Report under the

Kyoto Protocol to the

United Nations

Framework Convention on Climate Change

Fifth National Report of the Government of the Federal Republic of Germany (Fifth National Communication)

Summary

The framework data given for the Fifth National Communication refer to the following areas:

- Legislation
- Population growth
- Geography / land use
- Industry
- Energy
- Transport
- Agriculture and forestry
- Waste management
- Private households.

In keeping with availability, the data refer to the years 2004 to 2009.

Environmental protection as a national objective, and the country's political structure

Since 1994, protection of the natural basis for life (environmental protection) has been enshrined as a national objective in the Basic Law of the Federal Republic of Germany. The Federal Republic of Germany is a federal state. The Basic Law (Grundgesetz) defines the division of duties and responsibilities between the Federal Government and the Länder (states). In general, each Land (state) determines how its own state administration shall be organised.

Legislation

Legislative competence in Germany is divided between the Federal and the Länder levels. In certain areas defined by the Basic Law, the Federal Government has exclusive powers of legislation; it also has powers of concurrent legislation in certain areas, in cases in which uniform national legislation is required.[1] Exclusive powers of legislation do not apply in the case of environmental laws. The various areas of environmental law are assigned to the area of concurrent legislation. This enables the Federal Government to shape environmental legislation and to transpose EU Directives in the environmental sector.

Geography and land use

Land use

From 1996 to 2004, the share of agricultural land area in the country's total land area decreased by 1.1 percentage points, while forest area increased by 0.4 percentage points. During the same period, the total area covered by water increased by 339 km^2. In 2004, land devoted to settlement and transport accounted for 12.8% of Germany's total area.

[1]This requirement applies only to certain areas of concurrent legislative competence.

Land-use trends in Germany are characterised mainly by growth of the area used for settlement and transport, usually at the expense of agricultural land. In 2007, land for settlement and transport accounted for 13.1 % of Germany's total area.

Increases in the area given over to settlement and transport entail increases in climate-relevant pollution and in consumption of resources and energy.

Climate

In the interest of making regionally differentiated climate forecasts possible for Germany, regionalisation procedures are being used in further development of climate models. This entails complementing global models with statistical and dynamic regional climate models.

Various regional climate models have been produced for Germany, in national (REMO, CLM, WETTREG and STAR) and international (ENSEMBLES, an EU-FP6 project) research projects. Evaluation of the relevant data has not yet been completed.

The regional climate models REMO, CLM, WETTREG and STAR show comparable regional trends for air temperatures in part. The dynamic climate models REMO and CLM, for example, along with STAR, a statistical model, all point to warming trends that intensify as one moves further south. For the period 2021-2050, STAR calculates warming of 2 degrees Celsius, while the dynamic climate models forecast warming of 1 degree Celsius. WETTREG, a statistical model, shows warming that intensifies as one moves from east to west, with warming levels amounting to about 0.5 degrees Celsius.

The models also indicate that annual precipitation levels may well remain relatively constant. Precipitation cycles can be expected to change, however: precipitation could decrease by as much as 40% nation-wide in the summer, and increase by 0 % to 40% – depending on the model used – in the winter.

Economic development

In 2008, the country's gross domestic product (GDP) reached a level of EUR 2,492 billion.For the population as a whole, this translates into a per-capita figure of EUR 30,342.

Primary energy consumption has decreased slightly in recent years. This points to success in efforts to sever the links between economic growth and energy consumption. From 1990 to 2007, energy productivity in Germany increased by nearly 40%.

Energy

Energy consumption by sectors and fuels

Primary energy consumption in Germany has decreased slightly since 1990. Pertinent changes are seen especially in the sectoral structure of final energy consumption. Industry's share of final energy consumption has decreased slightly; its share of total final energy consumption shrank from 31.4% in 1990 to 28% in 2007. In keeping with that trend, increases occurred – solely as calculatory effects – in the corresponding shares for private households (from 25.1% in 1990 to 25.6% in 2007) and the transport sector (from 25.1% in 1990 to 30.3% in 2007).

In 2007, Germany's primary energy needs were met as follows (by fuels / energy sources, in %):

- Petroleum: 34%
- Natural gas: 22%
- Hard coal: 14%
- Lignite: 11%
- Nuclear energy: 11%
- Renewables: 7.2%

Electricity generation and consumption

From 1990 to 2007, net electricity consumption in Germany increased by 16%. During the same period, gross electricity generation increased by over 15%.

As to sources, in 2007 hard coal and lignite together accounted for the largest share of primary energy input for electricity generation – 51 %. Nuclear energy accounted for the next-largest share, 28%.

Energy prices

Import prices of crude oil, natural gas and hard coal have risen in recent years. The largest increase in this regard was seen in the price of crude oil and in that for gas, which is coupled to the crude-oil price (an increase of about 350% between 1991 and 2007).

The import price for coal fluctuated less during the same period, although it also showed an increasing trend. In May of 2008, for example, it was 41.5% higher than it had been in May of the previous year. Also between 1991 and 2007, consumer prices for the various relevant fuels climbed as a result of import-price increases, of lacking competition in the electricity and gas markets and of tax policy.

Transport

Transport trends for recent years show a moderate increase in passenger transports (26.4% between 1991 and 2007) and considerable growth in goods transports (66% between 1991 and 2007).

During the same period, road transports increased by 30%.

Motor-vehicle fleet

The total number of motor vehicles in service increased by 28% between 1991 and 2007, while the number of automobiles on the road grew by 27% during that period. The percentage of automobiles with diesel engines increased from 12% in 1991 to 23% in 2007. Between 1991 and 2007, the total number of trucks in service and the number of two-wheeled motorised vehicles in service each increased by 63%.

Fuel consumption

From 1991 through 1999, the transport sector showed increases in absolute fuel consumption. Then, consumption declined until 2005. Since 2005, fuel consumption has stabilised at the level seen in 1991. In 2007, a total of 11.5% less fuel was sold than was sold in 1999.

The specific changes in consumption of the various different types of fuel concerned have differed in terms of their percentage contribution to the overall decrease in consumption. Consumption of diesel fuel increased by 50% between 1991 and 2007,

while petrol consumption decreased by 31% during the same period. Also during the same period, kerosene sales nearly doubled (+95%).

Private households

In the category of final energy consumption by private households, energy inputs for space heating predominate (74%), followed by those for hot water supply (11.9%), mechanical energy (7.9%), other process heat (4.6%) and lighting (1.6 %).

The most important fuels in final energy consumption for space heating are natural gas (with a 45% share) and light heating oil (with a share of about 34%). Between 1990 and 2005, the average residence size (in terms of floor space) increased continuously.

Agriculture and forestry

In 2005, agriculture and agricultural land use generated some 104 Mt CO_{2eq} of GHG emissions, with some 41.62 Mt CO_{2eq} from ameliorated bog soils used as farmland or grassland, some 27 Mt CO_{2eq} of nitrous oxide emissions from fertilisation of agricultural soils and from agricultural N surpluses and about 17 Mt CO_{2eq} of methane emissions from enteric fermentation as main sources. The forestry sector is an important carbon sink, with a sink contribution of about 79 Mt CO_{2eq} (in 2006).

Waste management

In 2006, about 46.5 million tonnes of municipal waste were produced in Germany. Since 1999, the volume of waste requiring management has steadily decreased, and in 2006 it reached about 13.7 million tonnes. The total volume of recovered waste has increased in recent years; at a level of over 32.7 million tonnes, that volume accounts for some 70% of the total amount of municipal waste produced

Legal basis and objectives of waste management

The underlying law regulating waste management is the Closed Substance Cycle and Waste Management Act (KrW-/AbfG). It establishes the following hierarchy of objectives: firstly, waste production is to be avoided; secondly, waste is to be used for substance or energy recovery; thirdly, where neither waste avoidance or waste use for substance or energy recovery are possible, waste is to be disposed of by environmentally friendly means.

