Federal Ministry
of Education
and Research

Research for Climate Protection and Protection from Climate Impacts

A contribution to the BMBF framework programme „RESEARCH FOR SUSTAINABILITY“

Imprint

Published by
Bundesministerium für Bildung und Forschung /
Federal Ministry of Education and Research (BMBF)
Publications and Website Division
11055 Berlin

Orders
In writing to the publisher
Postfach 30 02 35
53182 Bonn

or by
Phone: +49 (0) 1805-262302
Fax: +49 (0) 1805-262303 (0.12 Euro/min.)

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

Bonn, Berlin 2004

Printed on recycled paper

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Published on November 3, 2004

Contact: Federal Ministry of Education and Research, Division 622, D-53170 Bonn (Germany)
Information: www.fona.de

Content

1. A new orientation for research policy: Climate protection as a dual concept for sustainability

In its funding programme "Research for Sustainability", launched on 30 June 2004, the BMBF (Federal Ministry of Education and Research) announced a funding concept for climate research that is aimed at innovation, prevention and sustainability. This concept is presented in the following paper. Climate research and climate protection are the central aims of the Government's strategy on sustainability. Until now, research concentrated on how to improve our understanding of the climate system, the development of environmental policy instruments and the fostering of a new scientific generation.

In recent years, the German research community has made top-rate scientific achievements and was substantially involved in important successes internationally. Scientists at the Max Planck Institute for Meteorology in Hamburg and the German Climate Computing Centre, for example, have, with the aid of new climate models and scenario calculations, provided a crucial proof of the existence of an anthropogenic climate effect, i.e. that climate change is caused not only by natural effects but can also be traced back to human behaviour and economic activity. In addition, research results on climatic developments over the Earth's history to the present day compiled, for example, by institutes belonging to the Helmholtz Association and by the Potsdam Institute for Climate Impact Research, have received international attention. Furthermore, in the context of the European research project EUROTRAC, in which 30 countries participated under German coordination, work has been done on the scientific basis for sustainable improvements in air quality. Within the framework of the atmospheric research programme AFO2000, a new forecast model has been developed which helps the State Environment Office in North Rhine-Westphalia to provide citizens in advance with information about air quality in the following three days. The evaluation of the remote sensing data supplied by the European satellite ENVISAT has also provided a previously unparalleled ability to make statements on the state of the Earth's atmosphere and surface. Over the last 20 years, in Canada, northern Eurasia and Siberia, for example, an increase in vegetation, the earlier onset of spring and an extension of the vegetation period have been observed with the aid of satellite data. As a result, the climate research programme DEKLIM is now supplementing these satellite observations by using computer models, with which it will be possible to explain the effects of global warming on the vegetation in these northern regions.

Taken together, research projects such as those described above, and their funding, have in the meantime generated considerable knowledge with which politicians, industry and society can find orientation, and which is now also sufficient to put the results achieved so far into practice. The new funding concept therefore envisages a paradigm shift from basic research to applied research and development (R&D).

The concept is based on two key themes:

- Climate protection: the avoidance of further climatic changes on account of human activity, with a thematic focus on **"Strategies, Technologies and Measures to Reduce Emissions in Industry and Society"** ("mitigation"), aimed at long-term precautions to protect the climate and at the promotion of innovation, see chapter 2 and
- Protection against climate impacts: paths to overcome the consequences of climate change, likewise aiming at practice and application, focusing on **"Adaptation to Climate Trends and Extreme Weather – Strategies, Innovations, Markets"** with R&D initiatives to reduce the susceptibility of economies to climate and weather events ("adaptation"), see chapter 3.

In addition, the BMBF is accompanying these solution-oriented and practice-related key themes of its future project funding through co-financing Earth system research on a long-term basis in the Helmholtz Association of National Research Centres (HGF), the Max Planck Society (MPG) and the Leibniz Association (WGL). Basic research on the climate system and the atmosphere, on the improvement of climate models as well as on the links between basic scientific research in natural sciences and sociological questions ("integrated assessment", particularly in estimating the effectiveness of climate protection strategies in relation to long-term climate protection objectives) also belong to the key themes. The BMBF will also continue to provide financing for major items of equipment, for example a high performance dedicated climate computer at the German Climate Computing Centre in Hamburg, for research ships, or for HALO ("High Altitude and Long Range Research Aircraft") – a new airplane for atmospheric research – as prerequisites in terms of infrastructure for top-class research on Earth systems analysis and climate change. These contributions are intended to maintain the high international level of institutional research on the Earth's system in the coming years. In

addition, thematic research in the corresponding specialized programmes of the BMBF will continue to be conducted, among other things on energy- and material-efficiency and new technologies.

According to a survey by the International Group of Funding Agencies for Global Change Research (IGFA), in 2002 the BMBF provided 230 million euros for the support of research relating to global change. This figure represents 79% of the total expenditures for research funding in this field in Germany. About two thirds of this funding volume was allotted to climate and atmospheric research. In comparison, the other organizations that fund science projects, i.e. the German Research Foundation (DFG) and other sponsors of third party funds research, have invested 40 million euros or 14% and 20 million euros or 7%, respectively, to fund research on global change. These comparative figures document the high degree of political commitment of the BMBF to this sector, particularly when one considers that the BMBF additionally finances 50% of the DFG's budget.

Over the last few years, rapidly changing global developments have set research policy makers new tasks beyond the classical funding theme of controlling climate change, for instance the sustainable use of the global water cycle, protection of the biosphere, preservation of species diversity as well as the sustainable control of the rapid growth of the megacities of tomorrow.

The objective of the BMBF's project funding is to constantly redefine new research policy priorities that are necessarily caused by these dynamics of global change. Following the successes achieved in basic research, this concept is now the paradigm shift towards applied research and concrete innovations. This will not cause a gap in the total range of funding and research activities in Germany, as the BMBF will continue to fund the long-term Earth system research at the institutional level that falls within its area of responsibility. In the future, greater support will additionally come from the DFG and other sponsors of third party funding for highly qualified basic research, in particular at universities.

In the past, research in Germany was predominantly geared to precautions for the longterm protection of the climate ("mitigation"); adjustment to climate change and extreme weather ("adaptation") were given less consideration. This was only generally recognized over the last few years as a striking disadvantage, after extreme weather events, above all storms and tidal events on the Oder and Elbe rivers, caused substantial damage to the environment, the economy and society. Substantial costs for rehabilitation measures were demanded from the Government and society in general, as the necessary knowledge in terms of action to be taken and organization at the scene of the damage were mostly lacking.

The new sustainability concept for climate protection therefore pursues a double goal: one is the reduction of long-term climate changes induced by human activities and which are damaging to society and the environment, and the other is adaptation to climate change and to extreme weather events. It seeks to set new research policy priorities for a wide range of effective measures in the future both for the protection of the climate from the impact of humankind and for the protection of humankind from climate effects and extreme weather. Adaptation is a necessary strategy at all levels, in order to supplement reduction efforts against climate change. Combined together, these two starting points can contribute towards achieving the goal of sustainable development.

The BMBF's framework programme understands sustainability as an engine for innovation in government institutions, industry and society. The funding of climate protection research in line with these two goals follows from a policy starting point that is both multidimensional and integrated, combining economic, ecological and societal aspects of climate change. Conceptionally, therefore, the new funding concept also envisages an integrated perspective during the planning process – in the case of industrial funding for instance, across sectors and technologies along value chains and product lines. Public research and industrial development must be interlinked more closely and users from industry, society and politics must be involved in the identification of themes for scientific research and the setting of priorities. Industry and other players in civil society should also be included as funding recipients, in order to take account of research and development projects with an integrative concept. Likewise, contributions are needed to establish networks among all areas of R&D and also to improve the flow of information among industry, the scientific community and society.

It is to be expected that the realization of this new integrative concept for sustainable development will create many promising opportunities for improved communication, which is also targeted at cooperation, between all civil society players and policy makers. This would be a substantial prerequisite for an even better basis on which to found the political and public discussion of central climate-related questions and climate policy-related measures. Only with the inclusion of all relevant players

is it possible to achieve a balanced, overall climate policy analysis of the opportunity and risk scenarios for both the long-term climate problem and the short-term consequences of climate change and extreme weather events. The BMBF's political engagement with these problems and, above all, also time horizons, can at the same time be regarded as its political contribution to generational justice.

2. Theme: "Strategies, Technologies and Measures for Emission Reductions in Industry and Society"

2.1 Initial research policy position

In the context of the Kyoto Protocol and the European Union's burden-sharing agreement, the Federal Republic of Germany has committed itself to reduce the volume of domestic emissions of greenhouse gases by 21% compared to the base year 1990–95, in the period 2008–2012. This is an ambitious goal, also when making international comparisons.

By the year 2002 a reduction of approximately 19% had already been achieved. Germany is thus already close to achieving its pledged emission reductions; further measures are necessary, however, in order to achieve the 21% goal. The framework for climate-related policy activities of the Federal Government is set out in the National Climate Protection Programme dated 18 October 2000, which is currently being updated. Its main focus is to develop further existing policies and measures and to ensure that all relevant sectors make their contributions. An important question here is how the synergies that are already present can be intensified, e.g. regarding the combination of emission trading, ecological tax and fiscal reforms, the combined heat and power law (KWK-Gesetz), the law on renewable energies and the voluntary commitments of German industry. In addition, medium-term and long-term objectives must be specified, in order to prevent the global mean temperature rising by more than 2°C in relation to pre-industrial periods. The European Union and the Federal Government have set themselves this climate protection goal in order to avoid dangerous levels of climatic change as described in the context of the United Nations Framework Convention on Climate Change. In its draft progress report on the National Sustainability Strategy, the Federal Government has therefore declared that Germany will aim to reduce its greenhouse gas emissions by around 40% by the year 2020 in relation to 1990 if the European Union simultaneously declares its readiness to reduce emissions in the same period by 30%.

In the long-term, however, the further reduction of greenhouse gas emissions beyond the reduction goals for 2012 will remain a permanent task to be pursued vigorously on the environmental and innovation policy

front in view of the climate change-related pressure on the economy and society. Even if possibilities of greenhouse gas sequestration could contribute to overcome these problems, the scale of future challenges in order to avoid serious global climate change by means of global emission reductions is already beginning to emerge.

