WHERE THE NEW GROWTH COMES FROM

INNOVATION-POLICY IMPETUS FOR A STRONG GERMANY ON THE GLOBAL STAGE

RECOMMENDATIONS OF THE INDUSTRY-SCIENCE RESEARCH ALLIANCE

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EXECUTIVE SUMMARY: WHERE THE NEW GROWTH COMES FROM

The current global financial and economic crisis marks the beginning of a new decade of profound technological and social change. Germany has an excellent chance of emerging from the current challenges with its competitiveness enhanced. If that is truly to come about, however, we have to bethink ourselves of our real strengths and act now to set the proper course for our future.

Crises present threats – and they present opportunities. The basic political decisions we take today will not only have short-term impacts. They will provide the foundations for the further development of our civilisation and prosperity in a profoundly changing world. Germany needs to take an active and creative role in helping to shape the global changes underway. We certainly have the assumptions such a role calls for. At the same time, we must do far more than simply counter the turbulences with short-term damage-prevention and consumption-promotion programmes – we must safeguard, build on and expand Germany's global innovation leadership. We must realise that we are better prepared than many of our global-market competitors are for the global changes we all expect to come our way.

Germany is a world leader in exports of goods as well as in research output and development of innovative products and processes. In the category of industrial production as a share of gross domestic product, Germany ranks ahead of all other leading industrial countries. What is more, Germany's percentage level in that category has even risen again in recent years. That strength is now emerging as a special advantage, in that our value creation is more diversified than that of other highly developed countries, and our entrepreneurial landscape boasts a great variety of different sectors, fields and company structures. Co-operation between small, medium-sized and large companies, throughout value-creation and innovation channels, is more efficient in Germany than it is in other countries. In its breadth, our science system serves as a model for other countries. In its peaks of excellence, it is nearing world-class, via special investments in key focus areas, via co-operation and via suitable profile formation. This is why internationally operating German companies continue to carry out key high-end functions, such as research and development (R&D), in Germany.

Smart crisis policies reinforce existing strengths, emphasise emerging and forward-looking technologies and enhance the economy's innovation resources. The new president of the United States, Barack Obama, is working to use the economic crisis as an opportunity to modernise the U.S. economy and equip it for the future. We need to enact our own initiatives with a view to ensuring that other countries, in applying their own industrial and scientific modernisation programmes, do not surpass us in many technological areas.

History teaches us that future-oriented investments are the best entrepreneurial and economic tools for overcoming economically difficult periods. That is why, for example, Japan and Finland have acted over the past decade – during a period in which their gross domestic products have shrunk – to boost state and company investments in research and development. They have achieved new economic strength as a result.

Decisions for the future call for courage in setting priorities. Other countries are also hard at work on the global challenges that will shape our planet's future and our future everyday lives. We have to find concrete, specific answers to the question of what Germany's role in solving the "grand challenges" can be and should be. And such answers must devolve directly from the special strengths and characteristics of our industry and research sectors. In the process, we should devote less energy to watching what others are doing and more energy to setting an example for others to follow.

We are prepared for the technological megatrends of the next decade, a decade that will include revolutions in energy efficiency. We are technological leaders on the road into a future with less oil. We have a global edge in systemic coupling of high technologies for production of high-value, unique solutions to the complex problems that the industries of highly developed societies increasingly face.

This edge derives from two resources in particular: people and their ideas. These are resources that we need to cultivate and develop with great care.

To succeed, innovation policy needs more than investments; it needs the right framework. And rather than stopping at the boundaries of departmental or institutional responsibility, innovation policy must be overarching and free of ideology. In Germany, it must extend to all of the Federal Government's decisions: "Innovation has right of way".

Innovation policy also cannot stop short at national boundaries. We are part of an European economic and research area that is constantly growing more influential. We need to significantly enhance our ability to help shape, and participate in, policy at the European level. In our European actions, we need to eliminate the weaknesses that result from our own federal and institutional cacophonies.

To create a viable, thriving culture of innovation, we need clearly defined milestones, along with appropriate budgets and incentive systems for strengthening existing lead markets and developing new ones. We will not be able to achieve our politically defined national goals for the energy and climate-protection sectors unless we find ways of mobilising considerably more public and private funding toward such ends. Furthermore, we need to create lead markets for new technologies, via national consensus. Public institutions and infrastructures can serve as showcases for new products "made in Germany", thereby enabling such products to succeed on the world market. Also, over the coming decade we will need additional 40,000 highly qualified engineers and scientists each year. We will not be able to train all of these new specialists ourselves. Via a concerted national effort, we must work worldwide to attract such people – i.e. we must recruit them with the sorts of attractive programmes that other countries have long had in place. We need to see that the changes underway are an opportunity.

Yes, we will need ideas, bright minds and money to move ahead on the road into a new economic and technological age. Perhaps even more urgently, however, we will need confidence and reliable commitments that persevere and persist even as each legislative period gives way to the next. The perspectives outlined here include guidelines and priorities for sustainable national research, innovation and economic policies, policies that move beyond addressing crises and set a course for strengthening German technology leadership in a changing world.

This paper highlights relevant visions, goals and opportunities; describes research requirements; and recommends specific courses of action in five central technology areas that will profoundly change our society, economy and daily lives by the time the coming decade is over. Significantly, the real bases for innovation in these areas consist of effective basic and applied research and the ability to control and continually build technology drivers. Germany's research sector is powerful in the areas of nanotechnologies, biotechnologies, optical technologies, microtechnologies and materials technologies. With these strengths, in combination with innovative production technologies and innovative services concepts, Germany can position itself as a leading systemic innovator in the central technological areas described in the following sections.

HEALTH 2020 – LIFE EXPECTANCY: A FULL CENTURY

In the coming decade, as a result of demographic trends, and a growing demand for high-quality health care, the various segments of German society will increasingly find themselves having to struggle to obtain shares of the health-care sector's limited resources. In efforts to minimise unnecessary treatment, a trend toward greater prevention will emerge, in all care processes. Integrated, individualised care concepts will tend to supplant the highly fragmented care structures of today. Much greater emphasis will be placed on viewing people and their needs holistically. Innovative technologies – such as process-supporting information and communication technologies and molecular medicine – will enhance efficiency in health care. The coming decade will witness the growth of molecular medicine, as well as an evolution toward patients' own individual responsibility, in their health care, and toward health monitoring. New technical and organisational structures will facilitate seamless, integrated and individualised patient services in the areas of prevention, diagnosis, therapy and care

ENERGY 2020 – CLIMATE-FRIENDLY AND AFFORDABLE

The next decade will bring radical changes in the areas of energy consumption, transformation, storage and distribution: solar and wind energy, as well as energy from renewable raw materials, will increasingly replace energy from oil and natural gas. At the same time, the primary aims in this area must include using non-renewable resources thriftily, reducing specific consumption and minimising energy losses. Innovative storage technologies can facilitate intensive use of renewable energies. Efficiency improvements, energy storage and widespread feeding of non-centrally produced energy into intelligent grids can contribute decisively to climate protection and to the development of a reliable energy supply.

SECURITY 2020 – PROTECTING INDUSTRY AND SOCIETY

Security for our publics, security for our data networks and security for our infrastructures – these will be among the greatest challenges over the coming decade. Innovative solutions, functioning reliably even in the face of disruptions and faults, can help us tackle these challenges. This is an area in which Germany can bring special strengths to bear.

MOBILITY 2020 – ON ONE'S WAY IN AN OPTIMISED MANNER

Over the next ten years, the global mobility networks moving people and goods will change profoundly. The various modes of transport we depend on, automobiles, railways, aircraft and ships, will be safe and fast, and they will become much more environmentally friendly – throughout a spectrum that will include sustainable production, relevant energy transformation and energy-efficient use.

COMMUNICATION 2020 – TEACHING THINGS TO SPEAK

Information and communication technology (ICT) will play an ever greater active role in value-creation processes. Intelligent networks will simulate, monitor and optimise products and systems – and protect themselves against threats. ICT, a cross-cutting technology, facilitates and accelerates many forward-looking developments.

These five topic areas define central problems and challenges for the coming decade – problems and challenges that offer great opportunities for our country. If we set the right course, we will move toward a bright future.

The members of the Industry-Science Research Alliance

10-POINT PLAN: WHAT THE POLICY, INDUSTRY AND SCIENCE SECTORS NEED TO DO

The following 10-point plan translates the ideas of the Industry-Science Research Alliance into key measures and tasks that the policy, industry and science sectors need to take in order to strengthen and promote research and innovation in Germany.

The Industry-Science Research Alliance recommends:

EMPHASISE CONSISTENCY IN INNOVATION POLICY.

In enacting research and innovation policy, policy-makers should emphasise overarching concepts and approaches, effective across all relevant departments, and seek to function as an integrated "innovation ministry".

The Industry-Science Research Alliance recommends:

CONTINUE TO ACT BOLDLY IN PRIORITISING RESEARCH FUNDING.