The Waste Deposition Ordinance (AbfAblV) is another important legal framework provision. Among the impacts of that provision, since 2005, all landfilling of non-pretreated municipal waste has stopped. Also since 2005, the aforementioned provisions also prohibit landfilling of biodegradable waste and of waste with significant calorific value.

Waste incineration

In 2008, the incineration capacity of the 70 waste-incineration installations in place in the country amounted to about 18 million tonnes per year. The total throughput per installation increased from 191,000 tonnes in 1990 to 257,000 tonnes in 2008. In recent years, use of municipal waste as a substitute fuel has increased. In 2008, for example, some 0.7 million tonnes were incinerated in coal-fired power stations and about 0.9 million tonnes were burned in the cement industry. As of the end of 2008, a total of 15 power stations fired with substitute fuels, with total capacity of about 1.8 million tonnes per year, were in operation.

Mechanical-biological waste treatment

In 2007, a total of 46 mechanical-biological waste-treatment (MBT) plants, with total treatment capacity of about 5 million tonnes per year, were in service in Germany. Also in 2007, some 2.3 million tonnes of municipal waste were treated in a total of 30 mechanical waste-treatment (MT) plants. The total quantity of waste treated in both types of plants in that year amounted to 7.3 million tonnes. In addition, a total of 3 million tonnes of high-calorific fractions, and 0.2 million tonnes of metals, were separated out for processing/recovery.

Landfills

The number of municipal-waste landfills in operation in Germany decreased from 8,273 in 1990 to 130 in 2008.

The waste-management sector's contributions to climate protection and resources conservation

The measures described above reduced landfill methane emissions by about 80%, from 1.72 million tonnes in 1990 to about 0.36 million tonnes in 2008. In addition, considerable CO_2-emissions reductions are being achieved by using heat and electricity produced via waste incineration, by increasing recovery of iron and non-ferrous metals from sludges produced by waste-incineration installations and by fermenting biowaste to yield biogas

Inventories of anthropogenic emissions of greenhouse gases

As a Party to the United Nations Framework Convention on Climate Change (UNFCCC), Germany has been obligated since 1994 to prepare, publish and regularly update national inventories of greenhouse-gas emissions. All Parties listed in ANNEX I of the UNFCCC are required to prepare and submit annual National Inventory Reports (NIRs) containing detailed and complete information on the entire process of preparation of such greenhouse-gas inventories. In 2009, after having submitted inventories for the years 1990 through 2007, Germany submitted its seventh National Inventory Report.

Presentation, determination and structure of emissions data

Germany presents data on its greenhouse-gas emissions in tabular overviews, in substance-specific tables and in graphic form.

Accuracy of emissions data

Uncertainties determination is an important part of any complete inventory. In general, two methods for determining uncertainties are differentiated. The Tier 1 method combines, in a simple way, the uncertainties in activity rates and emission factors, for each source category and greenhouse gas, and then aggregates these uncertainties, for all source categories and greenhouse-gas components, to obtain the total uncertainty for the inventory. The Tier 2 method for uncertainties determination is the same, in principle, but it also considers the distribution functions for individual uncertainties and carries out aggregation using Monte Carlo simulations.

Currently, Germany reports only uncertainties that have been calculated pursuant to the Tier 1 method. Tier 2 uncertainties calculation is carried out only every 3 years. Pursuant to Tier 1, the inventory's total uncertainty for 2007 is +/- 9.7%.

Emissions of greenhouse gases

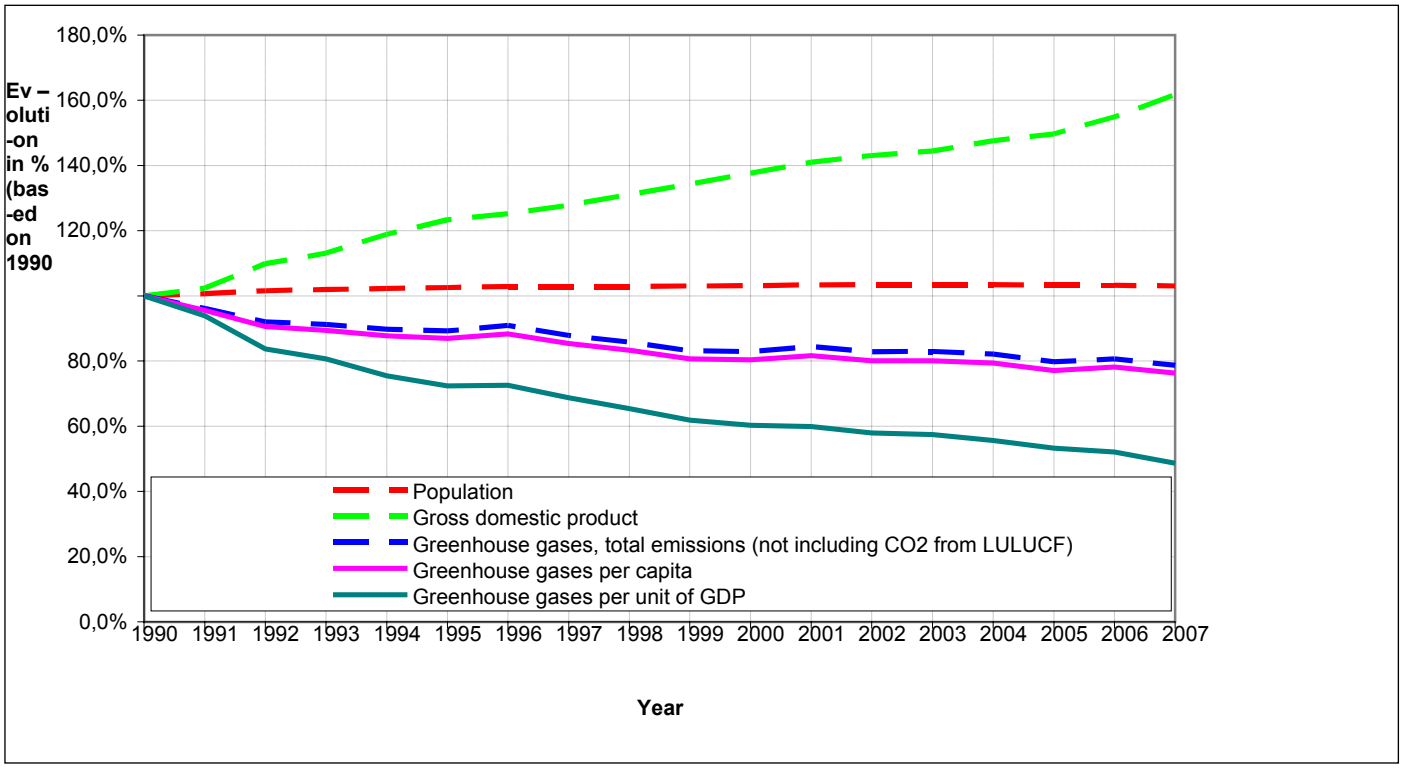
In the framework of internal burden-sharing within the EU, Germany has made a commitment to reduce Germany's emissions of all six Kyoto gases by 21% in comparison to the base year (1990 or 1995), by the end of the first commitment period, which runs from 2008 to 2012.

As of 2007, Germany had reduced its greenhouse-gas emissions by 22.4% with regard to the corresponding levels in the Kyoto base year. Consequently, Germany's emissions are below the annual level defined for the commitment period (2008-2012), and they are at a level at which a 21% reduction obligation, within the framework of EU burden sharing, is feasible.

Accounting for 87.9% of greenhouse-gas emissions, CO_2 is the most significant greenhouse gas (2007), followed by nitrous oxide, with a share of 5.8%, and by methane, with a share of 4.4%. The other "Kyoto gases" together account for a total of some 1.8% of all greenhouse-gas emissions.

From 1990 to 2007, Germany has succeeded to a considerable extent in severing the links between a) economic growth (+41.7%) and population growth (+3.1%) and b) trends in greenhouse-gas emissions (-22.3%). The following figure highlights this progress.

