications, counterfeit medications can present serious medical risks for patients. According to the World Health Organization (WHO), for example, about half of the medications sold in some parts of Africa are counterfeits.

Now, the **"EZ-Pharm"** research project is developing a seamlessly monitored, protected process chain for the pharmaceutical sector. The relevant approach calls for electronic protection by integrating radio frequency identification (RFID) tags in individual medication packages. In the process used, the RFID antenna is printed directly onto the package. Unlike labels, it thus cannot be removed without being damaged. With this tag, any product can always be traced, and its genuineness checked at any time by means of an "electronic certificate of genuineness". Such tracing and checking are made possible by combining a process and data model with a suitable data-processing infrastructure.

of about EUR 25 billion. The key elements of the new act include rights, under civil law, to obtain information from third parties; facilitatations in securing proof; and explicit wording to the effect that claims for damages may be demanded in the form of suitable license fees.

At the same time, via the BMBF's research initiative **"Innovation against Product Piracy"**, the Federal Government is harnessing research and innovation in the battle against product piracy.

Standardisation as a driving force for innovation

Norms and standards promote innovation, open markets and help provide a level playing field for companies. Internationally applicable norms and standards are especially important for Germany as an export nation. With a 14 percent share of the world market for R&D-intensive goods, Germany ranks first in sales of high value technology.

The Federal Government's **"Standardisation-policy concept"** ("Normungspolitisches Konzept") is aimed at systematically integrating standardisation in technology support. It is thus expected to shorten the time to market for innovations. At the same time, a focus is being placed on enhancing SMEs' awareness of standardisation issues. Furthermore, they are to be assisted in applying standards and in participating in the standardisation process.

PRACTICAL EXAMPLES

In the **project "Innovation with Norms and Standards"**, the BMWi is supporting the German Institute for Standardisation (DIN) in early, systematic identification of standardisation requirements in high-technology fields covered by the High-Tech Strategy (such as aerospace technology, microsystem technology, nanotechnology, medical technology and biotechnology). The aim of the effort is to provide an optimal framework for future innovations and thereby to promote the marketability of such innovations.

The **project "Transfer of R&D Results via Norming and Standardisation"** ("Transfer von FuE-Ergebnissen durch Normung und Standardisierung") is aimed at providing research institutions with targeted incentives for using standardisation as a commercialisation instrument in the translation of research findings into marketable products and services.

Reducing "red tape" and bureaucracy

"Red tape" costs time and money: for the general public, for companies and, of course, for public administrations themselves. Unnecessary formalities slow all economic action. For this reason, one of the Federal Government's central reform projects is to systematically reduce unnecessary bureaucratic overhead. In a December 2008 report on use of the established standard-cost model, and on progress in reducing bureaucratic overhead, the Federal Government identifies interim success: a total of **330 legal simplifications** have been saving industry over EUR 7 billion per year. What is more, application procedures for the public have also been simplified. By systematically reducing bureaucratic overhead, the Federal Government has been providing latitude for enhanced economic performance **www.bundesregierung.de/buerokratieabbau.**

Reducing obstacles to innovation will remain a major challenge in future. To make effective use of innovation resources, persons and organisations involved in innovation need additional latitude, especially options for further and improved use of the potential of innovative start-ups and for adequate, requirement-oriented innovation financing. The bottleneck resulting from inadequate venture and equity capital, a bottleneck that is worsening as a result of the financial and economic crisis, will have a significant impact in this area.

Apart from the issue of the available funding, it will be necessary to discuss the role of tax breaks in mobilising research and development work, especially tax breaks for SMEs and innovative start-ups. As part of the implementation of the review called for in the Cabinet resolution on the 2008 corporate tax reform, a Federal Government working group has studied the options for introducing tax-based funding for research and development. The working group's report indicates that **tax-based R&D support** is a feasible option and that it would have positive effects. While tax-based R&D funding provides advantages, in comparison to subsidy-based funding – inter alia, in the breadth of its impact – it does require considerable additional resources. No decision on this issue has yet been made.

3. Assuring the availability of a highly trained, skilled workforce

SUMMARY

Challenges and aims

No innovation policy can succeed without the availability of talented, skilled people. Training and qualification requirements are constantly increasing. The Federal Government is aiming to use education and training to ensure the continuing availability of a highly skilled, adequate large workforce. This is an aim that directly relates to our country's future.

Results and perspectives in efforts to assure the availability of a skilled workforce

In its efforts to ensure that enough skilled people are available, the Federal Government is relying on:

- The **"Getting Ahead Through Education" qualification initiative** ("Aufstieg durch Bildung"), which is designed to enhance advancement opportunities for everyone, regardless of social background. The Federal Government and the Länder have agreed on the goal of increasing expenditures on education and research, as a share of gross domestic product, to 10 percent by 2015;
- The **"Pact for Employment and Stability in Germany to Safeguard Jobs, Strengthen the Forces for Growth and Modernise the Country" (the second economic stimulus package)**, via which, in the framework of the Act for Investment in the Future (Zukunftsinvestitionsgesetz), over EUR 8.6 billion will be invested, in 2009 and 2010, in kindergartens, school infrastructures, higher education institutions, municipal and non-profit further training institutions and non-university research institutions and museums;
- The **action programme "The contribution of labour migration to securing the necessary pool of qualified workers in Germany"** ("Beitrag der Arbeitsmigration zur Sicherung der Fachkräftebasis in Deutschland"), which facilitates labour market access for foreign skilled workers and specialists;
- The **"Alliance to advise the Federal Government in matters of workforce requirements"** ("Allianz zur Beratung der Bundesregierung in Fragen des Arbeitskräftebedarfs"), which was established in March 2009.

Challenges and aims

The central challenges with respect to the future of growth and employment in Germany include ensuring the medium-term and long-term availability of a skilled workforce. Economic recovery and growth are possible only with well-trained people. Skilled workers, specialists and professionals are thus a key factor to provide for in any successful innovation policy. Qualification and training requirements have been steadily increasing, especially in production of high value and high-technology goods and in the services sector. At the same time, demographic change is making itself felt: as time passes, fewer and fewer young people will be living, learning and working in Germany.

Shortages of specialised staff are already apparent in some sectors and regions. Specialists with qualifications in the areas of mathematics, informatics, natural science and technology (MINT), and with completed technical training, at the technician and master craftsman levels, are in special demand. The Centre for European Economic Research (ZEW) is forecasting a shortage of between 180,000 and 480,000 skilled persons, resulting from ageing and structural change, for the year 2014.

The Federal Government is aiming to address the growing demand for skilled workers, specialists and professionals primarily by intensifying training and further training within the country, and by considerably increasing the numbers of women, older people and immigrants (already living in Germany)

in the workforce. If Germany is to succeed in the international competition for highly qualified and skilled persons, it will have to enhance the conditions for workers and specialists from abroad.