The Federal Government needs to press ahead, consistently and determinedly, with its efforts to prioritise its research support. In the process, it should concentrate and intensify its support on programmes oriented to lead markets and value-creation chains, in the following areas:

- Health – life expectancy: a full century
- Energy – climate-friendly and affordable
- Security – protecting industry and society
- Mobility – on one's way in an optimised manner
- Communication – teaching things to speak

At the same time, high-quality basic research should be safeguarded and promoted, and important technology drivers (such as production technologies, nanotechnologies, biotechnologies, optical technologies, microtechnologies, materials technologies) should be moved forward systematically.

In these technology areas of great relevance to society, research institutions and business enterprises should intensify their research and development co-operation. At the same time, they should provide adequate resources and infrastructures for the partnerships and cluster projects arising in such co-operation.

The Industry-Science Research Alliance recommends:

EXPAND INVESTMENTS IN THE FUTURE.

The state needs to expand its investments in education and research. The Federal Government and industry should work together toward the Lisbon goal of increasing research expenditures to a level of three percent of the country's gross domestic product.

To that end, the Federal Government should provide incentives to encourage industry to increase its expenditures on training, further training, research and development. Even during economically difficult times, business enterprises should remain explicitly committed to increasing their investments in research and development.

The Industry-Science Research Alliance recommends:

ELIMINATE LEGISLATIVE OBSTACLES TO INNOVATION.

Innovation-hampering laws and ordinances, such as provisions applying to "green" genetic engineering or taxation (interest barriers, losses carried forward, shifting of functions, etc.) need to be reviewed and adjusted as necessary. New draft legislation should be reviewed in light of its potential impacts on innovation in Germany.

The "Freedom of Science Initiative" („Wissenschaftsfreiheitsinitiative"), aimed at creating internationally competitive framework conditions for public research institutions, should be pursued further and refined. On all levels, policy-makers should continue to support greater autonomy for higher education institutions and research institutions.

Higher education institutions and research institutions, for their part, should make greater use, in the interest of efficiency and entrepreneurship, of the new freedoms available to them. In addition, they should apply incentives for the development of a vital, dynamic culture of innovation, oriented also to markets and real-world demand. To that end, they should avail themselves of the counsel and know-how of business enterprises. Conversely, business enterprises should increasingly include scientists in their own advisory bodies.

The Industry-Science Research Alliance recommends:

CRAFT AN INNOVATION-FRIENDLY TAX SYSTEM, AND PROVIDE TAX INCENTIVES FOR RESEARCH AND DEVELOPMENT BY BUSINESS ENTERPRISES.

The Federal Government should introduce tax-based promotion of research and development by business enterprises. In so doing, it would complement its thematic-focus approach in direct research support, with a thematically non-restricted, broadly effective instrument for companies of all sizes, in the interest of intensifying research and development in Germany.

The Industry-Science Research Alliance recommends:

STRENGTHEN INDUSTRY-SCIENCE CO-OPERATION, IN LASTING WAYS.

Strategic R&D partnerships between industry and science, in key technologies, need to be expanded. Companies should develop reliable, sustainable research strategies that enable science-sector partners to join with them in formulating long-term research goals. Higher education institutions and research institutions should reinforce their institutional strategies for co-operation, with the aim of being reliable, attractive partners in basic research, applied research and commercialisation.

Co-operation, and mutual understanding, between science and industry should be promoted especially through intersectoral exchanges – including temporary exchanges – of people. In comparison to other OECD countries, mobility between these two major areas is considerably underdeveloped in Germany. Policy-makers, industry and science should work together to promote and expand such mobility.

The Industry-Science Research Alliance recommends:

ENSURE ACCEPTANCE OF INNOVATION.

In co-operation with industry and science, the Federal Government should continue to promote the dialogue between science and society, with the aim of encouraging people of all ages in Germany to support and take an interest in education, research and innovation. For its part, the science sector should provide incentives that encourage scientists to look aside from their research and to take an active role in explaining science and communicating scientific findings. In their contacts to schools, higher education institutions and the general public, business enterprises should continue their intensive efforts to promote acceptance for science, foster enthusiasm for technology and encourage young people to enter science and engineering fields. In addition, they should participate in public discussion of controversial research issues.

The Industry-Science Research Alliance recommends:

ATTRACT PEOPLE TO RESEARCH AND DEVELOPMENT, AND PREPARE THEM FOR R&D CAREERS.

Working in co-operation with industry and science, the Federal Government should intensify its efforts, throughout all relevant areas, to counter shortages of highly skilled people. Such efforts should include measures to improve the quality of schools and higher education, to interest young people in technical professions, to develop the potential of women and of older employees and to improve the continuing education / further training system.

Without the help of highly qualified people from other countries, we will be unable to maintain our research and economic power. In light of this fact, the Federal Government should promote relevant immigration, via suitable campaigns and financial incentives programmes, and it should eliminate all bureaucratic and legal restrictions applying to immigration and permanent residence of highly qualified foreign employees. In addition, such efforts should not be limited to the academic realm; they should also focus on non-academic skilled people who show excellence in international comparisons. The overarching long-term aim of such efforts must be Germany‘s development into a knowledge society. Knowledge management – in both the entrepreneurial and societal realm – is thus a priority task for company managers and policy-makers alike.

Industry must intensify its in-company training, especially in areas in which shortages of highly skilled employees are expected. Via co-operation with higher education institutions, it must intensify its relevant efforts at the junctures between in-company training and academic education. To that end, it should provide pertinent know-how, infrastructure and adequate financial resources. What is more, industry needs to offer larger numbers of grants for academic education, especially for studies in “STEM” subjects (Science, Technology, Engineering, and Mathematics). Furthermore, the political sector should provide relevant additional incentives – for example, in the form of matching contributions for joint funding of grants.

The Industry-Science Research Alliance recommends:

BUILD GERMANY'S ABILITY TO INFLUENCE AND PARTICIPATE IN EUROPEAN RESEARCH POLICY.

Working in co-operation with stakeholders in Germany industry and science, the Federal Government needs to act quickly to intensify its dialogue with the European Commission, with the aim of ensuring that Germany has suitable influence on the design of the European Commission's Eighth Framework Programme for Research (FP8). In the process, it should work especially to ensure that fair terms apply with regard to financing (full-cost accounting) and to protection of intellectual property of research institutions. In addition, the Federal Government should continue to support introduction of the European Community patent.

The Industry-Science Research Alliance recommends:

INTERNATIONALISATION OF RESEARCH AND DEVELOPMENT: EXPLOIT THE OPPORTUNITIES FOR GERMANY.

Barriers to mobility need to be eliminated, with the aim of promoting and facilitating international exchanges of students and researchers. In the interest of intensifying international co-operation, developing knowledge and encouraging foreign investments in German research institutions, the Federal Government should support research institutions in their efforts, in co-operation with industry, and for the benefit of the German innovation sector, to open branch offices and locations in leading foreign knowledge societies and in growth centres of newly industrialized countries.

With regard to negotiations for world-wide harmonisation of patent laws, industry and science should agree on a joint approach that takes equal account of the interests of researchers and business enterprises.

1 THE HIGH-TECH STRATEGY. WHAT HAS BEEN ACHIEVED SO FAR

Since adopting its High-Tech Strategy, in August 2006, the Federal Government has been working to enhance Germany's position as one of the world's most research-intensive and innovation-intensive countries. Germany certainly has favourable indicators for such enhancement. It has an outstanding basis in the global competition. Germany is among the global leaders in exports, and its research output is one of the best world-wide. Industrial production, as a share of gross domestic product, is higher in Germany than in all other leading industrialised countries. Our sources of value creation are more varied than those of other highly developed countries, and our entrepreneurial landscape boasts a great variety of different sectors, fields and company structures. In its breadth, our science system serves as a model for other countries. In its peaks of excellence, it continues to develop at a world-class level, via investments in key focus areas, via co-operation and via suitable profile formation.

With its High-Tech Strategy, the Federal Government is pursuing the following main aims:

- Creating lead markets – markets in which Germany can develop global competitive advantages;
- Strengthening industry-science co-operation;
- Making the relevant framework more innovation-friendly;
- Working toward the "three-percent goal". "Three percent" refers to the level that R&D investments should reach, as a share of gross domestic product, in the interest of the EU's Lisbon goal of becoming the world's most competitive, most dynamic knowledge-based economic area by the year 2010.

The important partners in implementing that strategy include the Industry-Science Research Alliance. A group of experts, representing the areas of policy, industry and science, the Industry-Science Research Alliance is supporting implementation of the High-Tech Strategy by providing relevant advising. The group's members are all "multipliers" within their own companies, associations and institutions. As "promoters", they take responsibility for studying one or more of 17 defined fields of innovation, and of other cross-cutting topics within the High-Tech Strategy. They assess the fields' and topics' focuses and propose pertinent new initiatives.

From the perspective of the Research Alliance's members, there is no doubt that the measures undertaken to date within the High-Tech Strategy have provided important impetus for the further development of innovation in Germany.