The German economy and society will already have to incur substantial expenditures for the implementation of the medium-term reduction goal of 21%. However, the scientific and technological potential that currently exists may not be sufficient for subsequent, even higher reduction goals. Thus new starting points for consumption, manufacturing processes and products need to be developed that are more compatible with our climate goals. For this it will be necessary to envisage the integration of solution-oriented concepts for comprehensive system approaches into strategic business planning for R&D and also to redirect cooperation between public research, industry and consumers in the direction of this goal. However, in order to access all existing possibilities for meeting later even more stringent reduction goals, accompanying measures on the part of research policy makers are also necessary in addition to calls to businesses and the scientific community. The long-term character of the research approaches needed, their current remoteness from existing markets and their nature as application-oriented or industrial basic research necessitate this specific funding approach of the BMBF for sustainable climate protection in industry. In view of the several years that pass in R&D between the initial research idea and its practical implementation, only long-term funding can guarantee the intended partial redirection of climate research that is desired at the policy level towards specific R&D contributions to an effective and sustainable climate protection. This approach represents the research policy contribution of the BMBF to the climate policy of the Federal Government.

It must be recognized, however, that co-financing by the Government cannot substitute for scientific initiatives and, more importantly, private initiatives by industry. Co-financing is equally unsuitable for reducing the financial burden on enterprises from obligations resulting from command and control regulations on the reduction of greenhouse gas emissions by way of a new government subsidy. Funding of research projects by the BMBF to achieve sustainable climate protection can thus only be subsidiary in nature – it is meant to be an accompanying governmental support to the private initiatives of firms.

Developments that can be observed at the international level continue to show an unimpeded rise in emissions, with simultaneous increases in worldwide energy consumption. The economic situation in Germany is characterized by increasing pressures from globalization, rising demands on the competitive ability of businesses and the reduction of jobs in many industrial sectors. Nevertheless, a whole range of policy, technical and economic options to solve the problem of climate change have already been initiated in order to save energy and permit more efficient use of energy and raw materials, to fund the use of renewable energies, to design manufacturing processes that emit less greenhouse gases, to develop products that are more climate-friendly or to increase the sequestration of CO_2 in agriculture and forestry. New concepts must build on these and at the same time pursue further appropriate developments, in order to achieve effects that secure economic benefits and jobs.

However, apart from the measures undertaken by firms, it is only possible to overcome the long-term challenges if all elements of society are called upon to make a contribution.

The requirements of communication and integration of differing perspectives (see also chapter 4) are central aspects that must be considered in sustainability evaluations and strategies, in order to make the inter-relationships transparent between economic, social and ecological dynamics together with the possibilities for manoeuvre, bring potentially conflicting aims to the fore and search for solutions that promise to unleash positive feedback between all the dimensions of sustainability. This problem was identified as a theme in the framework of the BMBF programme "Research for Sustainability". Close coordination with the fourth point for action of this framework programme, entitled "Societal action geared to sustainability", is ensured.

Against this background the BMBF has set itself the objective of reviewing the classical theme of climate change and climate protection from the perspective of the requirements of sustainable development and of initiating processes to develop a suitable concept that is correspondingly geared to new activities. Although climate protection is a multi-dimensional problem, priority has been placed on climate protection mechanisms in industry in this concept. For this it was essential to examine existing measures, attempt coordination with other measures, particularly within the Federal Government, identify implementation barriers and decide on new options. Initial results are presented in the following chapters.

2.2 Sustainability concepts in industry

In 2002 the Federal Government presented a sustainability strategy entitled “Perspectives for Germany”, on which a progress report will appear shortly. Among the four priority areas therein is also “climate protection and energy policy”.

In addition and complementary to this strategy, businesses and trade unions are increasingly developing their own sustainability concepts, as the following examples demonstrate:

- In the year 2000 leading German firms, following an initiative of the BDI (Federation of German Industries), set up the forum “Sustainable Development of the German Economy” (econsense). In a dialogue with policy makers, approaches for achieving a sustainable climate for innovation are to be elaborated that point to paths for the practical implementation of the concept of “sustainable development" (see http://www.econsense.de).
- The joint “Ludwigshafen Declaration” of the chemical industry and the Mining, Chemical and Power Industries Trade Union dated 10 October 2003 draws the aspects of employment, growth, competitive ability and social justice into “the frame of sustainable policies for chemical products”. The statement made in the context of a “Pact for the Future of the Chemical Industry” that “We need to take an integrated approach in all policy areas that are of importance to the chemical industry – that is the core of a sustainable industrial policy” coincides in substantial respects to the research policy objective of the BMBF on sustainability that was initially referred to in this paper.
- In the statements of individual firms, integrated solutions to individual problems are increasingly becoming the focus of attention. These can be identified in formulations such as “Chemistry as a problem solver of many sectors”, as well as from concrete project initiatives such as the “Three Litre House” or the project to renovate a complete town district in Ludwigshafen in a comprehensively ecological manner that includes climate protection as a clearly identifiable aspect.

Against this background, and taking into consideration the Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, its implementation in the European Union (see the European Climate Change Programme, ECCP), and its implementation in Germany, new initiatives to reduce greenhouse gas emissions need to be identified and integrated into the relevant sustainability concepts.

Instruments that take into consideration diverging and, in some cases, conflicting aims will play a large role in the selection, evaluation and accompaniment of projects for sustainable climate protection. In some economic sectors, methods for analysing ecological efficiency are already being successfully applied. Now it is a question of applying these instruments to strategies and projects in the area of climate protection and/or developing them further. In this manner, several aspects can be regarded in comparative fashion and subjected to an interdisciplinary discussion. The communication and coordination processes that are initiated through this will be the major driving force behind successful project design in the sense of an orientation towards sustainability.

2.3 Theme identification

Over the last two years the BMBF has helped to initiate, and has also co-funded, discussion forums between the scientific community and industry in order, on the one hand, by way of a “mutual learning process”, to find research fields of economic interest for public research and, on the other hand, to provide businesses with orientation assistance and to bring closer the conceptual knowledge that already exists for its implementation in management options. Trade associations such as VCI (German Chemical Industry Association) and BDI were involved, as were the National Committee for Global Change Research and the European Academy for the Study of Consequences of Scientific and Technological Advance in Bad Neuenahr-Ahrweiler.

In order to be able to derive concrete goals for R&D that have a close industry focus, and a structuring that enables the setting of thematic priorities and the conceptualization of integrated projects of key importance to the future funding measures, the BMBF initiated a process a few months ago between businesses, the scientific community and the ministry – which is still ongoing – to identify research themes. In this connection, the BMBF has requested DECHEMA e.V. to compile a special analysis from a business perspective, entitled “R&D for Climate Protection”. Several preliminary discussions with numerous industry representatives and a series of workshops, organized by DECHEMA, have taken place and have led to integrated theme proposals in areas of general interest. The theme spectrum that was dealt with, for example, covered construction, housing and building materials, processes for efficient use of energy and resources, separation and sequestration of greenhouse gases in industrial processes, agriculture and forestry, as well as the evaluation of different options to protect the climate.

The themes referred to are currently being examined cross-sectorally, as well as for their interlinkages and summarized in a comprehensive project study that will be published in autumn 2004. These themes focus especially on the substantial potential for reducing the emission of climate related gases in the above-mentioned areas. In this connection, it needs to be stated that the energy industry, as the largest emitter of carbon dioxide, has not been regarded separately, as appropriate questions are addressed through the Energy Research Programme of the Federal Government, which is being coordinated centrally by the Federal Ministry of Economics and Labour (BMWA). Upon completion of the study, the BMBF plans to evaluate the results together with other affected departments, primarily the BMWA, the Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL), the Federal Ministry of Transport, Building and Housing (BMVBW) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), and link them with the respective funding activities on energy efficiency and sustainable climate protection of each department. Some of these departments have already been involved with various themes that featured at the workshops that took place.

Climate protection measures are essentially based on three goals: energy saving, increasing energy efficiency and the development of a sustainable energy supply structure – within the given framework of the resolutions on exiting nuclear energy and expanding the use of renewable energies. The development of a sustainable energy supply on the basis of renewable energy and power stations with reduced emission requires long-term research efforts at the domestic and international levels. These have been incorporated, for example, into the Government's Energy Research Programme. On shorter time scales, however, substantial potential exists in the areas of energy conservation and energy efficiency. This is where the theme identification process that is presented in the context of this funding concept comes in. It takes into consideration the fact that German industry also plays a key role as a driving force behind innovations that protect the climate. In particular, industry sectors that are strongly interconnected with other branches, for instance the chemical industry, and whose products are a starting point for other industry sectors, can unfold wide-ranging effects via sustainable technologies and products.

Since the mid-1990s, German industry has made voluntary commitments on several occasions, in order, through its own supplementary efforts, to contribute to the fulfilment of the climate protection goals pursued by the Government. In the meantime, a clear decoupling of energy consumption from economic development can be seen, with increases in energy efficiency also being reflected in reduced greenhouse gas emissions. In relation to economic performance, considerable reductions in CO_2 emissions were achieved. It was primarily German industry that contributed to this development, reducing its emissions in comparison with 1990 by approximately one third.

In its revised statement on voluntary commitments as part of German industry's agreement on climate protection, dated November 2000, the chemical industry committed itself to reducing the greenhouse gases contained in the Kyoto Protocol that are relevant to its branch, such as energy-related emissions of carbon dioxide and nitrous oxides, for example N_2O, by 45–50% in CO_2 equivalents between 1990 and the year 2012. In addition, the chemical industry committed itself to further improvements in energy efficiency, so that it should be possible to reduce specific energy consumption by 35–40% over the same period. In 1995 and in an extended voluntary agreement from December 2000, the German cement industry promised a further decrease in carbon dioxide emissions arising from cement production. Taking 1990 as the base year, the specific energy-related CO_2 emissions are to be reduced by 28% by the target period 2008 to 2012. In total, i.e. also taking into account the proportions for raw materials, this corresponds to a 16% reduction in specific emissions of CO_2 during the production of cement. And finally, the German steel industry made a commitment to the Government to reduce its specific carbon dioxide emissions by around 22%, compared with 1990, by the year 2012.

Monitoring of the combined heat and power agreement will start in 2004, financed jointly by German industry and the Government. It will encompass an evaluation of the concrete results that have been achieved over the last few years. A fundamental question in coming years is how to develop the voluntary commitments further and integrate them with other climate policy measures that are being implemented.

The declared aim of the various branches and groupings belonging to the forest and timber industry in relation to sustainable forest management, formulated at the German Forestry Summit in 2001, leads to the expectation that CO_2 sequestration will increase on account of increased carbon supplies in forests and an increase in the use of wood and wood products.