At the same time, the Federal Government views education and qualification as indispensable not just with regard to meeting national workforce requirements, but also as the keys to individual advancement and success. Education and qualification are keys to social participation, orientation and social cohesion. The important goals in relation to assuring our future include ensuring that all people in Germany are able to develop their skills and talents.

Results and outlook

As it evolves into a knowledge society, Germany needs to intensify its investments in education and science. With its Cabinet resolution of January 2008, the Federal Government clearly indicated its intention to strengthen educational opportunities in all areas of life. The approved package of measures, including efforts by a range of different government departments, is aimed at further enhancing the country's training and further training system, in terms of both quality and breadth of impact, as well as improving permeability in all educational areas. A total of some EUR 6 billion has been made available for relevant new measures and programmes in the period 2008 to 2012. Nearly all of the measures in question either commenced in the course of 2008 or will soon commence.

These Federal Government measures set clear priorities on improving the transition from school into vocational training, on promoting qualification and upward mobility opportunities and on providing further training. The new measures introduced include grants oriented to career advancement ("Aufstiegsstipendium"), for persons who are highly qualified by virtue of their work experience and who wish to take up higher education studies. These grants are in great demand. Another new instrument is the "educational bonus" ("Bildungsprämie"), which provides incentives for further training. In addition, efforts are being made to interest more young people to enter training or studies in MINT fields (mathematics, informatics, natural science and technology). A "National Pact for Women in MINT Occupations" (**www.komm-mach-mint.de**) is oriented to the important role that women can play in meeting the demand for skilled workers, specialists and professionals. At the same time, special consideration is being given to children and adolescents with migrant backgrounds – and to their parents.

In the coming years, major efforts will have to be applied to the transition between the phases of early childhood education, school, training and higher education. The Federal Government and the Länder plan to cooperate in making such efforts. At the "qualification summit" held on 22 October 2008, the Federal Chancellor and the heads of the Länder governments thus agreed, in their "Dresden Declaration", **"Getting Ahead Through Education. The Qualification Initiative for Germany"** ("Aufstieg durch Bildung. Die Qualifizierungsinitiative für Deutschland"), on a common catalogue of aims and measures. This catalogue takes account of all educational areas, from early childhood education to further training for working people. In autumn 2009, a first interim report on the status of relevant implementation is to be provided.

The following aims and measures of the Qualification Initiative for Germany are worthy of special mention:

- The Federal Government and the Länder agree that expenditures for education and research in Germany need to reach a level of 10 percent of the country's gross domestic product by the year 2015.

- Furthermore, every child should be fluent in German upon entering school. By the year 2010, the Länder plan to provide binding standards for assessing language skills, and by 2012 they plan to

ensure that intensive language training is available to children well before they enter school.

- The number of persons who fail to complete their schooling and training is to be considerably reduced. The Federal Government and the Länder are aiming, by 2015, to reduce the percentage of school-leavers without qualifications from the current level of 8 percent to 4 percent, and to reduce the percentage of young adults without vocational qualifications from 17 percent to 8.5 percent, i.e. to cut both levels in half.

- The Federal Government and the Länder have also launched the initiative "Qualification and connection" ("Abschluss und Anschluss"), which is designed to improve, in cooperation with industry, training preparation and transitions into vocational training, especially for disadvantaged persons. The initiative's important elements include a "training bonus" aimed at improving older applicants' opportunities, in a lasting way, to enter in-company training; and the introduction, into employment promotion laws, of a legal claim to support for adult/later schooling to obtain a secondary modern school qualification. Furthermore, the Länder are seeking to bring young people with migrant backgrounds up to the average achievement level of all school pupils.

- The Länder plan to provide the basis for better permeability between vocational training and academic education. Vocationally qualified persons who have three years of occupational experience will be eligible for subject-restricted higher education studies, while persons with master craftsman, technician's and business administrator qualifications will be eligible for a general higher education entrance qualification. Furthermore, the Federal Government is expanding opportunities under the Upgrading Training Assistance Act (Meister-BaföG). Especially talented, vocationally qualified persons who wish to take up higher education studies will be eligible for support in the form of grants oriented to career advancement. If third parties provide suitable support, such grant awards can be expanded. In addition, the Federal Government and the Länder plan to promote the development of study programmes suitable for people in training or in occupations.

- Plans call for the numbers of persons in each age cohort who enter higher education to be increased to an average nationwide percentage of 40 percent of each age cohort. The Federal Government and the Länder plan to continue the Higher Education Pact 2020, with the aim of achieving the estimated potential annual increase of about 275,000 additional new higher education enrolments by 2015. At the same time, special incentives for studies in MINT subjects are to be provided.

Extension of financing for studies and other education and training:

- **The new BAföG**
  The new Federal Education and Training Assistance Act (BafÖG) plays a significant role in enabling young people to complete training, regardless of their families' financial situations. School pupils receive support in a subsidy-only form, while students and trainees at higher specialised technical colleges and academies receive support, as a rule, consisting of a 50 percent subsidy and a 50 percent interest-free state loan. Currently, one out of every four students in first-time studies, and in the normal period alloted for studies, receives BaföG support.

  As of autumn 2008, the available support levels were increased by 10 percent, to a maximum level of now EUR 643 per month. Similarly, the available support levels for vocational training subsidies (Berufsausbildungsbeihilfe – BAB), pursuant to the Third Volume of the German Social Welfare Code (SGB III) were also increased. BAföG now also includes the following new elements: additional support is provided for students with children (EUR 113 per month for the first child, and EUR 85 per month for the second child); support for training undertaken completely in other European countries; and facilitated BaföG support for foreign adolescents who have perspectives for permanent residence in Germany (**www.bafoeg.bmbf.de**).
- **New Upgrading Training Assistance Act (Meister-BaföG)**
  With the Second Act for Amendment of the Career Advancement Training Promotion Act (AFBG or "Meister-BaföG"), which enters into force on 1 July 2009, support for further training oriented to promotion has been considerably improved, and more people will be encouraged to undertake further training programmes. This will contribute significantly to ensuring the availability of adequate numbers of well trained and skilled young people (**www.meister-bafoeg.info**).
- **Grants provided by associations for the promotion of the gifted**
  Associations for the promotion of the gifted (Begabtenförderungswerke) offer high achieving and socially committed students financial assistance and other types of integrative support – for example, via summer academies, support for studies abroad, language courses and networking. The aim of having the country's 11 associations for the promotion of the gifted support one percent of all students (as compared to nearly 0.7 percent in 2005) was achieved by the end of 2008 earlier than planned (**www.stipendiumplus.de**).
- **Grants oriented to career advancement**
  Since 2008, grants oriented to career advancement (Aufstiegsstipendien) have been awarded to enable talented people, already in occupations, to undertake studies. The prerequisites for such grants include outstanding results in vocational training and a higher education entrance certification. Such grants do not have to be repaid (**www.begabtenfoerderung.de**).
- **Education loans**
  With its education-loan programme, the Federal Government supports school pupils and students in advanced phases of training. Education loans are paid out monthly, in advance, and ininstalments of EUR 300, by the KfW Bank Group. Within any given training phase, up to 24 monthly instalments, or a total of EUR 7,200, can be approved (**www.bildungskredit.de**).