For example, state and business-enterprise R&D investments have risen continuously over the last few years. In 2007, the business-enterprise sector's R&D expenditures were up 2.8 percent over their level in 2006, reaching a total of EUR 53.5 billion. According to provisional figures, business enterprises' R&D expenditures in 2008 amounted to EUR 56.8 billion, representing a significant increase – 6.2 percent – over 2007. And an increasing trend is apparent in state expenditures on research and development. In the current legislative period, the annual R&D expenditures foreseen in the federal budget have increased by a full EUR 3 billion. In 2006, the state (the Federal Government and the Länder) spent a total of EUR 17.6 billion on research and development, thereby increasing its expenditures in this category over their 2005 level (EUR 17.2 billion). In 2008, the Federal Government alone invested some EUR 11.2 billion in R&D, or nearly 25 percent more than in 2005 (EUR 9 billion). A total of over EUR 12 billion in federal expenditures are planned in this category for 2009. As a result, the Federal Government is providing more funding for research and development than it ever has in the past.

The Federal Government and the Länder governments have also made key decisions in this area with regard to the future: in their "Pact for Research and Innovation", the Federal Government and the Länder have committed to increase funding for research institutions by three percent annually until 2010. In return, the country's major research institutions have made a number of commitments of their own, including a commitment to expand collaborative research networks and co-operation with industry.

LEAD MARKETS: THE SEED HAS BEEN SOWN, AND THE FIRST SEEDLINGS HAVE APPEARED.

The High-Tech Strategy is providing palpable impetus for the formation of lead markets. For example, a total of nine innovation alliances, linking the research, science and industry sectors, have been formed, with relevant financial commitments totalling EUR 3.8 billion. Of these commitments, industry is providing some EUR 3.2 billion, or nearly 84 percent. In addition to their orientation to development of lead markets, innovation alliances tend to feature disproportionately large financial commitments by industry. Examples of innovation alliances for which this is true include the alliances "Lithium-Ion Battery LIB 2015", "European Initiative 100 GET" and "CarbonNanoTubes". In each of these alliances, the investments provided by industry amount to at least six times those provided by the public sector.

INDUSTRY-SCIENCE CO-OPERATION: MORE LIGHT THAN SHADOW.

For a number of years now, industry-science co-operation in Germany has been setting standards, internationally, in terms of monetary levels: In 2005, industry channelled a total of EUR 1.1 billion (11 percent) of its external R&D expenditures to universities, and EUR 1 billion (10 percent) of such expenditures to non-university research institutions. As a result, a total of 14.1 percent of all research in the higher-education sector was industry-financed. That percentage figure for industry-financed research is considerably higher than the relevant OECD average, which amounted to 6.2 percent for the same year. In addition, "strategic partnerships" were initiated as a new concept for co-operation between industry and science. And this concept continues to benefit industry-science interaction.

In the framework of the High-Tech Strategy, new impetus for improved co-operation has resulted from the competitions "Exchange processes between business enterprises and universities" („Austauschprozesse zwischen Unternehmen und Hochschulen"), "Industry meets Science" ("Wirtschaft trifft Wissenschaft") and "Top-Cluster Competition" („Spitzenclusterwettbewerb"). With these competitions, the High-Tech Strategy has significantly improved co-operation between industry and science.

With the innovation competition "Industry meets Science" („Wirtschaft trifft Wissenschaft"), the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) is promoting new approaches for improved transfer of scientific and technical innovations into commercial applications, in the new German Länder. In this effort, a total of 32 innovative projects are receiving support, amounting to EUR 250,000 to 500,000 in each case, for a three-year period.

The "Top-Cluster Competition" of the Federal Ministry of Education and Research (BMBF) has chosen five excellent clusters as especially good examples of close, effective co-operation between industry and science. Over a period of five years, the clusters will receive a total of up to EUR 200 million to implement their strategies and to carry out research projects. A new competition round was launched in early 2009.

"SIGNO", an initiative of the Federal Ministry of Economics and Technology (BMWi), supports higher education institutions, business enterprises and independent inventors in legally protecting and in commercialising their innovative ideas. To date, the initiative has extended support to a total of over 6,000 small and medium-sized enterprises (SMEs) and start-up entrepreneurs. Since 2008, the programme has also provided support for institutional commercialisation strategies of higher education institutions.

In the competition "Processes for exchange between business enterprises and universities" („Austauschprozesse zwischen Unternehmen und Hochschulen"), the BMBF, working in co-operation with Stifterverband für die Deutsche Wissenschaft („Stifterverband"), the "business community's innovation agency for the German science system", has honoured and promoted outstanding global strategies, of six higher education institutions, for engaging in exchanges with business enterprises. The competition has revealed that many higher education institutions are now well-positioned, in terms of both strategy and organisation, to meet the requirements applying to co-operation with companies.

New solutions to issues of intellectual-property protection and rights of use, in the context of research co-operation, and for creation of greater latitude for scientific endeavours, provide further opportunities for achieving synergies by linking industry-sector and science-sector resources.

In addition, the available support instruments need to be further simplified and streamlined, especially with regard to participation of small and medium-sized enterprises (SMEs) in public research projects. Complex, lengthy application procedures for such participation continue to hinder innovation in this area. This is apparent, for example, in that the number of SMEs participating in R&D has not grown significantly, in spite of the new instruments available under the High-Tech Strategy.

STAYING THE COURSE.

Via an overarching approach that is unprecedented in working across all relevant departments, the High-Tech Strategy concentrates the Federal Government's innovation strategy. This approach has been broadly acclaimed throughout the industry and science sectors, as well as at the international level.

In the High-Tech Strategy, the Industry-Science Research Alliance sees a major opportunity to enact co-ordinated, interdepartmentally effective innovation policy. Such co-operation has already succeeded in a number of innovation areas defined within the context of the High-Tech Strategy (for example, in the areas of services and security, but not yet in plant biotechnology and in tax laws). In light of the dramatic global challenges prevailing in other areas (such as the areas of climate, environmental and energy research), Germany will have no alternative but to develop and refine national strategies that amount to more than simply a co-ordinated sum of individual departmental approaches. For development and useful application of such strategies, additional orchestration will be required, in both future conceptual efforts and in specific operational implementation of state funding policies.

What is more, a largely positive assessment results if one measures the High-Tech Strategy's success in terms of the extent to which all stakeholders in the relevant innovation areas have been mobilised. Integration of all stakeholders, in both programme formulation and in operational implementation, is a central structural element of the country's national security

research programme. Positive examples of ways in which the High-Tech Strategy is being specifically implemented within the various innovation areas, beyond the defined bounds of the Research Alliance, and being given a broad, lasting basis, include the establishment of the bio-economics research and technology advisory board („BioÖkonomieRat“) and of the “Taskforce Services”.

In enacting its High-Tech Strategy, the Federal Government has taken an important, decisive step in the right direction and provided important impetus. Germany‘s research and innovation resources have great potential, and the key now will be to continue working to enable this potential to be applied, fully and optimally, to the global challenges facing us.

2 CONTRIBUTIONS OF RESEARCH AND INNOVATION TO SOLVE GLOBAL CHALLENGES

2.1 Health 2020 – life expectancy: a full century

In the coming decade, as a result of demographic trends, and of growing demand for high-quality health care, the various segments of German society will increasingly find themselves having to struggle to obtain shares of the health-care sector's limited resources. In efforts to minimise unnecessary treatment, a trend toward greater prevention will emerge, in all care processes. Integrated, individualised care concepts will tend to supplant the highly fragmented care structures of today. Much greater emphasis will be placed on viewing people and their needs holistically. Innovative technologies – such as process-supporting information and communication technologies and molecular medicine – will enhance efficiency in health care. The coming decade will witness the growth of molecular medicine, as well as an evolution toward patients' own individual responsibility in their health care and toward health monitoring. New technical and organisational structures will facilitate seamless, integrated and individualised patient services in the areas of prevention, diagnosis, therapy and care.

The progress achieved in modern molecular biology research is giving indications of feasible new forms of diagnosis, prevention and therapy which, in some cases, are even already ushered. This trend can be expected to have a sustainable impact on our health-care system, as research in molecular biology and genetics continues to be supported and continues to produce important findings. Even as such progress continues, however, the occurrence of degenerative chronic disorders – and, thus, of chronic disorders requiring treatment – will increase. And as a result of demographic trends, issues of the affordability of needed – and potentially available – health-care services are becoming increasingly urgent. Expenditures on health-care services are expected to triple in industrialised countries by the year 2020. In the U.S., such costs are expected to reach about 20 percent of the country's gross domestic product, while in other OECD countries they are forecast to reach some 16 percent of GDP. Experts expect that most national health-care systems will be unable to survive the next 15 years.

No end of the cost explosion is in sight. Today's changed lifestyles, including unhealthy diets and lack of exercise, are boosting the frequency of metabolic disorders such as diabetes. Global mobility is driving the spread of infectious diseases, including both new diseases and diseases that were once thought to have been completely defeated. Allergies are becoming increasingly common. In addition, as average life expectancies increase, the frequency of chronic disorders, and the probability of multiple disorders, are increasing in older people.