The following examples from the chemical industry, the construction and cement industry as well as the steel

industry outline the progress achieved so far, and in particular the specific opportunities for further climate protection contributions of these industry sectors. They are all characterized by high energy intensity and by a high degree of cross-linkages with other industry sectors. This results in a correspondingly large potential for climate protection. At further stages of the process, other branches to which these characteristics apply, can be included, for example, the automobile industry.

2.4 Examples illustrating the significance of emission reductions in industry

2.4.1 Chemical industry

In addition to production challenges, the chemical industry is a key cross-sectoral industry and the driving force behind innovations for a multitude of industry sectors. Its contribution to overall value creation is particularly pronounced in Germany. Because of its high energy consumption, operating costs are strongly coupled to energy costs. In processes involving electrolysis, for example, electricity costs amount to approximately 50% of the entire production costs; in the production of polyurethane the figure is still around 10%. The manufacture of products in a way that conserves resources and uses energy efficiently therefore represents a permanent challenge for this branch of industry.

Apart from the efficient use of energy sources and the development of environmentally friendly manufacturing processes, the chemical industry, by way of its products, contributes significantly to emission reductions in other branches and other areas of society, e.g. also in relation to private consumption. Examples are thermal insulation materials for buildings or light materials for the construction of vehicles.

As far as energy efficiency in plants is concerned, the German chemical industry plays a leading role in the international competitive arena. Chemical plants constructed by German firms meet the highest environmental, security and health standards. In order to maintain and/or exploit this leading position further, it is necessary to press ahead, particularly with the development of innovative product ranges and the corresponding production processes and technologies. Those areas that have the potential to bring about system change for the conservation of resources and the introduction of processes that reduce emissions should therefore form the prime focus of Government R&D funding, rather than those that simply target the optimization of existing processes. This is the only way that our international competitive ability can be strengthened over the long term.

It is not unreasonable to expect that with early, pronounced commitment in plant and process technology related to climate protection, Germany could attain a place among the global leaders, similar to that for the export successes it has achieved in environmental technology, thus making climate protection an export success. This potential for symbiosis between economic efficiency and climate protection can be seen in the initial results of the theme identification process, for example, in catalytic production processes as well as innovative process technology.

2.4.1.1 Catalysis and new sources of raw materials

Catalysis is a key technology in the chemical industry. More than 80% of all products come into contact with catalysts at least once during the course of their synthesis. Efficient catalysers are thus the key to creating an optimized supply network, both economically and ecologically, that, starting with simple molecules, produce compounds with partly highly specialised functional characteristics and corresponding economic value. They allow access to new raw materials, to a reduction in the number of synthesis steps and to reductions in power consumption during the production process. Future research fields for catalysis that are relevant to climate protection include:

- *catalytic activation of the carbon–hydrogen bond in alkanes*
  Natural gases containing alkanes account for the largest reserves of fossil hydrocarbons. The conversion of petrochemical synthesis chains from olefins to alkanes would have a similar dimension to that which occurred when the change from coal to oil took place and simultaneously offers substantial potential for conserving energy, e.g. through the elimination of energy-intensive process steps.

- *the supply of hydrogen as a source of energy*
  In the total context of the far-ranging and extensive field of hydrogen technology, the chemical industry, and in particular catalysis, play an important role in the supply and use of hydrogen as a source of energy. Both the production of hydrogen, for example in mobile catalytic converters, and its transformation from chemical energy into electrical energy with the aid of fuel cells, present challenges for catalysis. The same is true for the decentralized stationary use of fuel cells, for which various studies expect 500,000 new units to be installed annually up to the year 2013. In addition,

interesting ideas exist in connection with alternative transport systems for hydrogen, in which the hydrogen is not transported in gaseous form, but is attached chemically to suitable transport media.

- *catalysis and renewable raw materials*
  In the petrochemical industry, chemical end products such as soaps, detergents, paints and varnishes, hydraulic oil, lubricating oil, fuels, printing inks, etc. have to be developed with the aid of numerous expensive synthesis steps. In the oleochemical industry, on the other hand, i.e. the chemistry of renewable oils and fats that are provided by nature and which therefore usually possess basic structures that are easily biodegradable, and can be produced in just a few steps with correspondingly less energy, end products with a high value creation factor are produced. However, the great potential of the oleochemical industry has been underexploited to date. Estimates for Europe assume that, in the year 2010, 15% of the lubricant market and 40% of the detergent sector could be based on renewable raw materials, and in particular on the basis of oleochemical products, if these areas were investigated and funded more intensively.

2.4.1.2 Intensification of processes and new technologies

When optimizing and intensifying processes, the potential for using conventional measures, e.g. combined power, or waste steam is limited. It is innovative process technologies that primarily offer totally new perspectives for climate protection in these areas. New reaction paths and regimes as well as targeted reaction control can eliminate process steps. It is also possible to carry out reactions with substantially less energy, minimize or even abandon the use of solvents, and radically shorten the time spent finishing products through higher yields and selectivity, thereby leading to efficiencies in power and resources that go far beyond the optimization potential of existing procedures.

This requires the linking of conventional equipment to components with meso- and microstructures, and increased local processing control, and is usually connected with the transition from batch to continuous processing. This new process technique represents a paradigm shift in the chemical industry. Exemplary new reactor concepts with the potential to protect the climate include:

- *microstructure devices*, i.e. reactors, mixers and heat exchangers with characteristic dimensions < 1 mm, that offer maximum material- and heat-exchange as well as controlled residence time conditions.
- *membrane reactors* – the combination of reaction level and selective material separation using membranes in a device to increase efficiency – membrane reactors are interesting for multi-phase reactions, among others.
- *spinning disc reactors*, in which liquids are continuously conducted into the centre of a rotary disc, where they form a thin film in which excellent medium- and heat-exchange takes place under the centrifugal and shearing stresses that occur. These reactors have very good potential for exothermic and solvent-free reactions during continuous operation.

2.4.1.3 Cross-sectoral significance of the chemical industry

Most chemical products serve other industry sectors as starting materials for their manufacturing processes. The press statement of the German Chemical Industry Association (VCI), dated 16 January 2004, on the innovation initiative of the Federal Chancellor, states that: "innovations from the chemical industry provide an annual turnover with new products to the value of 20 billion euros. The sector provides approximately 20 per cent of the entire research and development expenditures of the manufacturing sector and invests approximately 7.5 billion euros annually in Germany alone."

Take insulation materials in buildings, for example. In urban redevelopment projects such as the modernization of the company-owned housing district *Brunckviertel* in Ludwigshafen, maximum energy efficiency is being achieved in the existing building stock through use of innovative products and system approaches by a chemical company at the energy consumption level of the 5-litre house, and in one example, at the *3-litre house* level. The success of this project approach is based on the rigorous inclusion of all constituent members of the value chain and of all involved parties at the regional level. The fact that the development and supply of innovative products and solutions for thermal insulation are not sufficient by themselves can be seen in regard to the total situation of existing buildings in Germany. There are around 17–18 million buildings, of which approx. 14 million are single family and multiple family dwellings. According to the October 2000 data of the German Institute for Economic Research (DIW), CO_2 emissions in private households rose from 129 million tons in 1990 to

133 million tons in 2003. Despite existing technical possibilities and the substantial energy saving potential in terms of heating costs, the reasons for not economizing on carbon dioxide emissions in buildings can be found in the low level of efficiency achieved during renovation of around 37%. This means that during the normal renovation cycle two thirds of the potential energy savings remain unexploited. In addition to R&D efforts and the availability of products and solutions, other aspects need to be taken into consideration such as the elimination of information deficits, transparency to cater for the needs of the final customer and the design of suitable parameters for implementation.

How the products of the chemical industry contribute to emission reductions of climate-related gases in other sectors can be illustrated using agriculture as an example. Agriculture contributes substantially to the emission of some types of greenhouse gases. Approximately 45% of methane, around 52% of nitrous oxide as well as approx. 90% of ammonia emissions in Germany originate from agriculture, in particular from animal husbandry and nitrogen fertilizers. Amino acids to the extent of 1.2 million tons per annum that are manufactured using biotechnology, such as D,L methionine, Llysine and L-threonine, are increasingly being used in animal nutrition as feed additives to replace proteins that can only be applied in a less targeted manner, thereby considerably reducing nitrogen excretions in the form of ammonia. In addition, alternative forms of fertilizers based on agrochemistry are reducing the emission of nitrous oxide in agriculture.

Future application strategies for the ecologically efficient management of nutrients in agriculture must aim both at improved use of existing potential, e.g. through the use of ecological efficiency analyses under basic economic conditions and consideration of various management options, as well as the further development of chemical products that are suited to individual situations, e.g. from nitrification and urease inhibitors, in order to achieve additional emission reductions in the future. The potential of the chemical industry as well as its important position on the international market offer good conditions in this regard.

2.4.2 Cement and building materials industry

The building materials industry contributes to environmental and climate protection through a multitude of different technologies. Whereas the chemical industry supplies products for very diverse value chains and the potential for protecting the climate that is related thereto correspondingly requires a more differentiated analysis, the building materials and cement industry can be attributed to the more clearly definable building sector, the climate protection potential of which, at various levels, is more readily identifiable. With a total of approx. 15 billion tons per annum, the most common binding agent globally is clay, a building material that can even be manufactured using little energy. Cement follows thereafter, with 1.7 billion tons per annum, and gypsum with 0.2 billion tons per annum. With the aid of polymer dispersions, e.g. acrylate or ethylene vinylacetate, clay can be made water-resistant without losing its breathing property or its very favourable characteristics in relation to the microclimate in rooms. While clay plays only a small role as a building material in industrial nations, its global significance means that R&D efforts in this area offer substantial potential internationally for climate protection.

The cement industry is responsible for approx. 5% of global CO_2 emissions. In Germany approx. 2.6% of these CO_2 emissions can be attributed to cement production. A total of 0.694 tons of CO_2 are released in relation to a ton of cement. Around 62% of these emissions are caused by the transformation of the material (calcining), 28% by use of the requisite fuel and 10% by the power consumption of the aggregates and plants. The aim is to reduce energy consumption and the output of carbon dioxide during the production process through increased use of secondary raw materials and fuels as well as during transformation from pure Portland cement to composite cements.

Apart from innovations in process engineering and the use of alternative i.e. less carbon-intensive fuels, the substitution of the fired intermediate product (cement clinker) by other principal constituents offers big potential savings. Of special importance in this context is the granulated blast furnace slag, which can replace up to 80% of the cement clinker and thus help prevent the high proportion of CO_2 mentioned above that occurs in the manufacture of clinker (calcination). Of the 7.6 million tons of blast furnace slag that accrue in the German steel industry approx. 5.2 million tons were processed to granulated slag, around 80% of which is used in cement production.