- In addition, in cooperation with the social partners (employers' and employees' representatives), and by the year 2015, the Federal Government and the Länder are aiming to have participation in further training increase from the current level of 43 percent of the working population to 50 percent. In particular, persons with low qualifications are to be encouraged to participate more actively in further training. This will require specific efforts on the part of companies, employees and the social partners.

- The Federal Government plans to initiate a further education campaign; to develop strategies for enhancing all employed persons' interest in undergoing further training; and to promote further training activities for, and in, small and medium-sized enterprises (SMEs). The Federal

Employment Service plans to intensify its efforts in the area of further training support.

In January 2009, the Federal Government approved, as part of its second economic stimulus package, the **"Pact for Employment and Stability in Germany to Safeguard Jobs, Strengthen the Forces for Growth and Modernise the Country"**. In the framework of that package, for 2009 and 2010 the Federal Government will promote investments by the Länder and, especially, by municipalities, in kindergartens, school infrastructure, higher education institutions and research. To this end, a total of EUR 6.5 billion (65 percent of the total volume of the approved municipal investment programme, amounting to EUR 10 billion) will be provided. The Federal Government is expecting the Länder to contribute one third of this sum (EUR 2.166 billion), so that a total sum of EUR 8.67 billion will become available. This is the largest programme for investment in education in Germany's history.

Germany needs to succeed in the international competition for skilled people, and it needs to attract more people who excel. For this reason, in 2008, the Federal Government approved the **action programme "The contribution of labour migration to securing the necessary pool of qualified workers in Germany"** ("Beitrag der Arbeitsmigration zur Sicherung der Fachkräftebasis in Deutschland"). With effect as of 1 January 2009, the income threshold to qualify for an open-ended residence permit was reduced, for highly qualified persons, from EUR 86,400 to EUR 64,800. Furthermore, such residence permits also include work permits. In addition, access to the labour market has been eased for academics from the new EU countries. For such persons, review will no longer be required of whether in-country applicants would be available for the job in question. For academics from third countries, all fields of the labour market have been opened up (i.e. there is no restriction to the IT sector), subject to the condition, in each case, that no in-country applicants would be available for the job in question.

In the framework of the action programme, the Federal Government also plans to develop an instrument, with scientific support, for determining the current and future requirements for skilled workers and specialists.In March 2009, an **"Alliance to advise the Federal Government in matters of workforce requirements"** ("Allianz zur Beratung der Bundesregierung in Fragen des Arbeitskräftebedarfs"; "workforce alliance" for short) was established. In this framework, the social partners (employers' and employees' representatives), researchers, the Federal Government and the Länder, working on the basis of scientific forecasts, will estimate current, medium-term and long-term workforce requirements in Germany. The workforce alliance's research findings and deliberations will then provide a basis, in individual cases, for pragmatic decisions relative to meeting future workforce requirements.

At the same time, it will be necessary to make conditions for science and research in Germany as attractive as possible, in the interest of preventing departures of highly trained and skilled people. Future education policy tasks will include optimising assistance for individual education financing, and providing a coherent support system that guarantees equal opportunity and facilitates access to education for persons in all life situations. With regard to young scientists and academics in particular, it will be necessary to provide reliable state education support and a complementary range of education-loan programmes.

4. Science policy

SUMMARY

Challenges and aims

Excellent academic education ensures that a skilled workforce – scientists, researchers, professionals and workers – will continue to be available in the future. Plans call for the German science system to rank among the top three science systems worldwide, by 2020, in terms of performance, competitiveness and positive momentum. Consequently, the best possible resources and conditions have to be provided at Germany's higher education institutions and research institutions.

Results and outlook

The German science system has been modernised, and the German science sector's attractiveness enhanced, by a range of measures that includes the following major reform instruments:

- **The Initiative for Excellence**, aimed at promoting cutting-edge research at universities;
- **The Pact for Research and Innovation**, aimed at intensifying support for major science and research organisations;
- **The Higher Education Pact 2020**, aimed at creating additional capacities for students and at reinforcing excellent research at higher education institutions;
- The new provisions, in the framework of the **"Freedom of Science Act" initiative**, that are providing greater latitude and options for research institutes in the areas of autonomy, own responsibility and academic/scientific freedom, and that are eliminating bureaucratic obstacles.

Challenges and aims

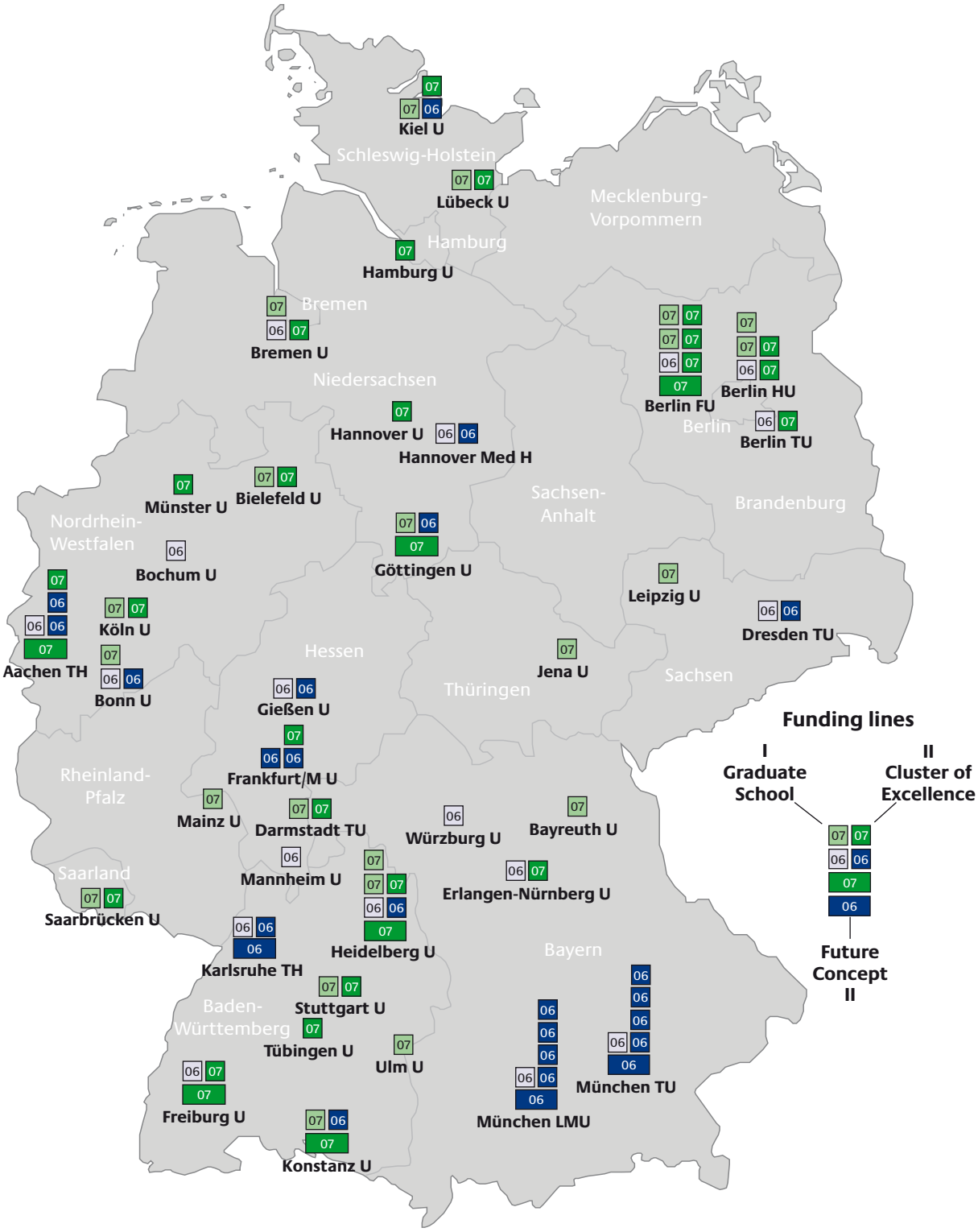
Germany's science system is functionally differentiated – it may be understood as a large complex of sub-systems that each perform a specific function for the whole. This structure has been a success, in principle. For example, Germany is among the world leaders in terms of scientific and academic publications and patents. At the same time, this position could be strengthened via stronger networking between non-university research institutions and universities, and via better cooperation between such science sectors and industry.