Fig. ES 1 *Relative development of emissions indicators since 1990*



[Development in % (with regard to 1990); Population; Gross domestic product (GDP; Greenhouse gases, total emissions (not including CO_2 from LULUCF); Greenhouse gases per capita; Greenhouse gases per unit of GDP]

Emissions of fluorinated greenhouse gases

Different trends can be seen in the development of emissions of the "F-gases" (PFC, HFC and SF_6) during the period 1990 to 2007. From the base year 1995 through 2007, HFC emissions increased by about 154%. PFC emissions have been reduced considerably since 1990. By 2003, they had fallen by about 80%, and the total decrease in those emissions since the base year 1995 was about 70%. From 1990 to 2007, SF_6 emissions increased by 16%.

Description of the National System of Emissions Inventories

The German National System fulfils the requirements set forth in the UNFCCC's *Guidelines for National Systems*. The National System serves the preparation of inventories conforming to the principles of transparency, consistency, comparability, completeness and accuracy. The Federal Environment Agency (UBA) has been assigned the task of serving as the "Single National Entity" (SNE; national co-ordinating agency) for Germany. The SNE assumes responsibility for planning, preparing and archiving inventories, for providing inventory descriptions in inventory reports, and for carrying out quality control and assurance for all relevant process steps. The key tools used to carry out those tasks include the database "Central System on Emissions" (CSE), a central, national database for emissions calculation and reporting and for central storage of all information required for emissions calculation. Within the Federal Environment Agency, a "Quality System for Emissions Inventories" (QSE) provides the framework required for good inventory practice and for routine quality assurance. In addition, the inventory-preparation process is

supported by a "Working Group on Emissions Inventories", a co-ordinating committee.

Policies and measures – projections and sensitivity analysis

All of the measures, data and results described under the above heading have been taken from the 2009 Projection Report

Methods

For Germany's 2009 Projection Report, a research consortium has prepared scenarios for greenhouse-gas trends in Germany in the period 2005 through 2020.

In addition to describing the applicable general and political frameworks, as well as the political measures and instruments used for climate protection since 1990, the report describes sector-oriented measures that have already been implemented – and that are taken into account, in emissions estimates for individual sectors, in the "with measures" scenarios.

In connection with the scenario analyses, climate-policy and energy-policy measures – including measures enacted to date and measures going beyond action to date – were analysed in detail with regard to their impacts on trends in greenhouse-gas emissions in Germany. The analyses consider emissions of the greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6), which are covered by the Kyoto Protocol, for the source categories "energy", "industrial processes", "product use", "agriculture" and "waste management". The analyses do not cover the source categories "land-use changes" and "forestry".

An energy-system model and an emissions-calculation model were used in scenario development. Via those models, the results of detailed sectoral analyses – some of which were themselves model-based – were translated into a consistent, complete quantity framework, for energy requirements and greenhouse-gas emissions, that is fully compatible with the German greenhouse-gas inventories (as of the 2008 Inventory Report). Specific studies were carried out for the areas of space heating and hot water supply, electrical appliances, industry, commerce-trade-services, transport, electricity generation from renewable energies and electricity generation from fossil fuels. Furthermore, specific studies were carried out for volatile energy-sector emissions, e.g. process-related CO_2, CH_4 and N_2O emissions. For selected source categories (HFC, PFC and SF_6 emissions, and for agriculture), results of other studies were adopted or processed.

The Federal Government has not endorsed the results of the presented scenarios for trends in greenhouse-gas emissions in Germany for the period 2005 through 2020.

Framework data

When the framework data for the calculations on which the present report is based were defined, the economic and financial crisis had not yet begun. In particular, the current economic growth forecasts for the coming years, predicting only slight or even negative growth, were not yet available. Calculations on the basis of different growth rates would yield different results.

Numerous important frameworks play a key role in development of energy-requirements and emissions scenarios. Such frameworks include demographic and economic framework data and projected development of energy prices. Table ES-1 provides an overview of the most important framework data for the scenarios.

The scenario trends are based on a demographic development whereby Germany's resident population peaks in the period 2005 to 2010 and then decreases slightly in the following years, eventually returning to an expected level of just below 82 million inhabitants in the year 2020. Nonetheless, a continuing trend toward smaller households causes the total number of private households to increase slightly until the year 2020.

Table ES-1 Selected demographic and economic framework data, 2005-2020

	2005	2010	2015	2020
Demographic trends				
Residential population (1,000s of inhabitants)	82.438	82.039	81.790	81.328
Private households (1,000s of households)	39.178	40.108	40.629	41.185
Economic trends				
Gross domestic product (billions of €)	2.241	2.483	2.701	2.925
Gross added value in the manufacturing sector (billions of €)	455	521	563	606
Workforce in the manufacturing sector (1,000s of employees)	7.506	7.476	7.291	7.080
Workforce in the services sector (1,000s of employees)	27.265	27.866	27.534	27.101
Primary-fuel prices				
Crude oil (€/t)	314	299	306	338
Hard coal (€/t HCU)	65	78	79	85
CO_2-allowance prices (€/EUA)	18	15	18	20
Remark: All price and added-value figures are adjusted to 2005 prices				

Sources: Federal Statistical Office, Federal Office of Economics and Export Control, EIA, calculations of DIW Berlin

As to economic trends, economic growth is expected to continue relatively constantly until 2020, with the result that Germany's gross domestic product in 2020 is expected to be about 24% above GDP for 2005. During the same period, gross value addition in the manufacturing sector is expected to increase somewhat more strongly and amount to about 30%. As to employment, it is assumed that the manufacturing-sector workforce in 2020 will be about 10% below the corresponding level in 2005, amounting to a decrease of about 820,000 employees. In the private and public services sectors, slight workforce growth is expected, amounting to nearly 1.3 million, or an increase of nearly 5%.

As to trends in primary energy prices, crude oil is expected to cost about EUR 338 per tonne in 2020. In comparison to the corresponding price in 2005, that would amount to an increase of about 7.3% after inflation. The long-term trend for the price of hard coal is expected to be similar to that for the oil price. As a result, imported hard coal would cost about 30% more in 2020 than it did in 2005 (the corresponding high rate of increase results primarily from the low price level of 2005, which for various reasons was exceptionally low; the price level expected for 2020 fits well within the long-term relationships between oil and coal price trends). In addition, the scenarios assume that prices for EU emissions allowances will increase slightly as of 2010 and reach a level of EUR 30 € per EUA in 2020 (real price, based on 2005).

Development of energy requirements

Final energy requirements in Germany are calculated from energy inputs in the areas of households, commerce-trade-services, national transports and fuel inputs in

industry (including fuel inputs in power stations of the manufacturing and other mining sectors). Fuel requirements for international air and sea transports are taken into account solely for informational purposes in determination of final energy requirements for purposes of the projection.

In the *"with-measures" scenario*, final energy consumption in Germany increases only slightly from 2005 to 2020, although its structure changes considerably. From 2005 to 2020, petroleum products' share of that consumption decreases by about 6 percentage points, to a level of about 31% in 2020. Natural gas's share of total final energy consumption remains about constant, while electricity's share increases by slightly more than one percentage point. In 2020, natural gas and electricity meet about 29% and 21%, respectively, of final energy requirements. Renewable energies' share increases from 5 to 11 percent. On the other hand, the corresponding shares for hard coal and lignite, and for district heat, change only insignificantly.

In the *"with-measures" scenario*, final energy requirements for private households and the commerce-trade-services sector decrease from 2005 to 2020. For households, the relevant decrease amounts to 5%, while for commerce-trade-services it is 10%. Final energy requirements for national transports increase slightly from 2005 to 2010 and then return to the 2005 level by the year 2020. About half of the some 17% energy-requirements growth forecast for the industry sector for the period 2005 through 2020 results from vigourous expansion of industrial electricity generation. Fuel inputs for industrial power stations increase by a total of 48%. Energy requirements for international air transports are calculated to increase considerably (those requirements are not included in the total final energy requirements considered here). From 2005 to 2020, fuel and energy requirements in that sector are forecast to grow by about 47%.