The consistent utilization of existing potential depends to a large extent on market acceptance of appropriate composite cements. The lack of experience with these cements prevents their current use on a wider scale. The slower development of the strength of composite cements leads to a slower hardening of the different

parts and thus longer curing periods. On the other hand, the production of large, solid prefabricated parts has the advantage that less heat of hydration is emitted.

Intensifying the introduction of composite cements into everyday use thus requires contributions from the research community in order to prove their performance, with the aim of promoting its market acceptance by transferring the research conclusions that are generated and developing technical standards and regulations for these cement types. Research contributions to evaluate the performance of new cement types are therefore just as important in cement-making as the development and testing of technologies that reduce CO_2 emissions.

This example illustrates clearly that the consistent implementation of climate protection measures requires a comprehensive approach, which, in addition to solving existing technical problems, must essentially aim at developments further along the value chain. Further expansion of the closed loop economy, using secondary raw materials and coupled products, e.g. from the steel industry and power stations and/or secondary fuels from suitable waste products, therefore requires closer co-operation between partners from different branches of industry, starting with the raw material and continuing right up to the finished product.

2.4.3 Steel industry

The German steel industry is, on account of its production quantity, among the most energy-intensive branches. With a production volume of 45 million tons of crude steel (according to 30% of the EU market in 2002), Germany is the largest crude steel producer in the EU; it ranks sixth globally, behind China, Japan, USA, the Russian Federation and the Republic of Korea. The quoted quantity of 45 million tons crude steel correspond, according to data of the German Iron and Steel Institute (VDEh), to 60.5 million tons of carbon dioxide, i.e. 1.34 tons CO_2 per ton of crude steel. With blast furnaces for smelting iron ores the emission of carbon dioxide results primarily from the reduction process and only secondarily from the consumed energy. Carbon dioxide inevitably occurs as a coupled product, typically 12 tons of carbon dioxide per ton of pig iron, depending on the raw materials employed. The use of substances that contain carbon as a reducing agent is considered to be indispensable and non-substitutable. Clarification is needed as to what extent the modification of the blast furnace process can reduce carbon dioxide emission further, with as little increase in energy requirements as possible.

The following climate-relevant fields need to be developed for the production of pig iron and steel:

- increase efficiency of both energy and resources by higher rates of yield,
- optimization and shortening of process chains,
- new, innovative processes and higher performance materials,
- optimization of material flow through the use of coupled energy, e.g. process gases, waste steam and waste heat,
- closing of material loops, including recycling of secondary raw materials, by-products and residual materials,
- use of hydrogen-rich gases, such as natural gas or coke-oven gas, as reducing agents for the production of directly-reduced iron.

Thanks to production in high performance blast furnaces and process improvements, e.g. to lower the consumption of reducing agents or to shorten processing during the production of hot-rolled strip, it was possible to lower specific primary energy consumption in German plants by more than 30%. Germany is thus amongst the world leaders in terms of its technological status. According to the RWI (Rheinisch-Westfälisches Institut für Wirtschaftsforschung), carbon dioxide emissions arising from production with outdated technologies could be reduced by approximately 50%, i.e. 642 million tons, if the international standard was at the level of German steel plants. For this, however, the investment and operating costs of new, modern, innovative steel plants must sink. It is therefore necessary to develop more economical solutions that in particular also find market acceptance in Eastern Europe and China.

The idea of making steel from iron ore electrochemically via electrolysis is a visionary one. This would require long-term development but seems in principle to be feasible. The advantages of such a process would be that iron could be extracted in pure form as a liquid and electrochemically refined in a targeted manner e.g. with chromium, nickel, vanadium, molybdenum etc., and could be specifically carbonized in a bottom-up strategy. The products of steelmaking with the aid of electrochemistry would be iron and oxygen. In terms of climate protection, such a concept would only make sense if the necessary electric power could be produced in a manner that is CO_2-neutral, e.g. by bio fuels, biomass, wind or water power or if the production of power could be

coupled in the power station to the separation and sequestration of the carbon dioxide. A comprehensive evaluation of such approaches through use of the already mentioned ecological efficiency analyses is, however, an important prerequisite for relevant R&D projects.

In the subsequent treatment of steel, new continuous casting technologies, such as direct strip casting and twin roll casting, coupled directly to the actual steelmaking, process the liquid steel directly into thin sheets. Only approx. 15% of the energy requirements needed for decoupled continuous casting and/or hot rolling are required, in which the rolling material has to be reheated to a temperature of around 1,250°C, thereby consuming a great amount of energy. In principle, however, these new processes exhibit high technological complexity due to their proximity to a product’s final dimensions and also to the coupled processes, with diminishing possibilities for correcting errors during production. These provide further starting points for corresponding R&D projects.

The German steel industry supplies various branches directly or indirectly with rolled steel; in 2002 the amount was 36 million tons. New high-temperature steel materials that can be subjected to higher pressure and temperatures have the potential to contribute substantially to increases of the efficiency in power stations and thus to CO_2 reductions during their operation. In the automotive industry, HSD steel offers benefits as a lightweight construction material, which is advantageous for fuel saving. Important for protecting the climate in this area is not only the manufacture of products and basic materials that save resources and reduce CO_2 emissions, but also close co-operation and close association with those branches of industry further down the chain.

2.5 Consequences for further activities and the identification of themes

One of the main interim results of the discussion process that has been initiated so far is that the integration of options and measures relating to climate protection into strategies for sustainable development simultaneously presents challenges and opportunities.

On the one hand, the linking of technological and economic aspects with societal demands and environmental aspects leads to new requirements in regard to integrated concepts and an interdisciplinary, application-orientated approach. In comparison, past climate protection activities in many areas appear to have been structured relatively simply and were often limited to optimizing specific processes. Finding really new cross-cutting themes and links, or more effective forms of implementing existing know-how and converting these into research concepts, has proved to be a particularly ambitious goal in all the areas dealt with so far.

On the other hand, new, integrated climate protection strategies also generate new opportunities. Using, capturing and developing these by means of suitable R&D activities is of increasing significance. This is because the objectives and basic parameters relating to climate protection are, in view of international developments in various areas, highly demanding, complex, and in constant flux.

The process for identifying new themes that has been presented in this paper, as well as initial results, demonstrate that parts of the German industry share this view and have expressed their contributions to sustainable development in their own programmatic statements. A series of firms have opened their doors at an operational level to these new approaches and are ready to cooperate actively in the further technical design of a future concept called "R&D for Climate Protection".

In the three economic sectors chemicals, cement and steel, the investigation of appropriate questions and approaches by DECHEMA has already led to initial concrete starting points. The next stage of the process will be to discuss and develop these in depth. At the same time, the outcome of such a procedure for identifying themes can only possess model character, because other, possibly equally relevant questions from other areas must likewise be taken into account, e.g. the separation and storage of carbon dioxide or the areas of road transport, mobility and automobile manufacture. To enable this to be done, the funding concept under development must remain thematically open and flexible.

At the same time it is also necessary to remember that such questions should not be regarded solely from today's perspective. Many basic parameters are dynamic and in rapid development, e.g. instruments relating to climate policy, including emissions trading, global prices for energy sources, technological developments at the international level and also socio-economic variables, such as markets, attractiveness for export markets and consumer behaviour. These aspects have to be taken into account, by incorporating them into the research projects and even making them the subjects of scientific research.

From today's perspective, the following opportunities are possible for the implementation of research contributions:

- Establishment of alliances, networks or platforms to improve the exchange of information and for co-operation,
- Improvements in the diffusion of technology, e.g. across industry branches or through demonstration projects,
- Longer-term research and development that produces "visionary" concepts, e.g. for the already mentioned themes oleochemistry and the electrolytic manufacture of steel.

Special attention needs to be paid at this point to the embedding of such approaches into the existing R&D landscape and into the existing funding programmes of governmental and nongovernmental organizations and institutions. The success of future funding measures of the BMBF in relation to climate protection will also depend, above all, on the interlinking of these new approaches with thematically related activities of other federal departments and organizations, for instance with the COORETEC initiative of the BMWA on CO_2 reduction technologies in power stations powered by fossil fuels, which commenced in 2002.

Also important is the coordination with thematically related activities of the European Union such as, for example, the so-called Steel Platform, in which the European steel industry is represented and which aims to substantially reduce European emissions of carbon dioxide during steel production. According to current planning in the 7th EU Framework Programme (FP7), the Steel Platform together with other technology platforms in the context of the pollution-control technology action plan ETAP is to receive high funding priority. Ultimately, the success of national climate protection efforts will depend on the readiness of German firms to bring forward solutions and also to integrate their own potential into the research groups.

Upon conclusion of the theme identification process, dialogue with decision makers in industry and society will be intensified on the basis of this new funding concept, for example in the form of regional conferences, and continued up to the point of being able to formulate common strategic project groups at the research level.

3. Theme: “Adaptation to Climate Trends and Extreme Weather – Strategies, Innovations, Markets”

3.1 Initial research policy position

Climate and weather have always had a large influence on the lives of human beings and their economies. With the onset of the industrial age and corresponding economic growth, greenhouse gases have been released in increasing amounts through energy generated from fossil fuels and through the rising consumption of resources, thereby causing changes in global material cycles. According to today’s state of knowledge, this has not been without repercussions on our climate. In the 1990s, efforts to protect the climate through the limitation and reduction of greenhouse gas emissions were undertaken for the first time at the international level, mainly via the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Meanwhile, the difficulties involved in implementing such a treaty and realizing successes within a foreseeable period are becoming apparent. Development worldwide is still characterized by virtually unhindered increases in emissions as a result of the growth of economies and populations. Politics, science and society must in future continue to pursue the goal of reducing greenhouse gas emissions in order to avoid dangerous climate change, as defined by the UNFCCC. There is, therefore, no alternative to the long-term development of a sustainable power supply and initiatives for this need to begin as soon as possible. However, a number of other measures with the prospect of more immediate success are already at hand and are necessary for dealing better with climate effects and weather extremes. These concern the development and implementation of effective adaptation strategies to the present climate and its future changes, with the aim of reducing or preventing damage today and thus taking precautions for tomorrow. More effective adaptation measures are important for the developing countries but equally so for the industrialized countries of the north, as the extreme weather events and their consequences, in Europe for instance, over the last few years have demonstrated.