What is more, development of the European Research Area, and global competition for the best minds, are requiring Germany's higher education institutions and research institutions to develop and sharpen their international profiles.

In the interest of educating young scientists, researchers and the skilled workforce of tomorrow, the best possible resources and conditions have to be provided at Germany's higher education institutions and research institutions. Such conditions include academic opportunities for young people, internationally recognised degrees and reliably defined, open career pathways. Just as important are adequate staffing and infrastructures for research and teaching. Furthermore, it is vitally important to allow universities to be independent in their decision-making, management and administration – and to strengthen cooperation between higher education institutions and industry.

For this reason, plans call for establishing German higher education institutions and research institutions, with state support, as internationally leading, and internationally competitive, research centres. The Federal Government is working to promote excellence and to make scientific career pathways more attractive. Plans call for the German science system to rank among the top three science systems worldwide, in terms of performance, competitiveness and positive momentum, and to be the key European player in the pertinent international competition, by 2020.

Funding decisions under the Initiative for Excellence 2006/2007



Results and outlook

With the Initiative for Excellence, the Higher Education Pact 2020 and the Pact for Research and Innovation, important steps have been taken in this legislative period toward modernising the science system. The German science sector has significantly enhanced its profile as a result, and become more attractive internationally.

The **Initiative for Excellence**, which includes funding of EUR 1.9 billion and will run until 2011, is a new science-funding instrument. In the first two support rounds of the pertinent competition, a total of 39 graduate schools, 37 clusters of excellence and 9 "future concepts" (Zukunftskonzepte), at a total of 37 higher education institutions in 13 Länder, were selected for support. As a result, universities have been moved to the centre of the German science system. Efforts are underway to increase their international visibility as research centres, to improve their function in educating young scientists and researchers and to enhance their attractiveness for outstanding students and scientists from Germany and from abroad. Such efforts are thus helping to make the universities interesting partners for cooperation with non-university research institutions and with industry. As higher education institutions' profiles develop, a necessary process of differentiation in the higher education sector is progressing.

The German higher education sector has developed a climate of strong optimism and excitement as a result: the positive impacts of the Initiative for Excellence are reaching far beyond the higher education institutions that have been successful in the relevant competition. For example, new models for cooperation between a) higher education institutions and b) non-university research institutions and industry have emerged.

A report presented in November 2008 by a joint commission involving the DFG and the Science

The Pact for Research and Innovation – initial successes

The Pact for Research and Innovation has triggered numerous support measures, strategic processes and cooperation procedures that are helping the science system to transcend its "pillar principle" and enhance the quality of its research. The Pact has initiated structural change within the science system.

It has already produced tangible success, including:

- The numbers of doctoral students receiving support via structured doctoral-candidate programmes throughout all science organisations has been increased by 10 percent. The number of Independent Junior Research Groups has also been significantly increased – by 25 percent.
- The "Fraunhofer-Attract" programme, a programme of the Fraunhofer-Gesellschaft for recruiting and supporting excellent scientists, has been established.
- The Fraunhofer Technology Academy, of the Fraunhofer-Gesellschaft, which trains skilled people and managers already in working life – for example, via certificate courses and MBA programmes – has been established.
- The Helmholtz Management Academy, a pilot project of the Helmholtz Association, has been founded with the aim of imparting management and leadership skills to scientists.
- The Max Planck Society's "Fellow Programme" has been established. Under this new programme, participants – university teaching staff – have the opportunity to head a small research group at a Max Planck Institute, for a five-year period.
- "Leibniz-Humboldt" professorships have been introduced.
- A research alliance between the Gottfried Wilhelm Leibniz Science Association (WGL) and the Fraunhofer-Gesellschaft, charged with helping to protect cultural heritage, has been established.
- The XFEL European X-Ray Laser Project is being carried out, with international participation, in cooperation between the Helmholtz Association (DESY), the University of Hamburg and the Max Planck Society.

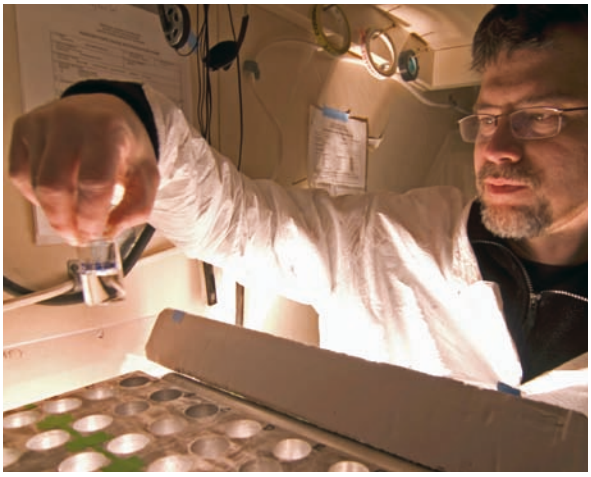
Council has shown that the Initiative for Excellence has contributed decisively to the enhancement of higher education institutions' profiles and to the creation of research-friendly structures. Young scientists and researchers have profited especially from these developments. Graduate schools and clusters of excellence expect the Initiative for Excellence to provide some 4,000 new positions and grants. It is important to make the best use of the energy and momentum in this process. For this reason, the Federal Government and the Länder agreed, at a "qualification summit" held in October 2008 (in the framework of a "qualification initiative"), to continue and improve the Initiative for Excellence following an evaluation process.