In the *"with-measures" scenario*, the gross electricity supply remains nearly constant in the period from 2005 to 2020, while gross electricity production decreases by about 10 billion kilowatt-hours (= 10 terawatt-hours – TWh), to about 610 TWh, reflecting a forecast that net electricity exports from Germany will disappear. The primary changes in the structure of the gross electricity supply include a politically determined decreasing role for nuclear power and a clear reduction in dependence on coal-fired electricity production. In 2020, nuclear power stations are expected to contribute 13% of the total gross electricity supply (the corresponding percentage in 2005 was 27%). For hard-coal-fired power stations, the corresponding figure is 19% (22%), while for lignite-fired power stations it is about 18% (25%). Use of natural gas for electricity production is expected to increase slightly, reaching a percentage share of about 14% (12%) in 2020. Renewable energies' share of electricity production is expected to increase from about 10% in 2005 to nearly 32% in 2020, with wind energy accounting for about half of the gross electricity supply from renewable energies.

Primary energy requirements are obtained from final energy requirements, from fuel inputs for electricity production, from consumption in other transformation sectors and from non-energy-related fuel consumption.

In the *"with-measures" scenario*, primary energy requirements decrease by about 2% from 2005 to 2020. At the same time, two different trends emerge with respect to the structure of the primary energy supply. Inputs of nuclear power, lignite and hard coal and petroleum decrease, while consumption of natural gas and of renewable energies increases, at two very different rates of increase. While natural gas consumption in 2020 is about 8% higher than it was in 2005, inputs of renewable energies grow by a factor of about 2.7. The most important contributions come from

biomass (which in 2020 accounts for about 11% of the primary energy supply) and wind energy (2.6%). Hard coal inputs decrease by about 6% from 2005 to 2020, while petroleum consumption decreases by about 10%, lignite consumption decreases by 27% and dependence on nuclear energy declines by 52% (in the framework of Germany's discontinuation of use of nuclear power). Nonetheless, petroleum will remain the most important primary fuel in 2020, meeting 33% of requirements, followed by natural gas (25%). In 2020, renewable energies' share of the primary energy supply is expected to be about 15% – and thus higher than the corresponding share for hard coal (12%).

Emissions trends

Development of greenhouse-gas emissions overall depends on development of energy-related greenhouse emissions and on development of greenhouse emissions from the areas of industrial processes, product use, agriculture and waste management.

Energy-related greenhouse-gas emissions consist primarily of CO_2 emissions from combustion of fossil fuels in energy sectors, and from the final-consumer sectors of industry, households, transport and commerce/trade/services, and of volatile CH_4 emissions from coal mining and from the oil and gas industry sectors.

In the *"with-measures" scenario*, greenhouse-gas emissions from combustion decrease by 118 million t CO_2 eq., or about 15%, in the period 2005 to 2020. About one-third (33%) of that emissions reduction is achieved by the final consumption sectors, although that result is a combination of considerable decreases in the sectors households, commerce/trade/services and transport (about 43 million t CO_2 eq.) and of a slight emissions increase in the industry sector (about 3 million t CO_2 eq.) that results from increased industrial own-electricity production. The total contribution made by energy sectors (not including industrial power stations) to reduction of combustion-related greenhouse-gas emissions amounts to about 67% for the aforementioned period. In the *"with-measures" scenario*, CH_4 emissions from coal mining and from the oil and gas industry decrease by about 48% from 2005 to 2020. That development results primarily from termination of hard coal mining in Germany.

All in all, energy-related greenhouse-gas emissions (combustion-related emissions and volatile emissions of energy sectors) decrease by 124 million t CO_2 eq., or 15%, in the period 2005 to 2020 in the *"with-measures" scenario*.

Along with process-related CO_2 and N_2O emissions, HFC, PFC and SF_6 emissions from industrial processes and product use also play a significant role in this context. In the *"with-measures" scenario*, only stabilisation of emissions at the 2005 level is achieved. Overall, greenhouse-gas emissions from industrial processes and product use decrease by nearly 17% (about 18 million t CO_2 eq.) in the *"with-measures" scenario*. As to greenhouse-gas emissions from agriculture, an emissions reduction on the order of nearly 6 million t CO_2 eq., or about 9%, occurs in the period 2005 to 2020, primarily as a result of the sector's structural development (livestock populations, etc.) .

By contrast, a considerable contribution to development of greenhouse-gas emissions results from trends in the *waste management sector*. The trends for CH_4 and N_2O emissions from that source category are determined – with a time lag of several years –, primarily by a number of measures for the waste-management sector, leading to an extensive ban on landfilling of organic waste as of 2005. As a

result, in the period 2005 to 2020, greenhouse-gas emissions from waste management decrease by about 6.5 million t CO_2 eq., or 50%.

Table ES- 2: *Development of greenhouse-gas emissions by sectors, 2000-2020*

	2000	2005	2010	2015	2020
	Millions of t. of CO_2 eq.				
With-measures scenario					
Energy sectors	351,3	366,1	336,1	315,7	287,8
Industry	99,2	104,6	100,2	105,4	108,0
Commerce-trade-services	54,6	54,2	50,9	47,2	42,8
Households	118,9	116,2	114,5	108,6	102,1
Transport	184,3	165,5	161,2	157,5	148,4
Volatile emissions from energy sectors	19,8	12,7	11,4	9,3	6,6
Industrial processes	101	106	99	90	88
Product use	1	1	1	1	1
Agriculture	67	64	60	59	58
Waste management	22	14	10	8	7
Total	1.019,5	1.004,0	944,7	901,5	849,6
with regard to 2005	*1,5%*	*-*	*-5,9%*	*-10,2%*	*-15,4%*
with regard to 1990	*-17,0%*	*-18,2%*	*-23,1%*	*-26,6%*	*-30,8%*
with regard tose year[a]	*-17,3%*	*-18,5%*	*-23,3%*	*-26,9%*	*-31,1%*
For informational purposes:					
International civil air transport and maritime navigation	*24,8*	*29,3*	*33,2*	*37,7*	*42,8*

Sources: Calculations of Öko-Institut, Forschungszentrum Jülich, Fraunhofer ISI, DIW Berlin and Dr. Ziesing

For *total greenhouse-gas emissions* (not including land use, land-use change and forestry), the *"with-measures" scenario* shows a decrease of 154 million t CO_2 eq., or 15.4%, for the period 2005 to 2020. With regard to the relevant basic level defined in the framework of the Kyoto Protocol, that figure represents a reduction of about 31% by 2020. At the same time, it must be noted that the emissions trends as described do not include developments in *international air transports* (and, to a lesser degree, in international maritime navigation). In particular, in the *"with-measures" scenario*, very dynamic growth in the international air transport sector causes pertinent greenhouse-gas emissions to increase by 13.5 million t CO_2 eq., or 46%, in the period 2005 to 2020

Climate-policy and energy-policy measures with the largest impacts

The emissions trends foreseen are based on various climate-policy and energy-policy measures and goals. In the *"with-measures" scenario*, the research consortium found that the following areas would make the largest emissions-reduction contributions by 2020 (in each case, the analysis does not take account of pertinent overlapping and indirect effects):

- Growth in electricity production from renewable energies: 36 million t CO_2,
- Revision of the EU emissions trading scheme: 15 million t CO_2,
- Integration of industrial N_2O emissions within the EU emissions trading scheme: 15 million t CO_2 eq.
- Introduction of additive requirements for fuels: 10 million t CO_2,

- Reductions in electricity consumption, as a result of various measures: 7 million t CO_2,
- The KfW CO_2-oriented building-remediation programme: 7 million t CO_2,[2]
- Introduction of the Technical Instructions on Municipal Waste (TA Siedlungsabfall) and of the Landfill Ordinance (Deponieverordnung): 6.5 million t CO_2 eq.
- Reduction of automobile-fleet fuel consumption in the framework of the European CO_2 strategy for automobiles: 6 million t CO_2,
- The Energy Saving Ordinance (Energieeinsparverordnung): 4 million t CO_2,
- The biomass/solar market-incentive programme: 4 million t CO_2.