The following examples demonstrate that improved adaptation to climate and weather is already of high economic relevance today. Industrial interests are therefore already taking increasing notice of the topic of adaptation. In addition, in government administrations, planning authorities and on the political level there is a

growing need for advice on the effects of climate and weather and a need for action. This results primarily from the following factors:

- It is unanimously agreed that the largest part of the economy already depends on the climate and weather either directly or indirectly.
- Climate and weather are not constant parameters. The currently measured climate trends and their projections suggest corresponding changes in the future and the progress reports of the Intergovernmental Panel on Climate Change (IPCC) point in this direction. These changes are unavoidable, even if the climate protection goals of the European Union and the German Federal Government are fully met.
- From a statistical perspective, unusual extreme weather events, which possess a high damage potential, do not occur with any regular frequency.
- The prompt implementation of appropriate adaptation strategies to climate trends and extreme weather events is expected to give rise to new opportunities for German industry, particularly on account of its pronounced export focus.

Against this background, improved adaptation attains its own significance in relation to the competitiveness of the economy and thus, at least in many sub-sectors, the retention of jobs. In addition, improved adaptation measures have the potential to exert positive effects on the public sector as well as on various environmental areas. In the following chapters, new approaches for future research and development funding are proposed that are primarily targeted at the needs of different firms, sectors and organizations in industry and society. Their problems and areas of interest are intended to provide the basis for discussion and co-operation, and to determine the direction of future collaborative projects and measures. In order to use public resources and exploit synergies in an optimum manner, value is placed on the active linking of activities and projects at federal and state level. Examples of this are the BMU concept "Adaptation to climate change in Germany" and the collaborative project of the state of Baden-Württemberg "Climate change – effects, risks and adaptation". The tight, cross-cutting interlinking of these research activities takes into account the interdisciplinary, action-oriented character of the necessary solutions.

3.2 Effects of climate and weather: Status and development

While the term "climate" marks the general framework of our weather patterns and can thus only be experienced by humans in the long term, our daily weather and in particular its extreme forms and effects determine human and economic activity to a considerable extent, independently of what causes these weather extremes. Three examples from the recent past illustrate this:

I.
Summer 2003 was unusually hot and dry: according to data from the German Weather Service (DWD), the average daytime temperature in Germany in June, July and August was 19.6 degrees Celsius, i.e. 3.4 degrees above average. All of Europe suffered from the heat. Around 20,000 people died as a consequence of the heat, approx. 4,000 of them in Germany, according to estimates of the World Health Organization (WHO). Rivers such as the Rhine and the Po, both of which have their sources in the Alps, exhibited extremely low water levels over several months, inland waterway transportation suffered large losses and power stations ran out of cooling water. In Portugal, the largest forest fires for 20 years raged.

Agriculture also suffered from heavy harvest losses of up to 30% for cereals. On the other hand, winegrowers expected to harvest a 'wine of the century'. Likewise, for example, firms in the tourist industry in usually cooler regions and beverage manufacturers counted themselves among the winners from this extreme summer.

This extreme weather situation affected the insurance branch in a comparatively neutral manner, as indicated for instance in a press release of the Münchener Rück at the end of 2003: "The economic damage in Europe reached an extraordinarily high figure of approximately 13 billion US$. Nevertheless, the burden on insurers, e.g. from damage caused by drought, is relatively small because diminished returns in agriculture due to drought are generally not yet covered in the European Union."

Summer heat waves like this one are unlikely to remain isolated events. A clear trend towards hotter and drier summers is identifiable merely from statistical analysis of the meteorological data measured so far, i.e. even without taking into consideration the prognoses that point in the same direction. The probability of a recurrence of an extreme event like the heat wave of summer 2003 has risen by a factor of about 20 in the last few decades.

II.
On December 26th 1999 the gale "Lothar" swept across the middle part of Central Europe, with wind speeds of over 200 km per hour. Eighty people died as a result of the storm. It left a trail of devastation, particularly in forests. In some areas, 20% of the trees were toppled or broken. In Baden-Württemberg alone, damage amounted to one billion euros.

At first sight of this picture of disaster, it is hard to believe that there were also winners. However, today one can see, for instance, that the forced rejuvenation of nature in only a few years has formed the basis for new mixed woodland that is well-suited to its location and is already starting to mature, with a concomitant increase in new habitat for four times as many animal and plant species as existed previously in the dense spruce forests.

III.
Just five years after the disastrous tidal flood on the Oder river that left behind 80 dead and damage in the billions, a tidal catastrophe on the Elbe and Danube rivers in August 2002 left 15 dead in Germany and damage totalling 9.2 billion euros. Funds for clearing away the damage were provided by the state, insurance firms and large donations from public collections. Assessments have shown that appropriate preventive measures would have avoided some of the damage at just a fraction of the cost. Although it is hard to influence and gain control over such events, possible adaptation measures are increasingly being discussed and tackled within the available limits. A corresponding report of the Ministry for Agriculture, Environmental Protection and Spatial Planning of the state of Brandenburg thus notes that: "Wherever local conditions make it feasible and the acquisition of property is possible, Brandenburg will move back dykes in order to enlarge the flood plain of rivers such as, for example, around Lebus an der Oder, Müggendorf-Cumlosen on the Elbe or the "black spot" near Lenzen."

These examples illustrate that, even in an apparently constant climate, adaptation to extreme weather events is necessary. However, the climate is also constantly changing, influenced by natural and human activity. In this regard the majority of the average rise in global temperature of 0.6°C (±0.2°) that has been observed during the 20th century can be traced back to anthropogenic emissions of greenhouse gases. Climate modelling results suggest that the observed rise in temperature will continue to intensify. By the year 2100, temperature increases will lie in the range of 1.4°C to 5.8°C, depending on the assumed scenarios for developments in society and economies, the globalization of national economic systems and the intensification of technology transfer. In addition, climate variability could increase as well as the probability of even greater and more frequent extreme weather conditions, as illustrated by the examples above, which would pose far greater problems for economies and society in view of the necessary adaptation measures. However, as the following text box indicates, the ability to make prognoses on differing time scales has improved considerably in the last years.

The short-range forecast, for instance, represents a simple interpolation of the present weather situation, for which models are generally not needed. The prognosis period covers several minutes up to a few hours, and is of particular importance for providing weather advisories for pilots and also storm warnings, e.g. tornado warnings in the USA.

The quality of the short-range forecast, i.e. forecast periods of up to around 3 days, has constantly improved over the last few years due to further development of the models and the increased frequency of observations, particularly from satellites. While temperature and wind can be forecasted relatively precisely, precipitation forecasts are much less precise. Short-range forecasts are normally the task of the national weather services.

In contrast to short-range forecasts, medium-range forecasts cover periods of up to 10 days. In Europe these fall under the area of responsibility of the European Centre for Medium-Range Weather Forecasts (ECMWF). Substantial progress has also been made in this field over the last few years.

Seasonal forecasts are particularly successful for the tropics, as can be seen, for example, in the events associated with El Niño Southern Oscillation. Remote sensing of sea level height and surface temperature of the ocean in the tropical Pacific as well as buoy surveys of water temperature in that area, at depths of up to 500 metres, permit the early detection and prediction of El Niño and La Niña phenomena for periods of approximately six months. There seems to be only a very weak correlation to the weather and climate events in Central Europe.

Of great importance for 10-year forecasts for the Central European area is the observation of the so-called North Atlantic Oscillation phenomenon. Recent research results suggest that the surface temperature of the ocean in the North Atlantic is characterized by a very high degree of predictability over spans of decades.

Seasonal or 10-year forecasts predict a trend (with appropriate variances) for a larger region in the sense of a climatological average value, meaning that weather cannot be predicted because of reasons regarding the system. However, such forecasts can represent valuable decision bases for adaptation measures.

These forecasts have considerably extended the possibilities for adaptation measures. Apart from climate and weather, however, a further substantial factor has changed fundamentally in the last decades. More and more people and economic goods are cramming themselves into geographical conurbations that are susceptible to certain weather conditions. For example, according to the United Nations, in 1950 only one third of the world's population lived in cities. Today it is already half, and at the same time the global population is experiencing rapid growth. In coastal regions the population density has also increased. At present,

around 3 billion people, i.e. half the world's population, are concentrated in a strip of 200 km along the coasts. A doubling of this figure, particularly on account of coastward migration, is predicted for the year 2025.

Finally, the mobility of goods and people worldwide are not the only things that have altered – the organization of production processes and product cycles themselves have likewise changed considerably. During the course of globalization and the abandonment by many firms of inventory stocking in favour of just-in-time production, logistics and transport processes are becoming increasingly important and these are often weather-dependent.

Current planning processes in regard to weather dependence are based on statistics relating to past periods, including the extreme weather events that have been observed. Very little consideration is being given at present to other possible changes in the climate phenomena themselves, some of which have already been scientifically proven, or to other foreseeable trends which result from, for example, economic development in ecologically sensitive areas such as land use in river basins. With present management, however, neither industry nor society is sufficiently well prepared for the future. This applies even if one of the factors – i.e. the increasing occurrence of extreme weather events that scientists have predicted – fails to occur.

New innovative strategies and methods to adapt to a changing environment mean not only reducing risks for society and industry – they also simultaneously open up new social and economic perspectives, particularly in a globalized world. This is illustrated by examples in the next chapter.

3.3 Examples of the significance of climate and weather in various economic sectors

3.3.1 Preface

In the following examples, the significance of climate and weather is presented for selected branches of the financial sector, the electricity supply industry, the building services industry, the tourism industry, the urban construction industry as well as agriculture and forestry. Climate trends and extreme weather are perceived as more than just a current or potential trend. From the perspective of firms in these sectors, operational risks and opportunities for new products and services, new business processes and comparative benefits over competitors already exist today. Special significance is thereby attached to the financial sector on account of its particular interest in risk and opportunity management. In addition, as the financial backer of the majority of industry, it is dependent on industrial adaptation strategies and therefore should have a central role as a promoter and multiplier.

The following details are based on research conducted in 16 sectors of industry and commerce by the technology centre of the VDI in Dusseldorf, on behalf of the BMBF. During the course of this research it was noted that several sectors are able to react appropriately with sufficient flexibility to climate and weather phenomena, whereas others do not currently believe that it will have much impact on their field of business activity in the future.