The Federal Government and the Länder have approved the **Higher Education Pact 2020**. The Pact calls to increase the entry rate into tertiary education, on a nationwide average, to 40 percent of each age cohort. In addition, higher education institutions are to be enabled to meet sharply increasing enrolment demand.

By 2010, a total of 91,370 additional new students (in comparison to the corresponding figure in 2005) are to be accepted – so the first "pillar" of the Higher Education Pact. To this end, the Federal Government will provide some EUR 565 million, for provision of additional enrolment capacities, through 2010. At the October 2008 qualification summit, the Federal Government and the Länder agreed to continue the Higher Education Pact 2020 as necessary and, for the period 2011 to 2015, to provide for up to some 275,000 additional entrants into tertiary education. At the same time, special incentives for studies in MINT subjects are to be provided.

The Higher Education Pact is already sending important signals: the downward trend in new enrolments has been stopped. In 2007 and 2008, the number of new students increased again, and the entry rate into tertiary education, according to provisional statistics of the Federal Statistical Office, was 39.3 percent in the 2008 academic year.

The second pillar of the Higher Education Pact 2020 introduces programme-overhead financing into support provided by the German Research Foundation (DFG). DFG-supported research projects receive additional support amounting to 20 percent of their basic funding awards. Overhead financing, for which EUR 700 million are being provided for the period 2007 to 2010, is improving higher



education institutions' options and latitude, thereby strengthening already excellent research.

On 31 January 2009, the DFG submitted a report to the Federal / Länder Joint Science Conference (GWK) regarding experience with the new programme-overhead financing. On the basis of that report, the Federal Government and the Länder will review the programme and decide on its further design and structure for the period as of 1 January 2011.

In addition, the role that top scientists can play in enhancing the science system's competitiveness is being emphasised. The **"Women Professors Programme"** ("Professorinnenprogramm") is designed especially to support highly qualified women. Under the programme, the Federal Government and the Länder plan to create some 200 new positions for women professors over the next five years.

The **Pact for Research and Innovation** has intensified support for the major science and research organisations supported jointly by the Federal Government and the Länder: the Helmholtz Association of German Research Centres (HGF), the Max Planck Society (MPG), the Fraunhofer-Gesellschaft (FhG), the Gottfried Wilhelm Leibniz Science Association (WGL) and the German Research Foundation (DFG; in its role as a research-funding organisation). The Federal Government and the Länder have signalled their intent to make every effort to give the science and research organisations a reliable basis for financial planning and to increase annual financial contributions to each of them by at least three percent through 2010. The research organisations, for their part, have committed to enhancing the quality, efficiency and performance of their research and development. This commitment thus provides for such

actions as sharpening profiles, expanding cooperation with industry, moving into new research areas, promoting young scientists and researchers and intensifying support for women, including women in management positions.

The Federal Government and the Länder agreed, at a "qualification summit" held in October 2008 (in the framework of a "qualification initiative"), to continue and improve the Initiative for Excellence following an evaluation process. The Joint Science Conference (GWK) has already prepared a relevant draft.

In addition, the Federal Government plans to enhance Germany's position, in the international competition of science systems and innovation centres, via the **"Freedom of Science Act" initiative**. In the framework of a pilot project, initially slated to run until 2010, the country's major non-university research institutions will be accorded additional latitude in managing their own financial resources and staff. At the same time, the basis for modern, task-oriented and results-oriented control of the research organisations will be provided. Such control will be supported by financial controlling measures suitable for the science sector. In its 2009 report, the Expert Commission on Research and Innovation (EFI) affirmed that the initiative points in the right direction. It also recommended that non-university research institutions be given additional autonomy, and that budget responsibility be transferred to them.

Initiative for a "Freedom of Science Act" ("Wissenschaftsfreiheitsgesetz")

1. **Introduction of global budgets for science and research organisations**
   In the 2009 federal budget, those funding amounts that the organisations manage under their own responsibility, and the defined areas to which the organisations may allocate funding, have been expanded.
2. **Attracting and keeping the best minds**
   In the interest of attracting the best minds to the German research sector, and of convincing them – even in the face of strong international competition – to remain in Germany, the 2009 federal budget gives the Max Planck Society (MPG), the Fraunhofer-Gesellschaft (FhG) and the Helmholtz Centres the option, in certain cases, of departing from Art. 34 Civil Servants' Remuneration Act (Bundesbesoldungsgesetz) in determination of salaries for level "S" (W 3) positions. The Federal Government plans to request the Länder to approve this policy.
3. **Promoting science-industry networking**
   In the interest of promoting and accelerating the pace of science-industry networking, the 2009 federal budget authorises the MPG, the FhG and the Helmholtz centres to pass on up to 5 percent – in individual cases, up to EUR 10 million – of institutional funding to a legal entity in which they have a stake, or to which they belong, for institutional purposes involved in networking with the science sector or cooperating with industry. Transfers of funds to recipients abroad are subject to the consent of the German Bundestag's Budget Committee.
4. **Simplifying construction of suitable facilities for the science sector**
   The country's science organisations need to be given the additional infrastructure they require as soon as possible. In cooperation with the Federal Ministry of Transport, Building and Urban Affairs (BMVBS), therefore, and in a procedure similar to the relevant procedure applying for the MPG, a simplified procedure for construction projects of the FhG and the Helmholtz Centresearch is to be introduced.
5. **Facilitating fast and efficient procurement of goods and services**
   In the interest of facilitating fast, efficient procurement of goods and services in orders of up to EUR 30,000, the BMBF and the BMWi have already acted as follows with regard to the organisations within their portfolios: orders for goods and services up to this threshold value may now be procured via negotiated contracts. An amendment of the regulations governing works contracts (Verdingungsordnung für Leistungen) is pending, and the Federal Government plans to use that process as an occasion to bring about additional research-specific facilitation in regulations governing procurements below the EU threshold.

5. Internationalisation and the European Research Area

SUMMARY

Challenges and aims

Global challenges call for international cooperation and jointly developed scientific solutions – and global markets offer opportunities for innovations of German companies, opportunities that need to be used. The Federal Government aims to improve Germany's position in the global knowledge society further and to assume international responsibility in the search for solutions to global problems.

Results and outlook

The Federal Government's internationalisation strategy is reinforcing European and international networking by the science and R&D sectors, networking that is a decisive basis for innovation. Examples of measures undertaken in the first year of the strategy include:

Better use of opportunities in international cooperation

- Attraction of foreign scientists, including both young scientists and scientists who are leaders in their fields (for example, via Alexander von Humboldt professorships).
- Expansion of international cooperation in the Federal Government's funding programmes.
- Enhancement of Germany's presence abroad via German centres for science and innovation (Russia, India, Japan, Brazil, U.S.) and via science representatives.
- Multilateral dialogue on the international research agenda has been intensified via the declaration from the G8 summit in Heiligendamm.
- A successful advertising campaign has been launched that is promoting Germany as a location for studies, science and innovation.