Germany has an outstanding basis to cope with such challenges: Germany has a strong and diversified chemical industry, producing innovations such as innovative materials for medical technology; a pharmaceutical industry with a grand history and innovative medications; and a broadly diverse biotechnology sector that develops completely new concepts in treatment and diagnosis. All of these assets represent advantages that need to be reinforced, concentrated and interlinked, with a view to developing suitable new solutions.

The answer to many of the challenges facing us in the health-care sector lies in specifically targeted, individualised prevention. This insight arises from the vision for the "mature citizen", i.e. the citizen who, on the whole, takes much greater responsibility for protecting his or her own health than most members of our society now take. The motto for this approach is "health management" – not "disease management". The aim is to prevent diseases, rather than having to cure them.

When a patient falls ill nonetheless, in spite of all precautions, the vision also calls for his or her doctor to be able to administer medications that are tailored to his or her individual genetic make-up, and thus are both effective and free of side-effects.

If this vision of health protection is to become a reality, new care concepts will be required, throughout a spectrum ranging from provision of individualised, specific information and advising to regeneration. At the same time, stakeholders will have to focus on the society as a whole and to take interdisciplinary, interdepartmental and cross-cutting approaches in making relevant decisions. Future economic perspectives will have to focus not just on the direct costs of health care (medications, visits to the doctor, etc.) but also, and increasingly, on the relevant indirect costs, which can often be considerably higher. The latter include reductions in productivity, for example – a centrally important factor in any economic study of the health-care sector.

DIGITAL INFRASTRUCTURES HELP REDUCE THE COSTS OF HEALTH-CARE SERVICES.

Systematic, interoperable use of state-of-the-art information technologies, in conjunction with greater intra-institutional and inter-institutional networking, opens the way to greater efficiency, integration, comparability and knowledge transfer in all clinical and administrative processes. Telemedicine could be of great use in providing affordable medical services to the millions of Germany's citizens who suffer from chronic disorders such as cardiac insufficiency or diabetes.

BIOMEDICINE OPENS UP NEW OPPORTUNITIES FOR PREVENTIVE MEASURES.

Future research and development will focus especially on early diagnostics at the molecular level – with the help of state-of-the-art medical technology such as modern laboratory diagnostics and imaging procedures – and development of new forms of therapy.

The new possibilities inherent in molecular-based preventive medicine are of fundamental importance. Our knowledge of the molecular mechanisms by which diseases develop, and of the genetic changes that correlate with higher risks of disease, is still rudimentary. Major prospective population studies – conducted on Germany-wide and Europe-wide levels – play a useful role in this area. If we are to meet the complex challenges of determining the causal links between specific genetic changes and specific progressions of disease, we will have network system-biological research at the global level. Such research will make it possible to identify markers for specific disease risks, to diagnose diseases in their very early stages and to predict therapies' success rates and likely individual long-term outcomes.

INDIVIDUALISED MEDICINE OPENS THE WAY FOR EFFECTIVE REGENERATION.

Since each and every person is a unique individual, medical care should be individually adaptable. Along with individualised preventive and diagnostic measures, new individualised procedures in regenerative medicine (such as tissue engineering), and individually adjustable medical equipment, are helping to restore and safeguard human health. As an added benefit, individualised medicine's role in facilitating regeneration can also help cut costs.

Efforts to provide relevant information and foster awareness lay a foundation for the health-oriented preventive efforts that people can undertake under their own responsibility. Consequently, medically reliable, cost-effective means of providing information and advising (including susceptibility-oriented counselling) need to be developed.

HELPING SENIOR CITIZENS STAY INDEPENDENT LONGER.

Demographic trends in Germany call for new and better ways of enabling senior citizens to stay independent longer. Experts foresee a growing demand for useful, practical solutions that can help elderly persons, and those otherwise in need of assistance, stay independent in their everyday lives. Such solutions, grouped under the term "Ambient Assisted Living", could well include such innovations as robots.

ESSENTIAL POLICY ACTIONS:

1. **Promote biomedical research.**
   It is vitally important to provide effective, targeted support for molecular-biology, cell-biology and genetic research that can enable the full potential of molecular medicine to be realised in human health care. To that end, the various project-support initiatives underway need to be effectively co-ordinated, and new programmes need to be launched in areas lacking project support.

2. **Obtain needed basic information.**
   Major national cohort studies play a key role in enhancing individualised risk determination, early detection and prevention. They are indispensable, long-term investments in epidemiology and preventive medicine. The necessary bases for such studies, with regard to structures and financing, need to be provided.

3. **Develop disease-specific research networks.**
   The priority research areas in which such networks should be established include cancer, cardiovascular disorders, metabolic disorders, neurodegenerative diseases, infectious diseases, asthma, allergies and autoimmune diseases. Such research networks must also include translation centres that facilitate activities "from bench to bedside and back to bench". If Germany is again to become "the world's pharmacy", pharmaceutical development needs to be promoted via strategic partnerships.

4. **Act jointly.**
   Suitable policies that strongly promote translation and prevention research – or even make such research at all possible – can succeed only through concerted efforts and partnership by stakeholders from the Federal Government, the Länder and the industry and science sectors. In such research networks, industry and science must work hand-in-hand, from the outset, via public-private partnerships.

5. **Optimise management of health-care facilities.**
   In patient treatment today, costs are often greatly increased via unnecessary repetition of examinations and diagnostic measures and via redundancy in medication regiments (resulting, for example, from combination of prescriptions by different medical specialists or from different hospital stays). Unified management of patients' cases thus can benefit patients, doctors and the health-care sector as a whole. Introduction of electronic patient records is a first step toward such management, and an indispensable part of cost-cutting in this sector.

6. **Determine the benefits of new diagnostic methods.**
   Research into new diagnostic methods, therapies, medical imaging procedures, etc. should increasingly be supported by medical-economic studies. The aim of such an approach is to ensure that new technologies and methods slated for introduction are assessed in terms of both their potential medical benefits and likely economic impacts. Such an economic perspective, for example, would consider the impacts of more precise diagnostics on related, subsequent care steps, such as therapy and rehabilitation. A clear understanding of a new advance's benefits, with regard to the relevant overall process,

can facilitate and accelerate the advance's market penetration. In general, therefore, such understanding can enhance success rates in translation of inventions into innovations.

7. Give priority to prevention.
To date, preventive measures are still being undervalued in assessment of medical services and in new research projects. If the aims for the country's health-care sector are to be achieved, substantial and organisational repositioning towards prevention is necessary.

8. Ensure access to innovation.
Extensive deregulation will be needed in order to facilitate access to innovations and to make innovations as widely available as possible. Medical and medical-technology innovations must be made available to patients as rapidly as possible – although, needless to say, such efforts must not be permitted to compromise patient safety. Lengthy certification procedures need to be reviewed with regard to their necessity. This need is especially great for procedures applying to new, highly specific diagnostic tools, whose translation "from bench to bedside" is often hampered by the high costs of extensive clinical studies.

2.2 Energy 2020 – climate-friendly and affordable

The next decade will bring profound changes in the areas of energy consumption, transformation, storage and distribution: solar and wind energy, as well as energy from renewable raw materials, will increasingly replace energy from oil and natural gas. At the same time, the primary aims in this area must include using non-renewable resources thriftily, reducing specific consumption and minimising energy losses. Innovative storage technologies can facilitate intensive use of renewable energies. Efficiency improvements, energy storage and widespread feeding of non-centrally produced energy into intelligent grids can contribute decisively to climate protection and to the development of a reliable energy supply.

The challenges are enormous: according to forecasts of the International Energy Agency (IEA), the world's energy requirements will grow by 50 percent by the year 2030. Experts predict that we will use more electricity in the next 25 years than humans have used throughout the entire period since the beginning of industrialisation. The dilemma inherent in this trend is that industry, households and the transport sector now obtain over 80 percent of their primary energy needs from fossil fuels – from resources that will be in ever-shorter supply.

Germany's economic performance, employment levels and public prosperity are linked fundamentally to the country's access to

a safe, reliable, efficient and environmentally compatible supply of suitable, affordable energy – and to its ability to use energy efficiently. And improvement of demand-side energy efficiency holds the greatest potential for reducing energy consumption.

The Federal Government has defined ambitious aims in this area, at both the national and international levels. Its aims are so ambitious that they cannot be reached via marginal product improvements. Radical innovation, and new approaches in energy re-search, are needed. Energy research must provide environmentally compatible, climate-friendly and affordable solutions for the entire society and its requirements – throughout the entire spectrum of energy use, including electricity production, low-emission mobility and low-CO_2 housing. In the framework of a balanced energy mix, existing technologies need to be improved, and new options need to be developed. From a current perspective, we cannot afford to ignore any available technological option – including nuclear power.

We must develop technologies that

- facilitate sustainable resources extraction and production;
- reduce energy consumption, including consumption of electricity, heat and fuels, in all applications;
- make energy transformation, and especially electricity production, more efficient;
- support decentralised grid feed-in, transport and distribution of electricity and heat, with lower losses, even over large distances; in this context, integration of decentralised and renewable energy sources will play an increasingly important role;
- enable cost-effective storage of large amounts of electricity.