Sensitivity analyses

The results were assessed with the help of a range of sensitivity analyses. Those analyses revealed that energy-price trends (especially with regard to the transport sector, and considerably less with regard to the industry and energy-industry sectors) and overall economic development (with regard to total energy-related greenhouse-gas emissions) play highly significant roles. The model analyses showed that the changes considered in the basic assumptions pertaining to emissions levels can lead to differences on the order of about +20 to -30 million t CO_2 eq.. In comparison to the base-year emissions level, that corresponds to a range of about +1.6 to -2.4 percentage points.

Vulnerability, impacts of climate changes and of adaptation measures

Over the past three decades, climate changes have occurred that have had impacts on nature and the environment. The indications of such impacts include melting glaciers and the earlier arrival of spring.

The temperature and rainfall projections (Chap. 3.4) for the future indicate that additional impacts can be expected. The greater the global climate changes actually are, the greater such impacts will be. Impacts of climate changes can be grouped as follows:

- Impacts resulting from continual changes (such as seasonally shifted vegetation periods, earlier commencement of breeding for bird species within a given region, long-term changes in new groundwater formation and lower winter heating requirements). For most areas of action in question, such impacts will tend to be felt in the medium term.
- Impacts related to more frequent and / or more intensive occurrence of extreme weather events, such as torrential rains, storms and storm tides, heat waves and long droughts. Such impacts include forest fires, floods and low water, and heat stress.
- Impacts of increasing climate variability. Climate fluctuations could have near-term impacts – for example, droughts could occur at short intervals, thereby

[2] This refers to assumptions from the year 2007. The database used for this report, relative to policies and measures, was taken from the 2009 Projection Report. Currently, considerably larger reductions are expected, as a result of since-introduced fund increases in support programmes for energy-efficient building and modernisation, although the total impacts of those increases cannot yet be estimated.

overwhelming the ability of the agriculture and forestry sectors to respond and adapt. Such variability could complicate the task of adaptation.

In addition to affecting natural systems, climate change also affects economies and societies. Regional differences in the availability and use of natural resources – such as differences in water availability – along with environmental impacts, such as habitat loss or fragmentation, as well as (on the other hand) land renaturation, can have regional and local impacts on adaptation capability and, thus, can influence the severity of impacts of climate change.

Regional differences can also arise with regard to positive or negative impacts. For example, persistent droughts could threaten harvests in agriculture and forestry, while new basic climatic conditions could make it possible to use new crop varieties. Certain areas, such as tourism, expect higher average temperatures to benefit German coastal regions.

For the sectors

- Agriculture
- Forests
- Biological diversity
- Water resources
- Transport and tourism
- Health and
- Coastal regions

vulnerability and possible impacts of climate change have been described, and relevant options for addressing such effects have been identified.

For some areas, the possible impacts of climate change, and the relevant possible adaption options, need to be studied in greater depth.

Financial support and technology transfer

In the period 2004 to 2008, the German Federal Government strongly increased its support for developing countries in the areas of greenhouse-gas-emissions reduction, adaptation to climate change and technology transfer. Such support is provided in the framework of bilateral co-operation; via multilateral co-operation in the framework of the UN Framework Convention on Climate Change – especially via the Global Environment Facility (GEF); and through multilateral co-operation, via development banks and UN organisations. In the area of bilateral co-operation alone, Germany increased its support from US$ 581 million (in 2004) to US$ 1.03 billion (in 2006).

The focuses of such support include renewable energies, along with efficiency enhancement and adaptation support in the water-resources sector. In general, support is aimed equally at economic development and environmental protection. The Federal Government supports multilateral initiatives. Its contributions to the GEF alone amount to US$ 74 million annually.

Research and systematic monitoring

Many ministries in Germany, along with their subordinate or affiliated institutions, are involved in promoting research in the areas of sustainability, climate change and adaptation to climate change.

Such research activities cover the following areas (which themselves can be broken down more finely):

- Climate system, variability and interactions within the earth system
- Monitoring and data management
- Research into climate impacts
- Energy and mitigation research
- Adaptation to climate change
- Options for economies and societies
- International co-operation

Such activities, along with a broad spectrum of observation and monitoring systems, are described in the chapter on research and systematic monitoring.

Education, training and efforts to promote public awareness

General policies relative to education, training and promotion of public awareness

The Federal Government's climate-protection initiative has a national component and an international component. The national component is making an important contribution to the achievement of Germany's national climate protection target. While the European emissions trading scheme governs CO_2 emissions of industry and the energy industry, the national climate protection initiative is focused on consumers, industry, municipalities and social and cultural institutions. The International Climate Initiative supports measures for adaptation to climate change and for protection of climate-relevant biodiversity in developing and threshold countries.

Climate protection as a topic in education for sustainable development

In the 1990s, the concept of "education for sustainable development" developed in Germany. This concept interlinks education with complex issues such as climate change. Education for sustainable development helps to make people aware of, and learn about, climate protection as a central future issue. It also makes it possible to broaden the relevant scope of action and activities for consumers and producers. In this context, a range of activities has been initiated in the areas of

- Training in schools and training programmes, and
- Vocational training.

Efforts to promote public awareness, and campaigns

Since 2006, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has conducted advertising campaigns and issued publications relative to climate protection issues.

Relevant examples include:

- The advertising campaign "Climate protection keeps us busy" ("Klimaschutz beschäftigt uns"; 2006/2007)
- The magazine "Ohne Eis kein Eisbär" ("Where there is no ice, there are no polar bears"; 2007)
- The brochure "Climate protection pays" ("Klimaschutz lohnt sich")

The Federal Environment Agency (UBA) offers additional media-based information, and it has intensified and expanded its relevant activities in recent years.

1 Introduction

This report on climate protection in Germany is the fifth report by the Federal Republic of Germany to the Conference of the Parties in accordance with Article 12 of the Framework Convention on Climate Change. It continues a series of such national reports; the previous reports in the series date from September 1994, April 1997, July 2002 and July 2006. The fifth national report on climate protection in Germany has been compiled on the basis of the "UNFCCC reporting guidelines on national communications".

Pursuant to Article 12 of the UN Framework Convention on Climate Change, all parties are required to prepare "national communications", at regular intervals, that include inventories of their greenhouse-gas emissions and emissions projections and that describe the policies and measures they have taken in accordance with their obligations under the Framework Convention.

The present report informs the Conference of the Parties regarding the status of implementation of climate protection measures in the Federal Republic of Germany. It also provides information about the design of policies and measures, within the existing socio-economic framework, which have direct and indirect impacts on greenhouse-gas emissions. In a further step, it outlines the impacts to date, and the projected future impacts, of the so-described policies and measures, and it discusses the impacts of climate changes and of relevant adaptation measures. Furthermore, the report provides a broad overview of the following:

- Financial support and technology transfer, and
- Education, training and efforts to promote public awareness.

2 Framework data

2.1 State framework conditions

2.1.1 Environmental protection as a state objective

Pursuant to the Act of 27 October 1994, protection of the natural basis for life (environmental protection) is enshrined as a state objective in the Basic Law (constitution) of the Federal Republic of Germany (Art. 20a Basic Law). This specifies that the state, aware of its responsibility for future generations, safeguards the natural basis for life within the framework of the constitutional system by means of legislation and, in accordance with legislation and law, through executive powers and jurisprudence.

2.1.2 Structure of the state

The Federal Republic of Germany is a federal state. The Basic Law regulates the division of duties and responsibilities between the national and regional (*"Land"*) levels.

As a rule, the *Länder* decide for themselves how their administration is to be organised. The administrative structures of the Länder vary from one *Land* to another. In general, the Länder are divided into government districts (*Regierungsbezirk*; EU NUTS 2), administrative districts (*Landkreis*) and larger non-

district cities (kreisfreie Städte; EU NUTS 3) and individual municipalities. Within the framework of the law, the municipalities (local authorities) regulate all local-community affairs under their own responsibility.