An active role in European research policy

- The European Research Council (**ERC**) is adding excellence to European research support.
- The European Institute for Innovation and Technology (**EIT**) is facilitating the establishment of "Knowledge and Innovation Communities" (**KICs**).
- **Eurostars**, a funding programme for SMEs, has been successfully launched.
- **Joint Technology Initiatives (JTI)** are carrying out their own research agendas, aimed at strengthening industrial competitiveness (for example, for hydrogen-based systems and fuel cells).
- **ESFRI** is creating new pan-European research infrastructures (such as XFEL and FAIR).

Challenges and aims

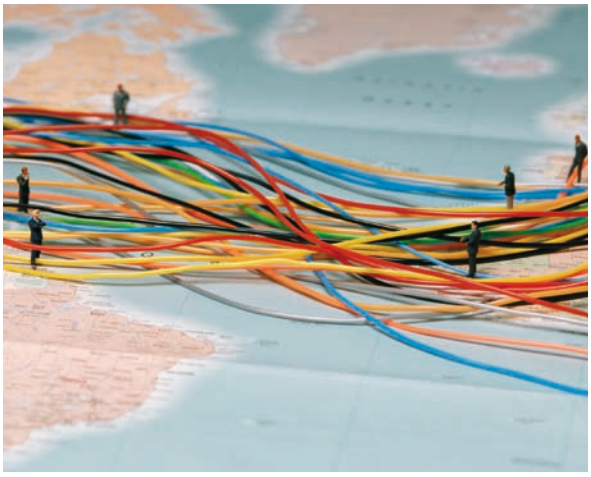
Germany, an internationally outstanding science and research centre, finds itself facing growing competition. Innovation stakeholders need to safeguard access to the world's knowledge. This takes place most effectively via cooperation with international partners who can best complement one's own know-how. In addition, companies will seek partners with whom they can improve the competitiveness of their products, via integration of the most powerful available technologies and components.

The Federal Government is aiming to develop and use the potential of an enlarged Europe without borders, and of market globalisation, in line with Germany's interests. It is also working to concentrate international and European resources, thereby working toward Europe's Lisbon goal of making Europe the world's most competitive, most dynamic knowledge-based economic area.

Results and outlook

In February 2008, in the interests of improving Germany's position in the global knowledge society, the Federal Government approved a **Strategy for Internationalisation of Science, Research and Development**. This strategy is aimed at strengthening Germany's science and innovation sectors through transborder cooperation in science and research. As a result, Germany will become a leading destination for outstanding researchers and students from throughout the world. In addition, cooperation with developing countries in the areas of education, research and development is being lastingly reinforced via the establishment of science and innovation centres. At the same time, with its outstanding research landscape and technology leadership in many high-technology areas, Germany is contributing specifically to meeting global challenges, and it is assuming international responsibility. Overall, internationalisation is a key factor for success in global competition. It is thus a key element of any modern innovation policy.

Under the internationalisation strategy, and in close cooperation with the science, industry and policy-making sectors, specific measures for enhancing use of opportunities in international cooperation, and for intensifying bilateral and



multilateral cooperation on key future issues, have been taken. At the same time, impetus is being provided for the science and industry sectors' own internationalisation initiatives.

With its foreign science policy, the Federal Foreign Office is providing additional support for academic exchanges with other countries. International science and research ties support the achievement of foreign policy aims. At the same time, they promote research and development in Germany, thereby strengthening the German economy. An **"Initiative for Foreign Science Policy"** ("Initiative Außenwissenschaftspolitik") will provide additional funding in 2009 to extend the available instruments and add relevant new measures. The pertinent efforts include the establishment of centres of excellence abroad, for joint research and teaching, expansion of the network of science representatives (Wissenschaftsreferenten) at German embassies, attractive grant programmes, promotion of German as a foreign language and of German literature studies, and intensified information and communication. As a result, the Federal Foreign Office is contributing to the Federal Government's strategy for the internationalisation of science and research.

International cooperation enhances research and innovation competence

The measures already undertaken in the first year of the internationalisation strategy's implementation include:

- Promoting the international mobility of German scientists, and enhancing the attractiveness of German training and work programmes. The Alexander von Humboldt professorship, the largest international prize for researchers and the Sofia Kovaleskaya Prize (which is being continued) support outstanding scientists and young foreign scientists and researchers in transferring their work to German higher education institutions from locations abroad.

- Working in cooperation with science and agency organisations (DFG, HGF, FhG, DAAD, HRK), and with international chambers of commerce, the Federal Government has developed a basic concept for German Houses of Science and Innovation. This concept is to be used as a basis for the establishment of an initial group of four Houses, located in Russia, India, Japan and Brazil. A decision regarding an additional House, located in the U.S., will be made very shortly. The Houses will be charged with serving German science and research organisations in presenting themselves as a group in other countries, as well as with providing a forum for encounters, service and networking.

- Internationally, nationally and regionally oriented funding programmes are being coordinated more effectively. Increasingly, specialised research-funding programmes include bilateral and multilateral cooperation, and an international orientation, as integral elements. At the same time, international networking by innovative SMEs, and SMEs' participation in international networks and clusters, are being supported.

Success via international networking

The BMBF has established an Internet portal for German information and communications relative to international cooperation in education and research. In a single point of access, **"Kooperation-International"** ("International Cooperation") presents extensive information on a broad range of cooperation opportunities. The portal is aimed at all persons and organisations interested in cooperation, and functions both as a guide and as a communication platform. The portal's some 200,000 monthly "hits" testify to its success.

www.kooperation-international.de

- In the G8 and OECD frameworks, multilateral dialogue for an international research agenda has been established to address important global issues. The issues concerned especially include the joint battle against climate change, safeguarding the earth's energy future and battling poverty and infectious diseases. In the context of the G8 declaration of Heiligendamm, the Federal Government declared its readiness to assume leadership in dealing with such issues.

- The Federal Government has been intensifying the coordination of instruments for development cooperation and for scientific-technological cooperation, with the aim of initiating lasting science-based development processes and creating the basis for scientific cooperation with developing countries on equal terms.

Promoting Germany as a centre for innovation

The Federal Government has been supporting international advertising campaigns, in important focus countries, to improve Germany's visibility as an attractive location for studies, research, development and innovation. Such measures facilitate the initiation of R&D cooperation between research organisations and research-intensive companies, and they help attract scientists and researchers, including both up-and-coming and leading scientists and researchers, to Germany. In the longer term, such measures can also help to boost German research organisations' success in contract research and to trigger investments in Germany.

The first advertising campaign, **"South Korea Pilot Measure"** ("Pilotmaßnahme Südkorea"), carried out from November 2006 to mid-2008, was a major success: over half of all participating German institutes and organisations have already launched R&D projects with Korean partners and over 80 percent were able to find new partners in Korea. In

addition, agreements on the joint use of research infrastructures were signed, new technologies and prototypes were jointly developed, further training measures for the international market were developed, framework agreements for the recognition of qualifications / degrees were signed and numerous exchanges of scientists were agreed.