GERMANY HAS OUTSTANDING TECHNOLOGICAL RESOURCES.

In general, with its many internationally competitive science institutions and industrial sectors, and its know-how in the areas of energy efficiency and climate protection, Germany is in an outstanding technological position. Its highly capable industrial sectors include energy, chemicals, electrical engineering, machine tools, optical engineering and software. German companies in these sectors are extremely well-connected and integrated within their various value-creation chains and with the country‘s internationally renowned science institutions. Examples include innovation alliances, within the framework of the High-Tech Strategy, for organic light-emitting diodes (OLED), lithium-ion batteries and organic photovoltaics. Long the world‘s leading exporter of industrial products in general, Germany now needs to become the world‘s leading exporter of highly efficient products and technologies for energy use, transformation, storage and distribution. Energy research can thus be expected to contribute decisively to the further development of Germany‘s high-technology sector.

RENEWABLE ENERGIES WILL NOT BECOME WIDELY ADOPTED UNTIL THEY ARE COST-EFFECTIVE.

In the area of renewable energies, energy research is focussing especially on making such energies economically competitive as rapidly as possible. The key topics in this area include reducing the costs of producing electricity with solar-thermal, photovoltaic, ocean-energy and wind-energy systems, and lowering the costs of producing electricity and heat from biomass and geothermal energy.

Care must be taken to ensure that use of renewable raw materials for fuel production, electricity production and industrial applications does not threaten the world‘s food supply. To this end, a second “green revolution”, making use of all available technological options, is needed.

High-performance energy-storage systems are a key basis for use of renewable resources. And unless dramatic advances in energy efficiency are made, renewable energies will never be able to satisfy the world‘s energy hunger. Consequently, we need to greatly improve the efficiency of our energy-storage systems. In light of renewable energies‘ growing share of overall electricity production, high-performance batteries need to be developed. The types of storage systems needed include both lightweight batteries with high energy densities, for electric cars, and large battery systems for storing electricity generated from wind and solar energy.

INTELLIGENT GRIDS ARE A KEY TO FLEXIBLE ENERGY-SUPPLY STRUCTURES.

Integration of fluctuating, highly decentralised energy sources will necessitate high-performance, flexible and intelligent energy grids. Improvements in power electronics, and in communications and control technologies, will help optimise management of the overall energy-supply system (including production, transmission, distribution and use).

At the same time, use of more energy-efficient systems, in both the industrial and small-consumer sectors, has the potential to reduce energy losses greatly, thereby cutting both costs and emissions on a large scale.

ESSENTIAL POLICY ACTIONS:

1. **Establish a comprehensive energy-research programme.**
   All stakeholders in this area should perceive energy research as a holistic combination of technological and economic research, and not reduce it to fragments such as resources research, CO_2-reduction research and efficiency research. Rather than multiple, different, departmentally driven energy-research programmes, our society needs a comprehensive national energy programme. Ideally, overall political responsibility for energy research should be defined by combining individual responsibilities.

2. **Make energy efficiency a central research topic.**
   In the interest of efficient, environmentally compatible and sustainable energy use, we need research and innovation in the areas of industrial process engineering; building technologies (improvements in energy efficiency of building skins, improved thermal insulation, greater use of renewable energies, optimised building-services systems and lighting systems); and mobility systems (internal combustion and electrical drive systems, alternative fuels.

3. **Give the primary energy supply a broad basis.**
   In the long term, the primary-energy basis for fuel production needs to be as broad as possible. New techniques for sustainable production of fossil fuels; new types of fuels (renewable raw materials, natural gas, gas hydrates, synthetic fuels, hydrogen); and alternative forms of energy production all need to be studied in terms of their overall

carbon footprints, throughout the spectrum from production to consumption, and in terms of their technical manageability and long-term availability. Those research ideas that are most promising, in terms of both economics and ecology, should then be developed to market maturity. Power-plant technologies need to be improved with a view to more efficient, environmentally compatible production of electricity and heat, in a process that must include further improvement of overall CO_2 efficiency and development of low-CO_2 power plants. Study and consideration of the various available forms of electricity and heat production must be unbiased and impartial, and their use should be optimised on the basis of scientific criteria.

4. Develop interdisciplinary solutions.
Energy research draws heavily on advances in a range of different fields. It must thus include, and closely interconnect, basic research and applied research and development. The especially important areas of energy research include materials and tools for the various electricity-production technologies; catalysis research for energy-efficient production processes; biotechnological research for provision and use of renewable raw materials; and software research for intelligent system solutions.

2.3 Security 2020 – protecting industry and society

Security for our publics, security for our data networks and security for our infrastructures – these will be among the greatest challenges over the coming decade. Innovative solutions, functioning reliably even in the face of disruptions and faults, can help us tackle these challenges. This is an area in which Germany can bring special strengths to bear.

The security technology of the next decade is currently being developed in Germany. For example, operators of Berlin‘s new main airport, Berlin-Brandenburg International (BBI), which is to begin operations at the end of 2011, plan to use innovative, interoperating technologies to provide an unprecedented level of security. The airport‘s terminal is to be equipped with a comprehensive security-management system. Self-configuring networks for the airport‘s apron and hangar areas will boost security in traffic monitoring and control. New techniques for guiding streams of visitors, for baggage handling and for co-operation between security agencies will enhance the effectiveness of security measures and help protect the security system against disruptions. These plans, currently a vision, have every chance of becoming reality.

The basic element needed for moving such developments forward is a good infrastructure – an infrastructure, for example, like the one Germany already has in place. With that resource, we have a decisive edge, one that we must seek to protect and build on in the future.

"Resilience" is the term that experts use to describe a system's ability to withstand disruptions and to regain its stable function or structure by adjusting itself. In the field of security technology, development and installation of such systems can be expected to receive top priority world-wide over the next decade. The tasks of security research include developing the methods, processes and technologies needed for resilient, fault-tolerate and robust security infrastructures.

A Delphi study carried out by the Fraunhofer Institute for Systems and Innovation Research (ISI), in the framework of the FAZIT research project, outlined the broad range of security systems and measures – including biometric access controls for public buildings and workplaces; continuous surveillance of public spaces, in the interest of crime prevention; extensive collection and evaluation of private data, for purposes of fighting crime – that would possibly or probably be in use by the year 2020. Such measures will meet with broad acceptance only if their necessity and benefits for individual citizens are apparent, however.

PROTECTION FOR THE ECONOMY AND FOR SOCIETY.

A resilient, robust basic security structure provides citizens with a high level of security and economic prosperity. For industry, it provides a stable, reliable and efficient operating environment. Such a security structure thus enhances Germany's position as an economic centre.

SECURITY TECHNOLOGY STRENGTHENS GERMANY'S SME SECTOR.

World-wide, the security industry has been growing at rates of three to four percent. In Germany alone, companies in central security sectors generate revenue of some EUR 10 billion. Germany's security sector, in which small and medium-sized enterprises (SMEs) play a key role, can realize enormous market success by providing innovative technologies. Germany's industrial and research resources in the area of security technologies, along with the country's well-developed infrastructure, provide an excellent basis for developing the country's security sector with a focus on resilience.

ETHICAL, PSYCHOLOGICAL AND LEGAL ASPECTS ARE KEY FACTORS.

Modern security products and systems will become part of every citizen's everyday life. The broad public acceptance that will be needed for the establishment of such systems can be achieved only if development of such systems takes account of relevant ethical, psychological and legal aspects, as well as aspects of straightforward technical feasibility. Therefore, such non-technical research areas must be given their rightful place in development of resilient security systems; in each case, the potential impacts on citizens must be studied and taken into account. In addition, relevant public discussion must be carried out, with the aim of introducing security technologies in forms that the public accepts.

ESSENTIAL POLICY ACTIONS:

1. **Take a role in shaping the future.**
   In light of the importance of security technologies and their use in Germany, Germany must take an active role in influencing and shaping a) European planning on security technologies and b) relevant market development.

   The European Commission has already initiated planning for the orientation of its security research over the next two decades. The focuses of the planning include the development of a "European Security Market" and of European security standards for relevant products.

2. **Actively shape and develop the market.**
   For civil-security research in Germany, inclusion in the list of priority areas under the High-Tech Strategy represents a breakthrough. The BMBF's first-ever research programme for civil security has been launched simultaneously with the security research programme within the European Commission's Seventh Framework Programme for Research (FP7). This gives German stakeholders in the areas of industry, research and government authorities the opportunity to apply the competencies and know-how they have acquired in the national programme to their participation in the competitive European market for security products and technologies.

3. **Continue pursuing scenario-oriented approaches.**
   Orientation of security research to scenarios – such as situations in which large crowds of people have to be protected and rescued, or in which supply infrastructures threaten to fail, with cascade effects – is a highly promising approach. Such an approach is especially useful and viable in combination with overarching topics, such as "emergency-response forces of the future" or "universal detector systems". It thus needs to be developed and pursued, in co-ordination with European activities, and made into an ongoing effort via continuing programme-based support and control, with the participation of research partners.

4. **Build networks that integrate all partners.**
   To achieve this goal, Federal and Länder authorities, relevant regional institutions, the private sector and pertinent European and international institutions will all need to co-operate closely.