Table 1: Administrative divisions in Germany as of 31 December 2007

		Districts (*Kreise*)			
Länder	**Government districts (*Regierungs-bezirke*)**	**Total**	**Of which, non-district cities**	**Länder**	**Government districts (*Regierungs-bezirke*)**
16	22	429	116	313	12.262

Table 1 provides an overview of administrative divisions in Germany.

2.1.3 Legislation

Legislative competence in Germany is divided between the Federal and the Länder levels. In general, the Länder are responsible for legislation. The Federal Government has exclusive powers of legislation in certain fields allocated to it under the Basic Law (e.g. foreign affairs, defence or currency system); it also has powers of concurrent legislation in many areas. In part, use of such powers depends on whether the national interest necessitates a uniform federal system.

On 1 September 2006, as part of a reform of Germany's federalistic system, legislative competencies were reallocated between the Federal Government and the Länder. In addition, provisions for framework legislation at the federal level were eliminated. The areas formerly covered by such legislation are now covered by exclusive or concurrent federal legislation or are the responsibility of the Länder.

Competence for environmental law is still not standardised. Pursuant to the aforementioned reform, the various areas of environmental law are subject to concurrent legislation. For some areas that previously belonged to the realm of framework legislation – such as certain areas of environmental law – a new form of substantive "divergent legislation" ("Abweichungsgesetzgebung"; Art. 72 (3) Basic Law) has been introduced. In this category, both the Federal Government and the Länder can issue provisions; in each case, the pertinent later act takes precedence. Consequently, priority of application applies. In specific instances of divergent Länder law, this means that the relevant federal act remains in force and continues to apply in those Länder that have not issued pertinent divergent acts.

As a result of such allocation of responsibilities, the Federal Government is able to shape environmental legislation. What is more, under the new system, the Federal Government is able to transpose all EU Directives in the environmental realm. Previously, under the framework legislation system (extending to such areas as nature conservation, landscape management and water-resources management), the Länder were responsible for relevant implementation, and that tended to produce delays.

At the federal level, draft legislation is tabled by the German Bundestag (lower house of parliament), the Bundesrat (upper house of parliament) or the Federal Government.

After an opinion has been expressed by the Bundesrat (in the case of government initiatives) and/or the Federal Government (in the case of Bundesrat initiatives), the draft legislation is sent, in compliance with certain periods, to the Bundestag for debate. Draft legislation arising from initiatives by parliamentary factions or by groups of members of parliament is placed directly on the agenda of the plenary sessions of the German Bundestag.

The Bundestag considers draft legislation in three readings. In the first reading, the draft legislation is referred to the competent committees, often without further discussion. In the second reading, held on the basis of the committee reports, amendments are discussed. In the third reading, a final vote is carried out.

If the bill is rejected by the Bundestag, the draft legislation has failed (it may be presented again at a later date). If the Bundestag passes the bill, the Bundesrat still has to give its formal assent in specific cases where this is required ("acts of consent" – Zustimmungsgesetze). The Bundesrat can moreover decide to oppose acts passed by the Bundestag, but it can be overruled by the Bundestag ("acts of objection" – Einspruchsgesetze). In the case of both types of acts (i.e. acts of consent and acts of objection), the Bundesrat may bring the matter before the mediation committee, which is composed of members of the Bundestag and of the Bundesrat. In the case of acts of consent, the Bundestag and the Federal Government also have the right to bring the matter before the mediation committee. If the mediation committee proposes amendments, the Bundestag must take a new new decision on the matter.

Once an act has been passed, it is signed by the Federal Chancellor and the ministers involved, and then passed to the Federal President for execution. On being signed by the Federal President, the act is deemed to have been "executed". After promulgation in the Federal Law Gazette, the act enters into force on the date stipulated in the act, or – if no such date was stipulated – on the fourteenth day after the day on which the Federal Law Gazette was published.

The Federal Constitutional Court can, on application, review laws for conformity with the constitution.

The Federal Government or a federal ministry may be empowered by law to enact statutory ordinances regulating further details of the implementation of the law in question. In addition, the Federal Government may issue general administrative guidelines. In certain cases, statutory ordinances require the consent of the Bundesrat. Administrative provisions require the consent of the Bundesrat in cases in which the Länder have administrative responsibility or in which administration is carried out by commission. Such cases are the rule in the environmental sector.

Federal laws, statutory ordinances and administrative provisions are usually implemented by the Länder under their own responsibility, and this also applies to the environmental sector. There are also areas of federal administration and areas in which the Länder implement federal laws on behalf of the federal level; such areas are supervised by the federal level.

Länder laws are implemented by the Länder themselves.

2.2 Geography and land use

2.2.1 Land use

In 2004, agricultural land (including bog and heath land) accounted for a total of 53.0% (189 324 km²) of Germany's total area. As a result, Germany's agricultural land area decreased by 1.1 percentage points in comparion with the corresponding figure for 1996.

By contrast, the area under forest increased – by 0.4 percent points compared with the relevant area in 1996 – to a total area of 29.8 percent in 2004 (106,488 km^2).

With a share of 2.3%, the area covered by water accounts for only 8,279 km^2 of the total area of Germany. Compared with the corresponding area in 1996, the area covered by water has increased by 339 km², largely as a result of flooding and renaturing of former sand, gravel and lignite extraction sites.

The area given over to settlement and transport in 2004 amounted to 12.8 percent of the area of Germany (45,621 km^2).

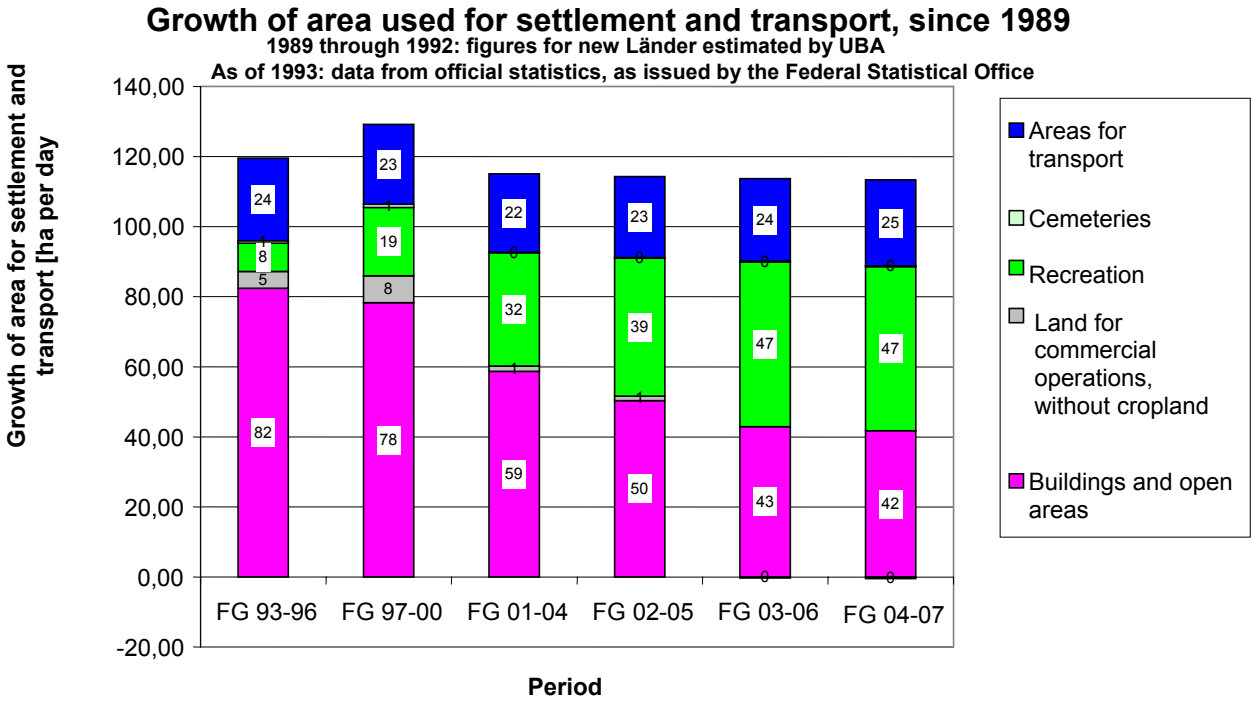
2.2.2 Land use for settlement and transport

Land-use trends in Germany are characterised mainly by constant growth of the area used for settlement and transport, usually at the expense of agricultural land. Recreation areas for people, and habitats for plants and animals, are being lost via urban sprawl and fragmentation of the countryside. This also reduces the options for producing food or renewable raw materials or energy crops on fertile land.