Currently, campaigns are underway with focuses on the areas of nanotechnologies and environmental technologies, and a campaign is being carried out with a focus on India. In late 2009, additional campaigns will be carried out: with a focus on production technologies and a focus on Brazil.

www.research-in-germany.de

An active role in European research policy

In light of globalisation, it is of central importance to strengthen Europe's competitiveness. Germany is contributing significantly to this effort.

- By playing a central role in shaping the **European Research Council (ERC)**, Germany has been able to have the excellence principle enshrined, for the first time, as the sole criterion for EU research support.

- The European Institute for Innovation and Technology **(EIT)** was conceived largely during the German Council presidency. Founded in September 2008, it is charged with developing strategic networks, for the "knowledge triangle" comprising education, research and innovation, in promising technology fields – networks consisting of business enterprises, research organisations, higher education institutions and other providers of research and education services. Such networks are expected to help close the gaps between research findings and successful market commercialisation. In a first call for proposals issued in 2009, "Knowledge and Innovation Communities" **(KIC)** were identified in a number of global requirement areas, including climate, energy and next generation ICT technologies.

- **Implementation of the Seventh Research Framework Programme (FP7):** Following the programme's first two years, Germany continues to show a high level of participation in FP7, with a share of 19.6 percent of support. German research organisations – especially MPG, HGF, FhG and WGL – have been especially successful: they receive 23.8 percent of the funding provided to research organisations in the Member States. German companies have also been successful, garnering 21.8 percent of support provided to private industry entities in the EU. In comparison to other Member States, most notably the UK, France and the Netherlands, Germany has thus been able to again increase its industrial share of the Framework Programme. Germany's involvement in the area of ERA-Nets, in which German organisations are active in over 60 projects, is also worthy of special mention.

- Germany is involved in six **"Joint Technology Initiatives"** (JTI), in which strategic research agendas (SRA) are being pursued in research areas of special importance for Europe: Innovative Medicines (www.imi-europe.org); nanoelectronics (ENIAC, www.cordis.lu/ist/eniac); embedded processing systems (ARTEMIS, www.cordis.lu/ist/artemis); hydrogen and fuel cells (Fuel Cell, www.hfpeurope.org), aviation and air traffic management (ACARE, www.acare4europe.org) and Global Monitoring for Environment and Security (GMES, www.gmes.info).

- The BMBF's **Eurostars** programme (a measure pursuant to Art. 169 of the EC Treaty) is aimed especially at SMEs, and at cooperative research and development in the framework of transborder European projects. SMEs are especially in need of support in using international cooperation to develop new customers and markets.

- In the **ESFRI Process** (European Strategy Forum on Research Infrastructures), the Federal Government is taking a central role in shaping new EU research infrastructures. With the help of this role in 2007/2008, for example, the XFEL European x-ray laser programme and the FAIR international accelerator facility programme were begun, with global financial participation. In addition, the Federal Government is supporting the development of a European Research Infrastructure Consortium (ERIC) that will facilitate the establishment of new pan-European research infrastructures.

As it has been doing in the aforementioned measures, Germany will continue to participate in European activities, at a level in keeping with its size and influence. Furthermore, this participation will especially involve an active role in the further development of the **European Research Area (ERA)**, in the framework of the "Ljubljana Process" and the "Vision 2020". For this reason, Germany has contributed significantly to the establishment of a Strategic Forum for International Cooperation (SFIC), which it will chair in 2009. Germany also plans to play a key role in shaping further ERA initiatives (such as Joint Programming, Researcher Mobility, IP Charter).

Furthermore, in the framework of negotiations for reviewing the **EU financial framework**, Germany is urging that even greater priority be given to education, research and innovation, in the interests of Europe's ongoing development into a modern, internationally competitive research area.

In the **German EUREKA Presidency**, the Federal Government plans to continue developing and strengthening the European network for innovative and market-oriented research. The primary aim in this connection is to increase the visibility of EUREKA, and to highlight its role in the European Research Area and in internationalisation – especially the internationalisation of SMEs.

The **European Year of Creativity and Innovation 2009** is expected to promote creativity as a driving force for innovation and as a key factor in the development of personal, occupational, social and entrepreneurial competencies. Germany supports the pertinent initiative of the European Union, and it has established its own Web site for the relevant implementation in Germany: **www.ejki2009.de**.

Outlook

By means of a multitude of measures and initiatives, the Federal Government has provided the basis for making Germany one of the world's most research-intensive and innovation-intensive countries. It has recognised the needs of the times and taken the necessary corresponding steps. Moreover, it understands that the current crisis provides all the more reason to stay this course. The Federal Government is acting now to provide the basis for the wave of innovation that will shape the coming decade. The guiding idea in such efforts is to protect the country's prosperity through investments in education, science and research. In the current difficult economic situation, growth-oriented policies are needed all the more. All stakeholders in the areas of education, science, research and development will thus have to make additional efforts – to ensure that Germany remains one of the world's most attractive locations for research and innovation, as well as an internationally leading provider of innovations.

The Federal Government will continue to emphasise research and innovation

With the help of modern, innovative technologies, products and services, Germany is making its own specific contributions to solving global challenges, even as it strengthens its own global competitiveness. Research and development will continue to be central policy areas; they are the strategic keys to assuring new, long-term growth. Germany is in an outstanding position, and it has great potential for developing new ideas with which new markets can be developed and shaped. That position, and that potential, will continue to be developed. Policy-makers, and the science and industry sectors, are called on to intensify their efforts to that end.

Innovation policy is a cross-cutting task

Via the High-Tech Strategy, the Federal Government's research and innovation policy has taken the right steps to address pressing and looming issues in coordinated, targeted ways. An overarching innovation strategy, cutting across all relevant topics and policy areas, is the right conceptual approach. Germany is continuing to pursue such a strategy – energetically and systematically. Now, the pertinent defined priorities must be reinforced, additional innovative fields must be developed, cooperation must be strengthened and innovation-policy instruments must be optimised.

Framework conditions that promote – rather than block – research and innovation

The first successful steps toward improving the relevant framework have been taken. Now, the good basis in place for innovation must be improved. In particular, the conditions for young, innovative companies and SMEs, for the venture capital market and for start-ups must be enhanced.

Further efforts to ensure enough skilled people are available

The Federal Government plans to do everything possible to make even better use of Germany's training and education resources and to further enhance Germany's attractiveness for foreign students and skilled people. Measures under the Qualification Initiative for Germany, in combination with an ambitious "ten-percent goal", provide enormous impetus for investments in education and research, and they will lead to considerable quality improvements. Along with the second economic stimulus package (Konjunkturprogramm II), the largest programme for investments in education and research ever undertaken in Germany has also been approved. The Federal Government and the Länder have agreed to combine their various activities and initiatives in the interests of ensuring the continuing availability of a skilled workforce and of improving the education system. Those measures, in combination with the Higher Education Pact 2020 and the action programme "The contribution of labour migration to securing the necessary pool of qualified workers in Germany" ("Beitrag der Arbeitsmigration zur Sicherung der der Fachkräftebasis in Deutschland") and with the support of the "Alliance to advise the Federal Government in matters of workforce requirements" ("Allianz zur Beratung der Bundesregierung in Fragen des Arbeitskräftebedarfs") will significantly strengthen Germany's skilled workforce.