5. **Link technology areas with each other.**
   Security research and technology need to be closely linked with developments and applications in the areas of energy, mobility, health and communications. Security aspects play a key role in the success and long-term viability of applications in these areas. Innovative self-repair concepts, redundancy, new IT technologies, new materials, new microelectronics and microsystems technologies (in areas such as robotics, biometry, sensors), etc., can all play important roles in this context.

6. Help define standards.
Industry-policy decisions and market impacts emerge with the help of new standards. For this reason, Germany needs to take a role in standardisation, especially in connection with the planned “European Security Label”. In the framework of the security research programme, for example, representatives of German interests should be involved in this process by calling for project proposals in the area of standardisation.

2.4 Mobility 2020 – on one’s way in an optimised manner

Over the next ten years, the global mobility networks moving people and goods will change profoundly. The various modes of transport we depend on, automobiles, railways, aircraft and ships, will be safe and fast, and they will become much more environmentally friendly – throughout a spectrum that will include sustainable production, relevant energy transformation and energy-efficient use.

In countries such as Germany, the transport sector currently accounts for some 30 percent of total primary energy consumption. Over the next decade, the relative importances of the different energy sources involved in that consumption will shift. Industrialised countries around the world are now promoting electrical drives, for example. Via a “National Electromobility Development Plan”, which the Federal Cabinet is slated to approve, Germany plans to become a lead market for electromobility in the next ten years. By the year 2020, one million electric cars may well be moving on Germany‘s roads. By 2050, virtually all traffic in Germany‘s cities could be fossil-fuel-free.

Germany‘s people are ready for such a transition: according to a study commissioned by the Federal Ministry of Transport, Building and Urban Affairs (BMVBS), 79 percent of Germany‘s citizens consider it important or very important, with regard to their own personal lives, for transports to be climate-friendly. A total of 98 percent of all respondents expect the political sector to promote new technologies aimed at lowering automobile fuel consumption. And they expect industry to invest in technologies that can make transports more climate-friendly.

The EU's climate-oriented requirements are providing the framework: in the coming decade, automakers will have to comply with clearly defined greenhouse-gas limits on the new vehicles they produce.

Such requirements for the automotive industry, as well as for infrastructures and mobility concepts, can be met only through research and development. A range of different approaches are now available:

NEW DRIVE TECHNOLOGIES AND INNOVATIVE MATERIALS CAN MAKE MOBILITY SUSTAINABLE.

The key areas in which the German automotive industry is working in this regard include sustainable mobility, especially electromobility and hybrid drive systems. Efficiency improvements in vehicles and their drive systems can also be achieved via lightweight construction, use of intelligent materials, use of new, innovative energy-storage systems and use of state-of-the-art power electronics. In this context, special technologies will be needed for production of new components for electric and hybrid drive systems. New recycling systems will also be required. Only with the help of such new technologies and systems will the German automotive, machine-tool and electrical engineering sectors, all strongly affected by the current crisis, be able to develop the great potential for value creation in the area of sustainable mobility.

The Advisory Council for Aeronautics Research in Europe (ACARE) has called for aircraft to use 50 percent less fuel, be 50 percent quieter and produce 80 percent fewer emissions by the year 2020. That goal represents an enormous challenge for the German and international aviation industries. In this area, Germany needs to develop its technology and innovation leadership by intensifying its relevant research – especially with an orientation to complete systems – and by intensifying its development of technologies for airframes and aircraft engines. In addition, Germany needs to be influencing European research programmes along these lines. Germany needs to take a role in ensuring that air-traffic growth takes place in accordance with criteria for ecological efficiency. And Germany's industry, research institutions, ministries and aviation sector must join together in contributing to such efforts.

INTELLIGENT SYSTEMS REDUCE FUEL CONSUMPTION.

Traffic jams on Germany's autobahns waste nearly 300 million litres of fuel per year, thereby emitting 715,000 tonnes of carbon dioxide. The answers to these traffic problems consist of new traffic-management technologies – including telematic systems; safe, cost-effective traffic-detection systems; digital models for traffic-situation determination and forecasting; mobility and traffic-information services; and passenger information and infotainment systems.

In addition, use of current and future global navigation satellite systems (GNSS) will spur innovation in services that require and exploit such systems' precision (dynamic route selection; security and logistics applications).

NEW CONCEPTS WILL ENHANCE LOCAL PUBLIC TRANSPORTATION SYSTEMS.

In 2007, Germany's citizens made a total of more than ten billion trips in trains, trams, busses and passenger ferries. Such statistics can be expected to climb even higher as reliability and service in transport systems improve. Key improvements in such systems include better scheduling and routing, fee concepts and billing systems.

OPTIMISED CONCEPTS ARE BOOSTING TRANSPORTS ON RAILWAYS AND WATERWAYS.

Future research in the railway sector can be expected to concentrate more strongly on product life cycles. This especially involves optimising costs and resources use in production, operation and further development of railway-transport systems. Another research focus is on ways of linking railway systems with other modes of transport; the degree to which they are so linked is a key factor in their success.

Globally, ships are the most important carriers of goods. Research in connection with ship transports needs to focus on ways of improving port systems, ensuring that they interface optimally with upstream and downstream logistics networks. In the area of new ship concepts, the key challenge is to harmonise safety, environmental and efficiency requirements with current special requirements pertaining to construction of cruise ships, naval ships, freighters and ferries.

ESSENTIAL POLICY ACTIONS:

1. **Emphasise new types of propulsion systems and innovative materials.**
   In the area of propulsion technology, innovative internal-combustion engines and hybrid-drive systems need to be studied, in connection with use of innovative materials. In municipal transports in particular, hybrid drive systems (employing such innovations as plug-in technologies) hold considerable promise for cutting fuel consumption and emissions. Other important research areas include vehicle, drive and energy concepts in which emissions-free drive systems are powered from on-board, high-performance electrical energy-storage systems. Relevant business models are yet another important focus of study. And hydrostatic and hybrid concepts, including electrical drive systems, have significant potential for use in mobile machines (agricultural machinery, construction machinery, conveyance systems) – potential that needs to be developed.
   In comparison to today's aircraft, the aircraft of the future will be lighter, quieter, safer and cheaper to operate. It can also be expected to provide higher levels of passenger comfort. To this end, relevant research in the areas of acoustics and cabin-climate control in aircraft needs to be moved forward. In the area of aircraft construction, further research must be devoted to innovative materials systems and propulsion technologies, with a view to enhancing the long-term environmental sustainability and cost-effectiveness of air transports.

2. Continue to build communications networks.
In keeping with visions for “intelligent infrastructures”, technologies for vehicle-infrastructure communication (Car-to-X) need to be developed; such technologies are needed as elements in traffic-management systems and in efforts to enhance traffic safety. Unlike GPS, Galileo, the European satellite navigation system, is not subject to military control. Galileo will be Europe‘s first unified system for localising persons and goods, for purposes of industry, commerce, transports and mobility. Use of this new system can be expected to usher in significant innovations. Relevant application-oriented research projects, with German participation, need to provide results that can serve as the global standard for future innovative services in this area.

3. Build and expand intelligent infrastructures and systems for all transport links.
Railways are important transporters of both goods and passengers. Via innovative solutions, obtained through study of economic production systems sited below the logistic level of complete-train transports, and innovative methods for analysing and carrying out integrated planning of intermodal transport chains, railway freight transports will make further – and necessary – technological advances.

In the area of passenger transports, the requirements imposed by an “ageing society” are becoming ever-present. At the same time, research efforts in this area are also on intermodal-transport information systems, including systems for guiding and informing passengers, municipal information systems and travel planning/assistance services. Further research needs to be conducted in the area of innovative solutions for improving passenger transfers – including both intramodal and intermodal transfers – and for optimising operational planning (computerised operational control systems) and maintenance.

2.5 Communication 2020 – teaching things to speak

Information and communication technology (ICT) will play an ever greater active role in value-creation processes. Intelligent networks simulate, monitor and optimise products and systems – and protect themselves against threats. ICT, a cross-cutting technology, thus facilitates and accelerates many forward-looking developments.

In today‘s world, ICT supports people in nearly all areas of everyday life and work. ICT systems make processes simpler and faster, and they provide comprehensive information for decision-making. ICT systems, including their embedded software systems, open the way to intelligent products and processes with new features and characteristics – to products and processes that give Germany decisive advantages in global competition.

As time passes, more and more machines and systems will “learn” to communicate with each other. The arrival of the next-generation Internet, with its key improvements, will ensure the continued availability of a high-performance basic infrastructure for many applications and services that entire economic sectors already depend on today. In future, intelligent, self-repairing networks will autonomously detect failures and security-relevant attacks and take measures to enable operations to continue smoothly.

A widely available, high-performance infrastructure will play a crucial role in meeting requirements for international data transports between suppliers, customers, company locations and

co-operating partners. At locations without fixed infrastructures, dynamic, self-configuring ad-hoc networks will transport information.

THE INTERNET IS CONQUERING NEW WORLDS.