Traffic and climate-relevant pollution grow as the number of buildings grows, and as infrastructure sprawls. What is more, buildings and infrastructure systems have to be operated, heated and maintained. That, in turn, increases consumption of resources – especially energy – and it burdens the public sector with high consequential costs.

In its national sustainability strategy, the Federal Government has set itself the target of limiting the appropriation of new land for settlement and transport to 30 ha per day by the year 2020. With a present relevant appropriation rate of 113 ha per day, that objective is still very distant.

Figure 1: Growth of area used for settlement and transport, since 1989



Source: Federal Statistical Office, 2005, 2008

Results of area survey broken down by actual use (reference date: 31 December)

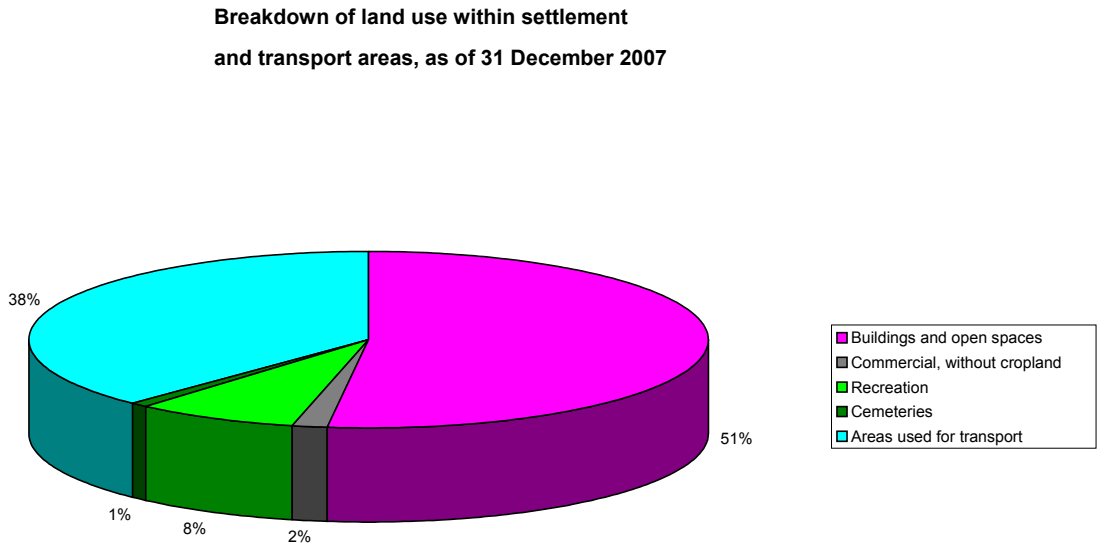
In some Länder, the comparison over time is affected not only by genuine changes in types of land use, but also by reclassifications and reallocations between the individual land-use types in response to changes within the official land-survey register (cadastre).

The area given over to settlement and transport in Germany has continued to grow in recent years. With regard to the end of 1992, the first year for which figures are available for Germany within its present borders, as of the end of 2007 the area used for settlement and transport had increased by 6,484 km² (16.1 percent), to a total of 46,789 km².

In just the four-year period from the beginning of 2004 through the end of 2007, the area set aside for settlement and transport increased by 1,648 km². The increase over those four years amounts to 3.65 % of Germany's total area for settlement and transport as of the end of 2003, and to 0.46 % of Germany's total land area. Of that growth, a total of 1,290 km² was settlement-area growth, while 359 km² was transport-area growth.

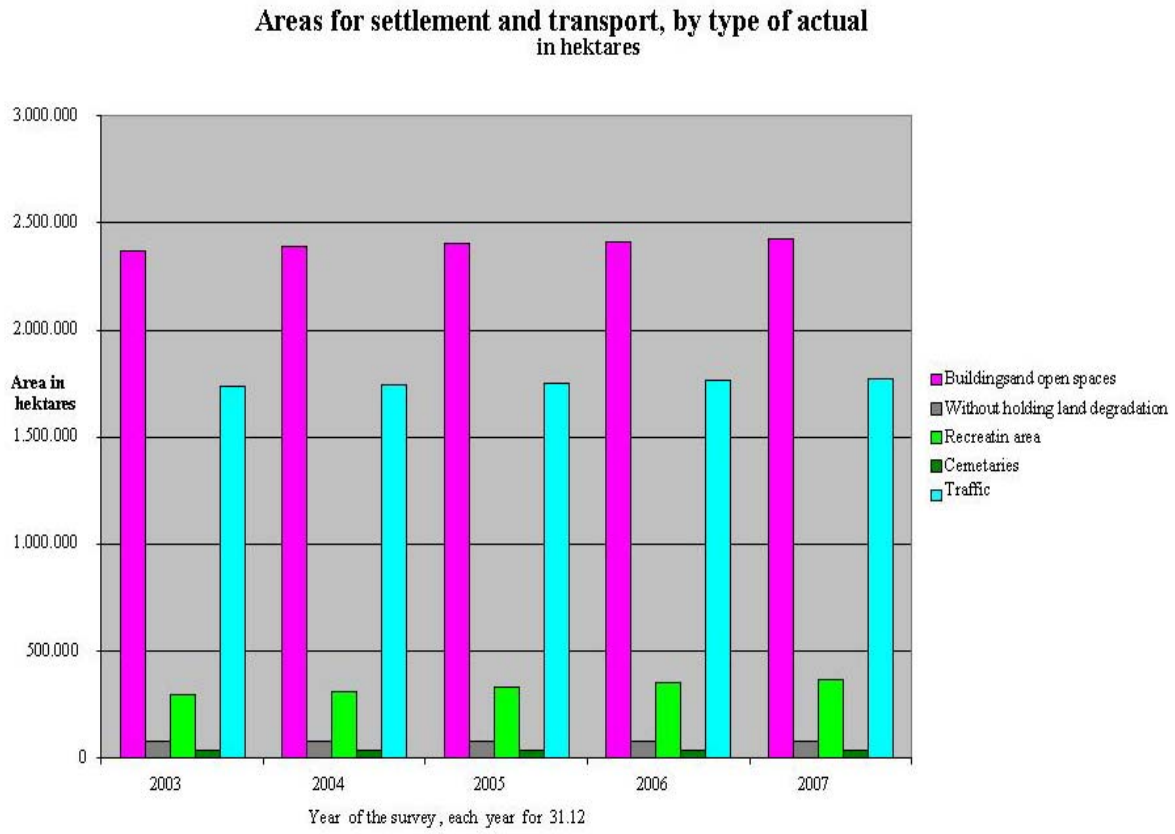
A range of different allocations, within the context of area reclassifications in one Land (state), has distorted an increase in recreational areas over the past four years, making it seem considerably larger than it actually has been. As a result, land use for settlement and transport, in the period from 2004 through 2007, is likely to have actually amounted to less than 100 ha per day.

Figure 2: Breakdown of land use within settlement and transport areas, as of 31 December 2007



Source: Federal Statistical Office, 2008

Figure 3: Areas for settlement and transport, by type of actual use



Source: Federal Statistical Office, 2008

2.3 Agriculture

2.3.1 Greenhouse gases produced by agriculture

Apart from energy-related emissions from fuel production or use, all agricultural emissions of the greenhouse gases CO_2, CH_4 and N_2O are produced via natural processes that can be influenced only to a limited extent. In other words, GHG emissions trends in the agricultural sector are closely tied to production trends . Projections for such production are subject to extremely large statistical uncertainties, however.