Neither of the above applies to the six sectors presented here, for these are usually characterized by long-term planning periods as well as investment and depreciation cycles. The power, building services and urban construction industries, as well as parts of the tourism business, build and operate infrastructure that is normally used over several decades. They cannot evade climate trends or extreme weather nor can they change their product lines. For sectors such as these that are not easily able to move into other areas, it is rational, and on a medium-to long-term basis economically necessary, to devote more resources to the early detection of weather and climate trends and to develop appropriate adaptation strategies to them. This also helps to secure business locations and jobs. Furthermore, these sectors are monitored very closely by the financial sector because capital for larger investments can normally only be procured on domestic and international financial markets, which react sensitively to signs and early indicators if an investment does not seem secure in the coming years.

In the case of the above examples, adaptation does not simply mean preventative economic risk management. It additionally provides competitive benefits for firms that react faster, more flexibly and strategically to climate and weather than their international competitors and ultimately opens new market opportunities too, such as in subtropical and tropical regions, which are already more seriously affected by weather extremes than Europe.

3.3.2 Financial sector

As the financial sponsor of industry, the financial system is presented as a cross-cutting sector here, in order to emphasize its pivotal role in the problematic of adap-

tation. The sector includes banks, insurance companies, re-insurers and institutional investors, in particular asset management companies, mutual fund firms and pension funds.

The financial industry is affected in several respects by the impact of climate trends and weather. First of all, it is directly forced, in the course of intensified international competition and rising risk prevention standards, to manage the indirect weather dependence of its business, to reduce it if necessary or to divest assets from its crossholdings portfolio. Secondly, banks and insurance companies offer products on the financial markets, which help enterprises to secure their businesses financially against weather risks and/or weather exposure. Common products of German banks are weather derivatives in the form of options and so-called swaps. The customers for these products in the retail trade, medium-sized firms and large-scale businesses come from sectors such as leisure, beverages, construction, power and agriculture. The market for such products is continually growing in Europe, both in terms of volume and number of transactions. The German market is the second largest of its kind outside the USA, and plays a leading role in Europe.

In the meantime the financial sector has produced numerous studies examining the weather dependence of sectors and businesses and the possible risk of a failure to adapt to weather and climate change by German industry. According to data from Deutsche Bank Research, weather irregularities play a direct or indirect role in approximately four fifths of global economic activity. Several key industries such as the construction, power, agriculture or leisure industries are especially sensitive to weather and are increasingly seen as vulnerable to climate change. As part of their business management, customers are increasingly being called upon to examine their dependence on the weather and to take preventive measures where necessary – measures that range from securing locations in the long-term to adjusting product ranges.

Sustainable management that is at the same time adapted to the climate has long-term effects on the competitive ability and net yield of a firm, thereby becoming a decision criterion for strategically oriented investors. Accordingly, a number of institutional investors and their advisers from the services sector, e.g. research departments and rating agencies, have taken initiatives geared to sustainable investment in which corporate or sectoral climate strategies play a central role. According to the Global Reporting Initiative (GRI), these include efforts to create global standards for the assessment of weather risks. Of key importance is the so-called climate exposure of firms and sectors that are exposed to weather extremes and climate changes directly and/or indirectly via changes in their basic conditions. New studies attempt to quantify both types of risk and to develop benchmarks with sets of indicators that compare the climate-related risk management of firms so that assessments can be made. Investment and financial decisions in the financial sector will thus be linked to the question of how highly exposed a firm is in relation to weather and climate change and how serious are its efforts to manage this risk.

To an even greater extent than banks, insurance firms and re-insurers play a pivotal role in terms of climate and weather. Businesses and private individuals take out insurance policies in order to protect themselves against financial damage from the influences of weather. The premium paid to insure a weather risk is currently the only quantitative indicator of the consequences of weather and climate. It becomes a management issue when insurance premiums experience a massive price increase, if not before. Liability claims and the volatility of share prices affect insurers in terms of higher direct costs. The value and share price of an insurance firm fluctuate greatly if it is affected by large claims for compensation or if the impression spreads that it has not made sufficient provision for weather- or climate-related claims. Re-insurers are usually also affected by such developments on account of their participation in insurance pools.

In order to be able to meet these challenges, the financial sector recognizes the need, in principle, to optimize the compilation and management of meteorological data, and in particular the systematic gathering of basic data and its supply in standard data formats and user programmes, while taking into consideration the needs of the banks and of the sectors that are particularly sensitive to climate and weather. Improved access to data should also be made available to interested customers, including links to international data sources. Further action is needed as follows:

- model calculations, specifically on medium-term climate trends, in order to optimize the assessment of claim potentials,
- research on integrated risk management systems and new forms of risk assessment for exposed cities and regions, and
- policy frameworks for new products from the insurance industry, together with their development.

In addition, information events and discussion forums that focus on climate and weather should be initiated for industry, as well as for chartered accountants and tax advisers. Educational opportunities on the management of weather risks should be provided at universities and colleges for occupational groups such as business administrators, lawyers and financial brokers.

3.3.3 Electricity supply industry

Weather, weather variability and climate trends have recently become very topical for the electricity supply industry in several respects. Those affected in particular are the energy producers and, in addition, the areas of electricity transmission and distribution, e.g. network carriers, power services and power traders. In all these areas over the past few years increasing weather dependence can be detected, such as, for instance,

- *weather dependence during demand and capacity planning*
  The measured trend towards warmer average temperatures simultaneously represents an opportunity and a risk for power and electricity demand. Higher average temperatures tend to lead towards a more even spread of demand over the course of a year and thus to a more evenly balanced utilization rate in power stations. Higher temperatures in the summer months increase the demand for cooling and air conditioning, which causes energy consumption to rise sharply, whereas in the winter and in months characterized by seasonal transition, demand typically sinks slightly. The change in demand structure and greater climate variability make it necessary to be able to predict fluctuations in demand better so that they can be compensated appropriately and, if possible, converted into revenues.

- *weather dependence of power plant technology and energy production*
  Power-mix considerations also find their way into the planning portfolios of power stations. Power station and network technologies are affected by climate trends and extreme weather in several respects. Different types of power station are affected by low water levels, floods and wind speeds to differing extents, which could eventually alter the feasibility and profitability of investments in power stations at some locations over the long term.

  More importantly for everyday business, however, is the fact that a power station breakdown has to be compensated almost immediately by other power stations. The capacity and operational planning of electricity producers is thus a central aspect of their competitive ability and their guarantee of security of supply. This planning will become more complicated on account of extreme weather and climate trends and requires an improved basis for estimating future developments. Gales and torrential rain are especially problematic for power distribution, since overhead power lines and transformer stations can be destroyed or their operating ability impaired. In addition to a need for improved planning instruments, information bottlenecks are caused by lack of an accurate data basis and the corresponding forecasts of development.

On the whole, businesses need an improved basis for planning and decision-making. For this, more reliable and timely information about the weather and the medium-term climate, and with higher regional resolution, needs to be developed in order to facilitate the planning of energy production and distribution.

Improvements to, and standardization of, the database are equally as desirable as suitable models for a more reliable forecast of weather and climate developments, with a higher regional resolution and a longer-term prognosis period. Also of importance is a user-oriented compilation of weather parameters, such as surface temperature, precipitation, wind speed, water levels in rivers and coastal waters as well as the flow velocity of waterways. On this basis new weather and climate services could be developed in co-operation with weather forecasting services and climate researchers.

3.3.4 Building services

The building services sector includes suppliers of building facades; heating, cooling and air conditioning technology; building control and automation; as well as facility management, i.e. building services that depend to a greater or lesser extent on technical information systems.

In the building services sector, weather extremes such as gales, torrential rain and hail count as controllable events, since buildings are normally designed to withstand "worst case" scenarios. However, there is a current need for research and adaptation in regard to the trend in climate and possible increased frequency of extreme weather events. Precisely on account of the global warming trend and the possible increase in the number of annual hours of sunshine, such as happened in summer 2003, both risks and opportunities exist for this sector.

The risks became apparent to the construction industry and the building services sector notably when a court

decision opened the way to their being sued for certain minimum standards for room climate. In the future, therefore, there is a greater risk that building occupants and operators will try to pass recovery claims on to a building's owner and charge him with negligence. According to an often quoted interpretation of this verdict, "In the future it will be important for employers who rent premises to select office buildings not only in terms of their attractiveness and advantageous logistical location, but also to inquire about the temperature behaviour of the property and to seek neutral, objective advice".

However, property engineers also perceive opportunities here since higher outside temperatures and stronger radiation from the sun increase the demand for products and services for the insulation, heat regulation, air conditioning and cooling of buildings. This is particularly so in the case of commercial buildings with large glass facades, but also in homes. For building operators, energy savings can be achieved by taking the climate into account during construction and facility management. In the medium term, building services that are appropriate to the climate should also lower maintenance and repair costs.

If the warming trend continues, it will also be profitable for firms offering building services to develop new products, technologies and services. These open up important export markets in subtropical and tropical regions such as China and India which, despite a marked exposure to climate, are increasingly constructing high value commercial offices and skyscrapers in accordance with western models.

In order to be able to counter weather and climate risks better and to take advantage of opportunities for new products, services and markets, a range of criteria needs to be met. Apart from the necessity of improving the temporal and regional resolution of data and models, also with a broader spectrum of parameters, which has already been mentioned for other branches, specific criteria can be seen:

- As a general rule, the development of interfaces between weather service providers and property engineers, based on European-wide and/or globally applicable standards and regulations, should be supported.
- Technical and legal appraisals should be financed, because the legal foundation in relation to properties is currently undergoing dramatic change. These range from design requirements for properties to liability questions on their design.
- Innovative approaches in the technical materials area should be funded systematically, for example improved design and planning instruments, i.e. integrated software tools for estimating the energy situation and operating costs of a building, new materials for the building services sector that could stimulate additional innovative thrusts in relation to optical and adaptive characteristics, or provide intelligent, adaptive building services.

In addition, it would be advantageous for discussion forums and trade platforms to provide information on climate and weather and present appropriate services as well as facilitate the dialogue with other players in the construction industry. A key feature in this connection is the funding of specific groups for small and medium-sized firms that generally have little capital and limited personnel.

3.3.5 Tourism

An intact natural environment, including climate and weather protection, has always been of great importance to the tourism industry but the basis of that existence could be endangered by possible climate changes and other burdens on nature and the landscape. For this reason, the main trade associations and organizations of the German tourism sector already signed a declaration in 1997 on environmental and climate protection in Germany and abroad, implementing it through many activities with the assistance of the Federal Government. In addition, representatives of the German tourism industry participate in international committees on sustainable tourism, especially in the implementation of the 1991 Alpine Convention and the environmental protection Protocol of the Antarctic Treaty. The fundamental need for action in the area of tourism to protect the environment, weather and climate, was re-emphasized in 2003 in a statement made by the World Tourism Organization. A concept paper of the Federal Government, approved by the German Bundestag in 2002, contains key points for interaction between environmental protection and tourism in Germany in more detail.