In more and more areas, companies will depend on the Internet as a powerful, cost-effective medium for data transport. As the "Internet of things", it will use radio-frequency identification (RFID) technology to guide material streams – for example, to ensure that transport containers reach their destinations. As the "Internet of services", it will organise and automate services of all kinds – including eGovernment services.

In future, products will be endowed will electronic memories. Producer relationships, supply chains and environmental factors will all become more transparent as a result.

The "Internet of services" will provide the basis for Germany's continued exporting success in the areas of automation, the automotive industry, energy technology, logistics and medical technology. New, resources-efficient processes – for business, production and transport – will become feasible in combination with innovative products equipped with embedded software systems and able to communicate securely with other products.

MANAGER FOR ENERGY AND SUSTAINABILITY.

With the help of new hardware and software solutions for intelligent energy management in IT components ("green IT") and other types of devices, ICT can help reduce energy consumption. Complex algorithms for load distribution, and sophisticated control software, will support continuous management of large numbers of different, small renewable-energy producers. New forecasting systems, able to "learn", will determine consumers' energy requirements and optimise energy use. Comprehensive economic simulations will identify future requirements of the society as a whole.

ENABLER FOR NEW CONCEPTS IN HEALTH.

Demographic changes in our society are creating a need for new concepts in the various areas of care and personal assistance. At the same time, they are creating new markets. "Ambient Assisted Living" (AAL) comprises technologies for enabling elderly and ill persons to continue to lead relatively normal lives in their own homes, in spite of needing care and assistance. The term also covers a wealth of new services that can help make the lives of healthy older people more comfortable and pleasant.

In a near future, innovative combinations of new, non-invasive sensors, secure ad-hoc communications platforms and intelligent data analysis will monitor the health of many persons – including healthy persons – make relevant, individualised recommendations and issue warnings whenever negative trends or critical situations arise.

SOLUTIONS FOR MORE SECURITY

Systematic security analyses can call business enterprises' attention to inherent risks in their business processes. Holistic security engineering can then be used to develop suitable solutions and recommendations. In the future, self-configuring sensor networks and mobile surveillance systems will monitor sensitive areas, critical infrastructures, entire buildings and even large areas. They will be able to report any irregularities, thereby playing a valuable role in preventing, detecting and responding to disasters and attacks. In emergencies, they will provide emergency-response forces with valuable information on the overall emergency situation.

HELPERS FOR MORE MOBILITY.

Communications technology is playing a central role in advances in transports on land, on water and in the air. In this area, all available technologies for situation identification and localisation need to be improved and standardised, with the aim of maximising availability of mobile applications and services. Intelligent assistants and location-based services will facilitate use of such tools, also usefully filtering the flood of available information by providing situation-adapted preliminary assessments and recommendations.

ESSENTIAL POLICY ACTIONS:

1. **Place a priority on systems leadership.**
   In the ICT market, German companies should not seek to compete with cut-rate producers; instead, they should concentrate on building their own strengths. German companies are leaders in the business-software sector. They have outstanding positions in development of innovative application software for embedded systems in the automotive, automation and medical-technology sectors, and they are among the world's best in development and production of intelligent sensors. Thanks to their special ICT expertise in the logistics sector, German companies have an edge in the area of new commerce and distribution concepts.

2. **Protect value creation in Germany.**
   Support projects should be attuned to ensuring that value creation, throughout entire innovation chains, remains in Germany, and that transitions from invention to innovation can take place in step with the short innovation cycles prevailing in the ICT sector. In support efforts, therefore, care should be taken to provide the largest funding shares for innovation-oriented research in sectors whose value-creation chains are located mainly in Germany.

3. Co-operate in clusters that cover the spectrum from idea to product.
Ideally, in work in innovation networks, pathways linking the successive steps of basic research, demonstrators, preliminary development, prototypes and product-function development should lead seamlessly to product integration and marketing and sales. Co-ordinated development of innovative services, conducted parallel to the product-development process, supports maturation of commercially useful unique product characteristics. By emphasising such an approach, Germany can ensure that it is favourably positioned in strategic future markets.

4. Place priority on practical usefulness.
User acceptance is the most important basis for any successful efficiency improvements via ICT. Researchers and business enterprises should seek to identify limits in this regard. They should conduct supporting acceptance research, and not blindly implement whatever may be technically feasible in the realm of human-machine interaction.

3 CROSS-CUTTING TASKS OF RESEARCH AND INNOVATION POLICY: CONCENTRATING RESOURCES; MOBILISING RESOURCES

To be ready for the technological and social challenges of the coming decade, the Federal Government needs to ensure that its research and innovation policy both concentrates resources and mobilises new resources.

CONCENTRATE RESOURCES

- Expand future investments in a focused way.
- Energetically continue thematically oriented research support.
- Bring together responsibilities in research and innovation policy.
- Help shape research policy in Europe.
- Orient immigration policy in keeping with strategic criteria.

MOBILISE RESOURCES

- Make tax policy innovation-friendly, and introduce broadly effective tax-based R&D support.
- Strengthen and encourage innovation alliances.
- Broaden operational latitude for higher education institutions and research institutions.
- Train, and provide further training for employees on all qualification levels.
- Ensure acceptance of innovation.
- Use education to promote openness to innovation.

3.1 Concentrating resources

EXPAND INVESTMENTS IN THE FUTURE.

In subscribing to the Lisbon goal of having three percent of GDP go towards research and development, Germany has established an ambitious aim for its investments in research. Additional research funding invested in the framework of the High-Tech Strategy, and business enterprises‘ own high levels of investment in research and development, are encouraging signals.

At the same time, Germany has failed to reach its investment goal even during economically vigorous times, and thus runs a risk of completely losing sight of it during the economic crisis. Policy-makers and companies need to respond to the current economic recession by expanding their forward-looking investments, and by doing so in especially bold and creative ways. That is how they can create a basis for overcoming the crisis.

ENERGETICALLY CONTINUE THEMATICALLY ORIENTED FUNDING.

The Federal Government‘s co-ordinated, future-oriented funding policy should be continued in the direction chosen thus far. It should be oriented to support throughout entire value-creation chains. At the same time, its focus should be intensified on programmes for the areas of health, energy, security, mobility and communications, i.e. considerably more research funding should be invested in those areas. In addition, it must not fail to consider important cross-cutting technologies; such technologies must also be boosted. Programmes of the Federal Government‘s various departments that operate in competition with each other, that are underfunded, or that simply parallel each other, redundantly, should be consigned to the past. In general, transfer of research findings throughout all companies must be ensured.

BRING TOGETHER RESPONSIBILITIES IN RESEARCH AND INNOVATION POLICY.

The High-Tech Strategy provides an example of how all of the Federal Government‘s technology-oriented and innovation-oriented departments can combine and concentrate their measures. In the framework of the Research Alliance, they are joining with industry and science representatives in identifying future challenges, prioritising support measures and designing innovation-friendly framework conditions.

The Federal Government should continue to apply co-ordinated, departmentally overarching innovation policies. The aim of such readily apparent concentration and combination must be to enhance the importance of education, research and innovation in the overall society‘s priorities and to foster willingness to invest in those areas. Specifically, this means:

- Responsibilities for research support and innovation-policy measures should be combined, in an overarching approach covering all relevant departments.
- The areas of research support, innovation and provision of an adequate relevant framework must be considered in one and the same context.
- Laws, and new draft legislation, should be reviewed in light of their potential impacts on innovation in Germany.

HELP SHAPE RESEARCH POLICY IN EUROPE.

In light of its size, Germany has a special responsibility to take an active role in shaping the European research area. In European research policy, Germany must seek to “orchestrate diversity” – and, specifically, to support its companies and science sector in influencing and participating in European research, and to set an example by enacting Europe-friendly initiatives. In particular, Germany needs to be enriching the discussion on the structure of the the European Commission’s Eighth Framework Programme for Research by providing constructive proposals, and it needs to be influencing relevant process design in the Joint Programming context. Above and beyond its own research-support efforts, the Federal Government should be taking an active role in shaping the relevant framework and promoting innovation-friendly legislation (stem-cell research, plant biotechnologies, European Community patent). In general, awarding of programme-oriented funding should take place within the framework of transparent competition – rather than of institutional awards. In addition, support should continue to emphasise effective co-operation between industry and science.

In introducing individual ERC grants for basic research and industry-driven programmes (Joint Technology Initiatives; JTIs), the European Union has expanded its funding portfolio in useful ways. At the same time, conventional collaborative research should remain the most important pillar of European research support.

ORIENT IMMIGRATION POLICY IN KEEPING WITH STRATEGIC CRITERIA.

To a greater degree than in the past, our immigration policy needs to be oriented to the criterion of how immigration can benefit our country. In light of the structural shortages of skilled employees that result from Germany‘s demographic development, Germany has no alternative but to offer highly qualified foreigners greater opportunities for immigration. Only by pursuing well-conceived and targeted immigration policies can Germany alleviate its shortages of skilled employees and attract excellent specialists. The Federal Government needs to continue to support such immigration, and to eliminate all legal and bureaucratic barriers to immigration and permanent residence of highly qualified foreign employees.