A modern structure for the science system

The Initiative for Excellence, the Higher Education Pact and the Pact for Research and Innovation have triggered dynamic developments in the German science sector. This positive development needs to be continued, so that the German science system can be among the world's top three science systems by 2020. For this reason, in October 2008, acting in the framework of their Qualification Initiative for Germany, the Federal Government and the Länder agreed to continue the Higher Education Pact 2020 as necessary, and to enhance their joint Initiative for Excellence and the Pact for Research and Innovation, following suitable evaluation, in the interests of offering young scientists and researchers in Germany internationally competitive conditions.

Taking an active role in shaping European research policy – networking and building even greater international orientation

In light of global challenges, research activities must have a strong international orientation. The Federal Government's strategy for internationalisation of the science sector addresses this need. It is strengthening international cooperation and taking an active role in shaping European research policy. Germany plans to stay this course, in the interests of further concentrating relevant international and European resources. Research and innovation competencies will continued to be strengthened via international cooperation, especially via internationally coordinated research agendas and privileged technology partnerships. Furthermore, Germany, as a key stakeholder, will help shape the European Research Area.

List of abbreviations

AAL	Ambient Assisted Living
AFBG	Act on further training oriented to promotion (Aufstiegsfortbildungsförderungsgesetz)
AKTIV	Adaptive and Co-operative Technologies for Intelligent Traffic (Adaptive und kooperative Technologien für den intelligenten Verkehr)
AVILUS	Applied virtual technologies in production and production design (Angewandte Virtuelle Technologien im Produkt- und Produktionsdesign)
BAföG	Federal Education and Training Assistance Act
BMAS	Federal Ministry of Labour and Social Affairs
BMBF	Federal Ministry of Education and Research
BMELV	Federal Ministry of Food, Agriculture and Consumer Protection
BMG	Federal Ministry of Health
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMVg	Federal Ministry of Defence
BMVBS	Federal Ministry of Transport, Building and Urban Affairs
BMWi	Federal Ministry of Economics and Technology
BuFI	Federal Report on Research and Innovation
CCI	Climate Change Monitoring Initiative
CNT	Carbon nano-tubes
CSC	Climate Service Center
DBFZ	Deutsches Biomasseforschungszentrum (German biomass research centre)
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
DHGP	German Human Genome Project (Deutsches Human Genom Projekt)
DIN	German Institute for Standardization (Deutsches Institut für Normung)
EBS	European Business School
EEG	Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz)
EEWärmG	Act on the Promotion of Renewable Energies in the Heat Sector (Erneuerbare-Energien-Wärmegesetz)
EFI	Expert Commission on Research and Innovation
EIT	European Institute for Innovation and Technology
EITO	European Information Technology Observatory
ELIPS	European Programme for Life and Physical Sciences in Space
EMEA	European Medicines Agency
EnEV	Act on Energy Saving (Energieeinsparungsgesetz) and Energy Saving Ordinance (Energieeinsparverordnung)

ERA	European Research Area
ERC	European Research Council
ESFRI-Forum	European Strategy Forum on Research Infrastructures
FhG	Fraunhofer-Gesellschaft
ForMaT	Forschung für den Markt im Team (Team research for markets)
FSI	Immediate Action Programme for Influenza Research (Forschungs-Sofortprogramm Influenza)
R&D	Research and development
GABI	Genome Analyse in the Biological System of Plants (Genomanalyse im biologischen System Pflanze)
GFZ	German Research Centre for Geosciences (GeoForschungsZentrum)
GMO	Genetically modified organisms
GWK	Joint Science Conference of the Federal Government and the Länder (Gemeinsame Wissenschaftskonferenz von Bund und Ländern)
GWP	German Water Partnership
HGF	Helmholtz Association of German Research Centres
HTS	High-Tech Strategy
IAE	Automotive electronics
IASS	Institute for Advanced Sustainability Studies
ID 2010	Information Society Germany 2010 (Informationsgesellschaft Deutschland 2010)
IEKP	Integrated Energy and Climate Programme (Integriertes Energie- und Klimaprogramm)
IFB	Integrated Research and Treatment Centres (Integrierte Forschungs- und Behandlungszentren)
IFM-GEOMAR	Leibniz Institute of Marine Sciences
ICT	Information and communications technology
INNO-KOM-Ost	Innovation Competence East (Innovationskompetenz Ost)
IPCC	Intergovernmental Panel on Climate Change
ISUP	Integrated Systems for Underwater Production of Hydrocarbons
JTI	Joint Technology Initiatives
KfW	KfW Bank Group (Kreditanstalt für Wiederaufbau)
KIC	Knowledge and Innovation Center
LIB 2015	Lithium-ion battery
LuFo IV	Aviation-research programme IV (Luftfahrtforschungsprogramm IV)
MINT	(Subjects in the fields of) mathematics, informatics, natural science and technology
MoRaKG	Act on the Modernisation of Framework Conditions for Venture Capital and Equity Investments (Gesetz zur Modernisierung der Rahmenbedingungen für Kapitalbeteiligungen)

MPG	Max Planck Society
NGFN	National Genome Research Network (Nationales Genomforschungsnetzwerk)
NIP	National Hydrogen and Fuel Cell Technology Innovation Programme
NCP (NKS)	National contact point (Nationale Kontaktstelle)
OLED	Organic light-emitting diode
OPV	Organic photovoltaics
Plant-KBBE	Transnational PLant Alliance for Novel Technologies – towards implementing the Knowledge-Based Bio-Economy in Europe
RFID	Radio Frequency Identification
SatDSiG	Act on Satellite Data Security (Satellitendatensicherheitsgesetz)
SIM-TD	Safe Intelligent Mobility – Test Area Germany (Sichere Intelligente Mobilität – Testfeld Deutschland)
SMEs	Small and medium-sized enterprises
Sprint	Systematisches Design zur Integration von Produkt und Dienstleistung - hybride Wertschöpfung in der Gesundheitswirtschaft (systematic design for integration of products and services – hybrid value creation in the health care sector)
SUGAR	Submarine Gas Hydrate Reservoirs: Exploration, Exploitation, and Transport
WBGU	German Advisory Council on Global Change (Wissenschaftlicher Beirat Globaler Umweltveränderungen)
WHO	World Health Organization
WING	WING – Innovations in materials, for industry and society (Werkstoffinnovationen für Industrie und Gesellschaft)
ZEW	Centre for European Economic Research (Zentrum für Europäische Wirtschaftsforschung)
ZIM	Central Innovation Programme for SMEs (Zentrales Innovationsprogramm Mittelstand)

Federal Ministry
of Education
and Research