Tourism is, in addition, a substantial economic factor both domestically and internationally, with further potential for growth. The tourism branch is thus already interested in environmental and climate protection for economic reasons. The guarantee of an intact environment and protection of the climate belong to the quality strategy of many firms. For tourism companies the main fears in connection with weather and climate change

are that their security of supply will be endangered, such as, for instance, water supplies in southern or tropical destinations and so, too, their long-term investments, for example in hotels and infrastructure; they also fear the loss of many warm water destinations.

Climate trends, however, also open up opportunities to adapt existing travel products and to use the prevailing conditions in an active manner. These primarily concern the creation of touristic models that can accommodate different weather conditions and customer groups, e.g. by promoting indoor activities and enabling synergies with other economic activities, e.g. exhibitions, trade fairs, concerts and sporting events. The main interest of tour operators, hoteliers, states and municipalities in Germany lies in more reliable weather and climate information that is better broken down by region and also more up-to-date in the short and medium term as well as seasonally.

In addition, the following points should be taken into consideration:

- the adaptation of infrastructure as well as town and regional planning to foreseeable weather and climate trends, and
- the creation of appropriate interfaces between weather services, the tourism industry and regulatory authorities.

Support could also be provided by setting up appropriate information events, discussion circles and networks for municipalities and states as well as generally developing integrated models for the analysis of the effects of climate trends and extreme weather on the tourism industry.

3.3.6 Urban construction and town planning

Weather and climate trends form a very topical theme for urban construction and town planning and one which is gaining more and more in significance. On account of the heat wave in summer 2003, a working group of the World Health Organization, in collaboration with city planners, has been working on a weather warning system for European cities. Many municipalities in Germany expect an increase in the number of similar heat waves and are assuming a general trend towards higher average temperatures in cities, with associated health problems.

The lack of adaptive urban planning and of buildings that are adequately suited to the climate is already leading towards a tendency to overheat and a lack of aeration in the inner cities. This problem will intensify in the future. In cities such as Freiburg or Ulm, it is already being perceived as a future image problem, since the aura of the "sunny south" and the "sunshine capital" of Germany could change, for example into metaphors such as "the stifling south". In addition, a revision of the building code is due in the context of a European adaptation law. This, inter alia, would require an ecological report and an environmental monitoring system in urban zoning plans. Construction projects that are well adapted to the climate will clearly be revalued upwards in the course of this legislative initiative.

The topicality and explosiveness of climate and weather changes for town planning and urban construction is shown in the broad span of already existing efforts in this area. Thus some southwest German municipalities such as Stuttgart, Munich and Freiburg are investigating how they can improve regional and local weather forecasts as well as early warnings before weather extremes, set threshold values for weather warnings, draw up emergency plans and optimize operational planning in emergencies. On account of their duty to exercise diligence, local authorities must inform the public and particularly sensitive establishments such as hospitals, nursing homes, homes for the elderly, day care centres and schools as well as public health authorities as promptly as possible about risks and must facilitate preventive measures.

Traditional building designs are oriented to the climate and meteorological data of the past, a practice which will not be sustainable in the future since existing building stock, due to its longevity, is not geared to a possible climate trend and its consequences. Scenarios for future climate developments must therefore be integrated now into new building designs. In the past, building designs for extreme scenarios, such as torrential rain, gales, heat waves and lightning, generally only considered the consequences for a building in terms of its constructional safety and operational functionality. Requirements in terms of health, safety at work, comfort, living quality and quality of location were not taken into account. Efforts are being made in this connection to protect houses better in the future against solar radiation and at the same time reduce heat dissipation from air conditioning systems. In most cities in southwest Germany and the Rhine-Ruhr district, urban climate analyses are being carried out that should make it possible to conduct city planning in a climate-compatible manner. Over the past few years, Freiburg, Stuttgart and Ulm have already awarded contracts for the first time for urban climate analyses, which explicitly dealt with the consequences of climate change for their urban climates.

In order to be able to take climate trends and extreme weather better into account in urban construction and town planning, interfaces should be created between the classic weather forecast, climate and environmental research and city climatology, and information transferred between them. The availability of more reliable climate scenarios and weather forecasts, with a high regional resolution, appear to be especially important for urban construction as well as for adaptive town planning. The parameter basis needs widening in this connection, for example in terms of air humidity, wind speed and precipitation intensity. Higher temperatures, higher air humidity values, and effects such as heat islands and air circulation bottlenecks need to be better taken into account in the areas of hygiene, health and quality of life. In addition, the following points need to be aimed at:

- stronger linkage between extreme weather and the construction industry and/or technical measures for properties,
- integration of climate trends in the area of flood protection, and
- improvement of early warning and emergency planning at municipal level.

Here again, information events are recommended. Discussion circles and networks should be established at local level and these should also be open to citizens, for example house builders and homeowners.

3.3.7 Agriculture and forestry

Agriculture and forestry are, by their very nature, severely affected by climate and weather. Policy makers, the public and scientists have been discussing the topic for years. Until now priority has been given to estimating anticipated climate changes at a global level, the anthropogenic causes and the correlations in the global climate budget, changes in material cycles as well as measures to protect the climate. However, climate changes on the regional scale are being observed, too, for example changes in precipitation conditions (a precipitation deficit – especially in eastern Germany) and the accumulation of weather extremes.

Climate change has among other things the following effects on agriculture, forestry and fisheries:

- changes in location, shifts in vegetation zones, and changes in the water resources of the landscape,
- changes in the profitability of agricultural crops and forests, rising production risks due to weather extremes and pests, as well as
- changes in the earnings situation of the agriculture, forestry and fisheries industries, of cultivated landscapes, of services to society and thus the development prospects of rural areas.

Measures in favour of climate protection can basically only have a limited effect, which is why it is necessary in the medium-term for agriculture, forestry, fisheries and the water management industry to adapt to the respective regional changes in climate and yields and also risks. Only a small amount of research work has been done so far. The first surveys on regional climate change have been published over the last few years, for example for Brandenburg and Saxony. One can assume that, in the coming years, demand will increase for information and decision-making aids for policy makers, government officials, industry and the public. Existing information deficits relate to estimations of:

- regional climate change and the development of weather extremes,
- regional effects on water resources in the landscape, on soils, vegetation and pests,
- regional changes to production and yield relationships in agriculture and forestry, and thus
- effects on the development prospects of rural areas.

In Germany, many possibilities exist for adapting to climate change and for securing sustainable land management, for example:

- in water management: water retention in landscapes that are endangered by drought, preventive flood protection and water use,
- in agriculture: the study and use of genetic resources for changed conditions in terms of climate, location and phytosanitary conditions, adaptation in terms of soil management, for example humus and patterns of cultivation, changes in crop species, adaptation of crop rotations and changes to types of use, adaptation in terms of pesticides and risk minimization strategies, as well as
- in forestry: genetic resources, tree species and selection of origin, silviculture techniques and risk minimization strategies. Agricultural policy measures are also being examined in this regard.

3.4 Consequences for the funding of adaptation efforts in relation to climate and extreme weather

The results of surveys in various branches and enterprises and also at state level show that there is both a need for adaptation efforts and a readiness to collaborate in appropriate groups and/or networks. The need for action can be detected for many different topics.

Improved adaptation strategies therefore open a broad spectrum for action. Research and development must contribute to the solution of many new questions in the interests of the economy and society. In addition, existing solutions to problem definitions must be developed further, made ready for specific applications and implemented into everyday practice. Research, innovation, education and information in the context of interdisciplinary networks between researchers and other players can make significant contributions towards accepting the "challenge of climate" in the interests of the universal desire for climate security. This can anchor it as an important factor in business management and environmental planning today and in the future development of society.

4. Climate protection and protection from climate impacts: A communication problem for educational research and practice

Sustainability, in the sense of this concept, attempts to use the entire spectrum of development potential in industry and society to ensure long-term stability and qualitative improvements for human life, without endangering the load-carrying capacity of ecological systems or social cohesion. This understanding of sustainability presupposes economic efficiency, social partnership and ecological compatibility as broad goals. It is not possible to optimize one without the other, without calling into question the desired process of sustainable development as a whole.

The simultaneous consideration of economic, social and ecological sustainability is a demanding task. Sustainable, 'three-dimensional' thinking and actions in increasingly global, complex connections and over periods spanning generations must be learned and tested. Public opinion polls have shown that people in Germany are becoming increasingly aware of sustainability as a guiding principle, particularly as an obligation to future generations; the term enjoys much credibility, but its full significance is still unclear (see, for example, Kuckartz and Grunenberg in their representative survey of public on environmental awareness in Germany in the year 2002).

The topic of climate protection is symptomatic of the challenges facing sustainable development because decisions taken at the local level contribute to the global process of climate change that is taking effect over the long term. On the other hand, this results in the opening up of both opportunities and risks in the economic, social and ecological spheres that are negotiated in local, regional and global decision arenas and affect citizens both in their private and vocational lives.

It thus becomes apparent that sustainable development and sustainable action must address the problem of *communicating along different goal corridors, decision levels and living environments*. The art of communicating and integrating different perspectives is also central to sustainability assessments and strategies, in order to make the reciprocity of economic, social and ecological dynamics and the room for manoeuvre transparent, to point out potentially conflicting aims, and to search for solutions that promise to unleash positive feedback among all the dimensions of sustainability.

Education plays a special role in communicating the principle of sustainability. In this respect, education, vocational qualification and the transfer of knowledge in all areas and at all levels of society open up approaches for long-term communication. Education provides orientation so that links can be made between the state of knowledge in different disciplines and technical areas. It also promotes the acquisition of personal and technical skills and contributes to giving citizens and experts the ability to take action and develop strategies. On the other hand, the anchoring of the concept of sustainability represents an important component of an education system geared to the future. For employees, skills connected with sustainable development will in future be part of the qualifications needed to help secure employment prospects.

It is therefore clear that climate protection, as a quintessential aspect of sustainable development, has a pivotal role in vocational training and further education. In the framework of the BMBF's future funding concept "Research for Climate Protection and Protection from Climate Impacts", numerous branches of industry and areas of society such as, for instance, urban construction, will in future come to grips with the topic of emission reductions and adaptation to climate change in their own interests. In the future, business activities and markets will be judged – in the same way as basic technologies, creditworthiness and capitalization – on whether they offer innovative solutions to the climatic exposure of a sector. It is important that the measures to be developed do not point in a stereotypical manner to the "environmental problem of climate", but continually take note of, and optimize, the cross-linking and feedback mechanisms between the economic, social and ecological foundations for human existence.