In this context, we expressly welcome the “Initiative for Foreign Science Policy” („Initiative Außenwissenschaftspolitik“). German research institutions‘ international co-operative efforts, and branch offices and locations, in internationally leading knowledge societies, need to be taking an active role in designing suitable campaigns and programmes for attracting excellent specialised employees. What is more, such immigration must not be restricted to the academic realm; it must also include internationally outstanding non-academic specialised personnel.

3.2 Mobilising resources

MAKE TAX POLICY INNOVATION-FRIENDLY, AND INTRODUCE BROADLY EFFECTIVE TAX-BASED R&D SUPPORT.
Tax policy is also innovation and investment policy. In the interest of its position in international comparisons of tax systems, Germany needs a competitive tax system, as well as an internationally outstanding research-funding system. It thus needs to review existing provisions in tax laws in terms of their "innovation-friendliness". What is more, it has to take due note of the fact that more and more competing countries now have tax-based systems in place for supporting industry R&D. It thus must seek to offer research-intensive companies, of all sizes, comprehensive incentives to conduct research in Germany. In addition, it must offer tax breaks to companies that, for reasons of their size (SMEs), their project diversity or their required long-term research orientation (as large industrial corporations), lack the necessary resources for certain types of research projects.

Tax credits are straightforward, broadly working and rapidly effective tools for supporting research and development. They are also useful to support the sorts of unconventional ideas that often lose out in traditional funding procedures. In the context of tax-based support approaches, companies can define their research aims completely under their own responsibility – i.e. have a key basis for successful innovation. Only with the help of tax-based approaches will companies continue to be able, in future, to provide two-thirds of all research investments and to foster and expand their innovation in spite of economic recession. For these reasons, Germany should act quickly to introduce tax-based research funding and to structure future interaction between project funding, institutionally oriented funding and tax-based R&D funding.

STRENGTHEN AND ENCOURAGE INNOVATION ALLIANCES.
Efforts to establish and reinforce innovation alliances, alliances within the meaning of large public-private partnerships, should be reinforced, since public funding in the context of such partnerships exerts considerable leverage in mobilising private investments. In the interest of such arrangements, public research support policy must be reliable, and companies should pursue long-term research strategies.

In recent years, industry-science co-operation has developed in the framework of strategic partnerships, including innovation alliances, top clusters and numerous small clusters. Such strategic partnerships develop and thrive via overarching research co-operation between universities, non-university research institutions and business enterprises. They facilitate "open innovation"; they open up innovation processes for large numbers of partners. They grow through their long-term orientation and their climates of mutual trust.

In times of crisis, all partners in the research and innovation sectors especially value consistency and reliability. All partners – and not only the Federal Government – are called on to stand by their programme plans and funding commitments. And companies in particular are called on to commit to long-term co-operation, the current economic challenges notwithstanding. At the same time, the science sector needs to define its research emphases even more sharply and visibly, and to combine its research and education resources across institutional boundaries.

Co-operation, and mutual understanding, between science and industry benefit especially from exchanges of people – including temporary exchanges – between those different spheres. In comparison to other OECD countries, mobility between these two major areas is considerably underdeveloped in Germany. Policy-makers, industry and science should work together to promote and expand such mobility.

BROADEN OPERATIONAL LATITUDE FOR HIGHER EDUCATION INSTITUTIONS AND RESEARCH INSTITUTIONS.
Higher education institutions and research institutions could contribute more effectively to innovation if they had greater discretionary latitude in the areas of personnel, budgeting and affiliation with business enterprises. Such added latitude can be expected to generate positive effects in research institutions' entrepreneurial activities, in their co-operation with business enterprises and in their abilities to retain and regain excellent scientists. The "Freedom of Science Initiative" ("Wissenschaftsfreiheitsinitiative"), aimed at creating internationally competitive framework conditions for public research institutions, should be thus pursued further and refined. The five-point plan that the Federal Government adopted in regard to that initiative in summer 2008 is a first important step in that direction. All participating departments now need to press ahead with implementation of that plan.

Higher education institutions and research institutions, for their part, should make full use, in the interest of efficiency and entrepreneurship, of the new freedoms available to them. In addition, they should apply incentives for the development of a vital, dynamic culture of innovation, oriented also to markets and real-world demand. In the process, they should avail themselves, more strongly than in the past, of the counsel and know-how of the business-enterprise sector. Conversely, companies should increasingly be adding scientists to their supervisory and advisory bodies, in the interest of fostering permanent, ongoing direct exchanges with the research sector.

TRAIN, AND PROVIDE FURTHER TRAINING FOR, EMPLOYEES ON ALL QUALIFICATION LEVELS.
The Industry-Science Research Alliance has engaged in intensive discussion of the various fields of innovation defined by the High-Tech Strategy. In most of the areas in question, a lack of highly skilled personnel poses a major barrier to innovation. The priorities in research and innovation policy must thus include efforts to ensure that enough young people are being trained in suitable ways and that highly skilled employees are receiving adequate further training and continuing education.

Innovations lead to changes in all areas of value-creation chains. Such changes present new challenges – challenges that cannot be met solely by academically trained young scientists and researchers. Therefore, intensive use must also be made of the capabilities of non-academic highly skilled employees – employees in Germany whose qualifications are in excellent international repute.

For higher education institutions, these requirements in the area of lifelong learning open up opportunities to develop market-oriented training and education programmes and to respond to a demand for further training and continuing education.

Industry needs to considerably expand its efforts in in-company training and further training, especially in areas in which shortages of highly skilled employees are expected. In this regard, industry should intensify its focus on its various interfaces to academic education, via co-operation with higher education institutions, by providing know-how, infrastructure and adequate financial resources.

Business enterprises have increasingly been offering grants for academic education, especially for studies in “STEM” subjects. Such initiatives should be considerably expanded. The political sector can promote and speed this process by providing relevant additional incentives – for example, in the form of matching contributions for joint funding of grants.

ENSURE ACCEPTANCE OF INNOVATION.

To be successful, innovations need to be accepted. Often, however, developments produced with major research funding meet with scepticism in Germany when they move from the laboratory to applications. Policy-makers, industry and science must seek to address public concerns by providing better information about technology and its applicable background and contexts. Public acceptance is best encouraged via discussion, information, transparency and credibility. In addition, high-quality science education is an important factor, since it helps enable people to be objective and free of prejudice in considering science and technology. Decisions based on knowledge – rather than just opinion – will meet with majority support only if public acceptance is encouraged in such ways. Germany‘s companies, science sector, general-education schools and political stakeholders are all called on to make the necessary efforts in this area – an area of vital importance to our country‘s future.

Examples of informational efforts oriented to specific audiences include initiatives such as the “Biotech-Mobil“ and “Nano-Mobil” travelling exhibits, the BMBF‘s Science Years and the Federal Government‘s “Nano-Dialog” programme. Others include the many “hands-on” demonstration laboratories operated by science institutions and business enterprises. Relevant insights are also being provided by the German engineers‘ initiative “THINK ING”; the “MINT-Initiative” of employers‘ associations; the “Knowledge Factory” („Wissensfabrik“), an effort sponsored by some 70 companies; the “School Partnership” („Schulpartnerschaft“) of the Chemical Industry Fund, aimed at enhancing the quality of chemistry education; and the “Tiny Tots Science Corner” („Haus der kleinen Forscher“) foundation.

USE EDUCATION TO PROMOTE OPENNESS TO INNOVATION.

The “openness” of interest in the present context includes not only openness on the part of consumers. It also includes openness on the part of young people – openness to scientific and technical education and to careers in science and industry.

The central challenge in education policy is to enhance the quality of education at general-education schools. And this challenge is especially great in the area of mathematics and science education. Internationally, pupils in Germany‘s schools show average – rather than excellent – levels of achievement in these areas. Furthermore, pupils with migration backgrounds tend to show especially poor achievement levels. This is a matter of special concern.

In this light, the Federal Government‘s “Qualification Initiative”, which is expected to improve quality in education and research, is to be welcomed. The package of measures planned in this context needs to be implemented promptly and broadly. The Industry-Science Research Alliance recommends the establishment of nationally binding education standards for the various individual school subjects, with a view to ensuring the quality of teaching at general-education schools.

Other causes for concern include chronic underfunding of higher education institutions, and the low German university enrolments in the OECD comparison. According to OECD figures, Germany expends nearly one percent of its GDP on its higher education institutions. The international average in this category is 1.7 percent. As a centre for innovation, Germany needs both superbly trained non-academic skilled employees and superbly trained higher education graduates. Germany needs to be achieving at least the OECD average in its higher education funding.

THE INDUSTRY-SCIENCE RESEARCH ALLIANCE

The Research Alliance supports the High-Tech Strategy for Germany. It identifies barriers to innovation, defines research tasks and makes recommendations with regard to needed action. Its members, drawn from the industry and science sectors, are convinced that Germany needs to have a leading position in the most important markets of the future. They are also convinced that Germany can, must and will attain such a position. (The Research Alliance‘s central focus)

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