The present funding concept therefore also covers educational measures, in order to:

- present approaches of sustainable action in the area of climate protection and make them comprehensible,
- practice integrative, foresighted thinking in complex 'three dimensional' connections,
- communicate the basis for decisions, exemplary solutions to problems, management rules and quality objectives for sustainable development,
- illustrate the innovative potential of the concept of sustainability, and thus
- promote a readiness to engage in everyday life, in the workplace and in society with the guiding principle of sustainable development.

These guidelines on the communication of sustainability goals can be profitably implemented in various educational sectors. For example:

- *measures in relation to educational work both in and out of schools*, in order to familiarize all citizens during the course of their educational path with the principle of sustainability, and to place this on a broader footing in the context of lifelong learning,
- *vocational training and further education measures*,
- *measures to transfer climate protection related knowledge* to industry and municipal administrations,
- *further education measures at university and scientific institutes* in order to embed integrative education and research perspectives at an early stage, as well as
- *general information and public relations measures*.

The strategies and options that have been put together for sustainable climate protection and protection from climate impacts can only succeed if they reach the appropriate addressees in industry and society and in education and further training, and if they are subsequently also implemented. The implementation of this funding measure therefore requires the initiation of appropriate communication and co-operation processes. The orientation towards applied research and the practical relationship of the projects that are funded will be strengthened. Due to the demanded integration of experienced partners and potential users, an intensive exchange between science and practice is ensured, thus providing a very good basis to achieve the above.

In the framework of this concept, the BMBF will promote accompanying measures that can be organized in a crosscutting manner above and beyond the theme of this funding priority. Interest groups and potential users will be included. Research findings need to be transmitted into everyday practice and the living environment, and discussed. The user's viewpoint is regarded as essential in this respect, in order to judge research concepts and, if necessary, adapt them to the needs of everyday life.

Apart from the above measures that deal with efficient communication of research findings geared to the appropriate addressees, funding is also available for communication and media training and to support action campaigns that increase public awareness.

A particular challenge in this respect lies in the integration of businesses, especially in regard to the substantial participation of small and medium-size enterprises

(SME). Such firms can frequently not be reached directly but rather indirectly, via chambers of commerce, trade associations, specialized consulting firms and also via the education system.

Education can support the communication effort necessary for sustainability. By means of the measures specified above, sustainable processes can also be embedded into everyday experience on a long-term basis. Each individual is called upon to transform the concept of sustainability into reality. However, everyone must have the possibility of educating themselves further at a practical and personal level, in order to acquire the necessary skills for action that will also enable them to participate in implementation steps.

5. Perspectives for the conceptualization and formulation of research projects

This funding concept is intended to initiate the targeted funding of projects in the areas of activity described in chapters 2, 3 and 4 in the fields of research, development and education. The objective of the funding measures must be application-based. The conceptualization of R&D projects that can be funded on the basis of this range of topics leads to the following perspectives:

- *Meteorological and climatological inputs*
  Since climate change is also attributable to anthropogenic causes, the funding measures envisaged to reduce the emission of greenhouse gases in industry and society ("mitigation"; see theme in chapter 2) aim to focus existing knowledge, which has already been researched in great detail, and convert it into practical approaches. The meteorological and/or climatological methods and instruments that are necessary for the transfer of knowledge in this sector, i.e. data, models and forecasts, have to a large extent already been developed and are available but they need customization at the project level, depending on the topics covered by the R&D project. A project-specific analysis can therefore assist in individual cases in identifying deficits that might still be present and developing interfaces for the project's implementation. As far as the individual project concept allows, such questions can also be specifically included in the design of the R&D projects. Thus, from an organizational perspective, working groups in the form of collaborative projects between researchers and users make sense.

  It is undisputed that there is also considerable demand for research initiatives on the theme of mitigation, in order to improve the meaningfulness of long-term climate forecasts. This mainly concerns R&D concepts for the reduction of methodological uncertainties that still exist with current climate models. The continuation of this research work – mainly on methodology – will, however, in future primarily remain an institutional research task of the BMBF via the Helmholtz Association and the Max Planck Society and is therefore not included in the project funding behind this concept.

  As far as the funding measures for adaptation to short-term climate trends and extreme weather events are concerned ("adaptation"; see theme in chapter 3), existing meteorological and climatological inputs for

developing models are probably still very incomplete. In this sector, therefore, in contrast to the topic of emission reduction, targeted project funding for the further development of models to improve weather and short-range climate forecasts, e.g. towards higher regional and temporal resolution and taking into account the respective environmental parameters, is both possible and necessary in the framework of this funding concept. Climate scenarios need to be derived that focus on adaptation problems, taking into account the relevant processes and regional requirements for their concrete implementation in each case. New, coupled modelling systems and corresponding computer capacity play an important role in the methodological developments that are necessary. These can be made available institutionally for a particular purpose and specific project on the climate modelling super computer in Hamburg (DKRZ) through the BMBF's computing allocation at that location.

- *Development of technologies, processes and products*
  Dealing with climate and weather in a sustainable manner for the future also requires new, climate-friendly products in different areas. This concerns both technical processes and those developments that facilitate and accelerate the conditions for their transformation into products and that open up markets for new services. Apart from innovative technical developments and products and the use of new materials, this concerns
  - the further development of technical regulations and standards, and
  - the analysis and recommendation of appropriate political and legal frameworks.

  New climate and weather services can be developed and offered that are customer-oriented and close to the market.

- *Management instruments for industry and society*
  The funding concept should also contribute to anchoring mitigation and adaptation strategies as management instruments in industry and society more intensively than has been the case so far. Businesses seeking long-term success in the market must be in a position to match all processes in the scientific-technical, economic and social environments and to take account of market trends. In the environmental planning field, in which the various interests and developments in society need to be taken into account, similar requirements exist. Effects of climate and weather must therefore be considered in the sense of integrated management and appropriate risk assessment against the background of other economic, ecological or social developments. New instruments grounded in R&D must be developed for risk management, strategic fields of activity and environmental planning in order to develop a new concept for improved climate security. Classification systems, supported by experts could be developed, in order to capture the climate and weather sensitivity of natural areas and also of civilization-related location factors and infrastructures and to make them available for precautionary planning by firms and regional decision makers.

  An important factor for the introduction and implementation of new instruments and methods is the establishment of networks between businesses, public authorities and other players from society as platforms for cooperation. These enable the planning and implementation of common projects and actions and the forging of alliances. Taking, for example, the BMBF regional innovation projects "InnoRegio" as a model, regional climate projects "KlimaRegio" could be established.

- *Knowledge transfer and innovation management*
  Ultimately, improved information management is also indispensable. It is often the case that sometimes existing information, even of fundamental importance for transferring the necessary knowledge or technology is not known or not considered relevant for the respective application or implementation. The complexity and diversity of the adaptation topics possibly also hamper the rapid diffusion of relevant research findings and management options into neighbouring or even completely different areas of application. To establish adaptation measures at the level of businesses or, for example, regional authorities, requires prior knowledge of the potential of existing data, instruments and methods and also of their potential for further development. Information events for specific customers or industry branches, geared to special events, different users, affected players or particular regions could help to close these gaps. Internet portals could also be established in this connection.

- *Integration of educational measures*
  The role of education in communicating the principle of sustainability suggests that the research projects should be accompanied by corresponding educational measures. How these measures are designed in detail and which target groups and/or educational areas they

address needs examining in individual cases as a function of the respective research topic. Cooperation is recommended in this regard with suppliers of educational programmes and educational institutions who already have experience in providing education in the area of sustainable development. Appropriate possibilities for cooperation can be opened up, for example, via the national activities planned for the UN decade "Education for Sustainable Development" and the work and communication structures developed for these.

6. Implementation aspects of the funding concept "Research for Climate Protection and Protection from Climate Impacts"

Under the overarching policy principle of sustainability, this new funding concept pursues the aim of translating existing knowledge of the climate into the solution of research policy tasks, which serve to protect the climate in the long term and also protect citizens from the consequences of short-term climate changes and extreme weather events, a theme which has become very topical lately. In order to do justice to the complexity of this problem, there are two basic elements of the concept: (a) measures to mitigate greenhouse gas emissions, and (b) strategies for adapting to climate trends and extreme weather, as presented in chapters 2 and 3 respectively.

Implementation and communication problems resulting from the paradigm of the "sustainability concept for climate protection" are common to both elements. However, this problematic, which affects research and education policy to the same extent, extends beyond the implementation problems in terms of project planning and funding cited in the sector-related examples of the themes. This is because the implementation problems associated with the conventional funding of network projects dealt with aspects such as the interdisciplinary and transdisciplinary nature of research concepts, the transfer of research findings into everyday practice, as well as the diffusion of new technologies into the human environment and their effects. However, the equilibrium between the competing economic, ecological and social goals envisaged in the sustainability concept presented here requires in addition a more extensive, programmatically integrated, comprehensive communication strategy. This was therefore made a specific task for education policy in chapter 4. The success of this funding concept will depend, to a substantial extent, on successfully communicating the guiding principle of sustainability intersubjectively, i.e. "between minds", and on its being accepted. It will also depend on recognizing, practising and understanding sustainability as a necessary contribution that has to be made to retain quality of life, both as an individual maxim for action as well as in a community context, whether through the scientific community for instance or through other players and groups in society.

In autumn 2004, the BMBF will publicly announce a funding programme on the basis of this concept, in

order to inform a broad clientele in industry, research and public administration, as well as members of the public interested in climate change, about the new funding possibilities. This public announcement is also intended to encourage interested research institutions in the public domain and industry to develop joint concepts for new solution-oriented research projects and to apply for research grants.

Due to the complexity of the subject, also at the project level, the possibility exists of preparing preliminary studies on specific themes, sectors or regions, which will subsequently be developed into application concepts. Research requirements, for example concerning data, predictions, technical developments, the establishment of networks or ideas for implementation can also be formulated. Topic-related workshops can also be held or funded, as long as these lead interested parties to a prioritization of themes or to integrative project concepts for network research. Another goal could likewise be the establishment of regional structures and networks that bring together specific aspects from different application areas and are based on common interests.

Applications for pilot or master projects will be selected in accordance with competitive criteria from the project proposals received.

Practical application and implementation enjoy high priority in the funding of appropriate R&D projects. Therefore, participants in the research groups from industry and public authorities will be expected to finance a proportion of the financial expenditures themselves.

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