Table 2: Development of agricultural activity data, 1990-2020

Year	1990	1995	2000	2005	2010	2015	2020
Reference	Greenhouse-gas inventory, 2008				Projection (MMS)		
Greenhouse-gas source and sink categories	Activity data (population)						
	[thousands]						
1. Cattle	19.488,0	15.890,4	14.538,1	13.035,6	11.440,0	10.845,1	10.250,1
Option A:							
Dairy cattle	6.354,6	5.229,2	4.569,8	4.236,4	3.939,8	3.780,9	3.622,1
Non-dairy cattle	13.133,4	10.661,2	9.968,3	8.799,3	7.500,2	7.064,1	6.628,1
2. Buffalo	NE	NE	0,6	1,1	NE	NE	NE
3. Sheep	3.309,6	2.799,1	2.743,3	2.643,1	1.654,8	1.654,8	1.654,8
4. Goats	90,0	100,0	140,0	170,0	k.A.	k.A.	k.A.
5. Camels and llamas	NO	NO	NO	NO	NO	NO	NO
6. Horses	491,0	598,8	735,2	784,8	736,4	830,1,	923,8
7. Mules and asses	NE	NE	NE	NE	NE	NE	NE
8. Swine	28.325,7	21.802,1	23.400,4	24.481,0	23.363,5	23.158,6	22.953,6
9. Poultry	113.878,7	110.035,5	118.303,0	120.562,3	113.559,8	123.341,2	133.122,6
10. Other *(please specify)*							
Other, non-specified	NE	NE	89.000,0	NE	NE	NE	NE
NE = not estimated NO = not occurring							

Sources: Dämmgen, Ulrich (2009b) Calculations of emission from German agriculture - National Emission Inventory Report (NIR) 2009 for 2007 : tables. Braunschweig : vTI, 402 pages, Landbauforschung - vTI agriculture and forestry research: Sonderheft (special issue) 324A, English; German ISBN13: 978-3-86576-049-4; ISSN: 0376-0723, Calculations of Öko-Institut; figures for number 8, swine: not including suckling pigs lighter than 8.5 kg.

In light of the continuing rapid growth of the world's population, and of correspondingly growing global food needs, additional emissions reductions can be achieved only by adapting agricultural production more closely to climate protection criteria. Examples of the available technical options include operation of biogas installations, improved storage and spreading of farm manure and properly adapted fertilisation and feeding.

Significantly, while GHG emissions in Germany could be reduced by reducing agricultural production, as long as food demand (especially demand for meat) remains constant, such reduction would tend to lead to shifting of production to other countries and, thus, to increases in GHG emissions elsewhere. What is more, soil degradation and climate conditions often eliminate any options for stable and growing agricultural production in those world areas in which the strongest population growth is taking place.

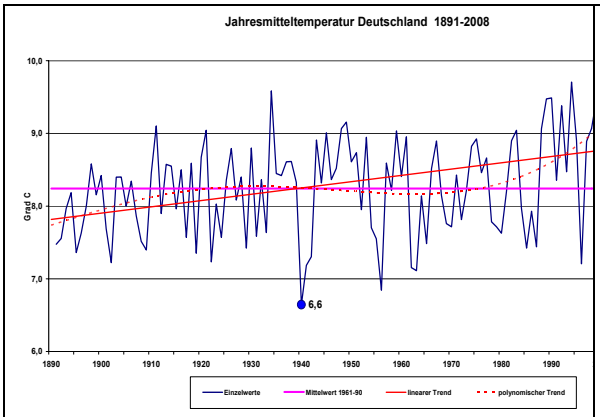
2.4 Climate

2.4.1 Climate changes to date in Germany

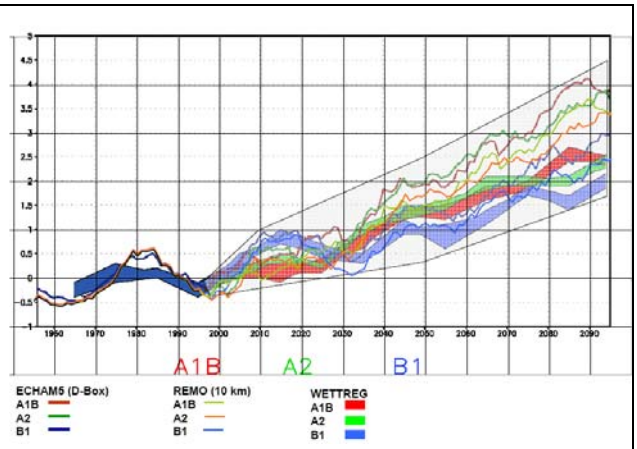
In the course of the 19th century, the average temperature decreased by up to 0.9 °C in central European regions. In some parts of central Europe (for example, in the Hohenpeißenberg region and in Vienna and Innsbruck), a relatively warm phase had occurred at the beginning of that century – around 1810. The lowest annual mean air temperatures in central Europe were observed in the decade 1880-1890. By contrast, average precipitation levels did not differ significantly from those seen in the 20th century. In the 19th century, alpine glaciers grew until about 1850; since then, they have been shrinking.

From 1901 to 2008, the mean air temperature in Germany has risen by nearly 1° C ("linear trend"; Fig. 4). What is more, the decade 1990-1999 was the warmest decade of the entire 20th century. In addition, the first years of the 21th century were considerably warmer than the average for the latest climate normal period, 1961-1990 ("multi-year mean"). The temperature increase observed since 1901 has been especially pronounced in south-western Germany. The mean annual temperature in the state of Saarland has risen by about 1.3° C, for example. In north-eastern Germany, temperatures have not risen as sharply since 1901. In Mecklenburg – West Pomerania, for example, they have risen by only 0.6° C.

Figure 4 : Time series for mean annual temperature / Change in mean annual temperature in Germany



Time series for mean annual temperature in Germany, with linear trend and polynomic adjustment to show the long-term trend (DWD, 2008).



Change in mean annual temperature [°C] in Germany, in comparison to the period 1961-1990, for scenarios A2, A1B and B1 [MPI-M, CEC 2007].

Changes in precipitation can also be seen in Germany. With regard to the beginning of the 20th century, the spatial average for mean annual precipitation in Germany has increased by about 10 percent, although the first two decades of the 20th century were relatively dry. Spring precipitation levels have increased markedly. In particular, for the month of March, calculations for the 108-year period 1901-2008, with regard to the corresponding monthly mean for the 1961-1990 climate normal period, show a mean precipitation increase of 34 percent. No significant overall trend has emerged for summer. On the other hand, distribution of precipitation within summer months has changed: lower precipitation in July and August is now largely offset by higher precipitation in June. With regard to the aforementioned mentioned reference period, winter precipitation levels have generally increased by about 19%. That observation notwithstanding, the observed winter trend is not yet statistically significant, since precipitation quantities vary strongly from year to year. Large differences in precipitation trends are also seen within Germany. For example, increases of yearly precipitation are largely limited to western Germany; in eastern Germany, increases during the winter half year are largely offset by decreases in the summer half year.

No significant trend has yet emerged with regard to wind speeds. Long time series for mean wind speeds show a number of periodic fluctuations.

2.4.2 Future climate changes in Germany

The spatial resolution of global climate models, which have horizontal grid widths ranging from 120 km to more than 200 km, is still too coarse to provide a basis for regionally differentiated predictions for Germany. For that reason, regionalisation procedures are used that draw on both a) statistical and dynamic regional climate models (also known as "regional models") and b) information gained from calculations with global models. With statistical procedures, the statistical regional models project meteorological time series from selected German climate stations into the future. With physical-numerical procedures, the dynamic regional models regionalise global climate projections, for central Europe, by mapping them onto a finer spatial grid with horizontal resolution as fine as (currently) 10 km.

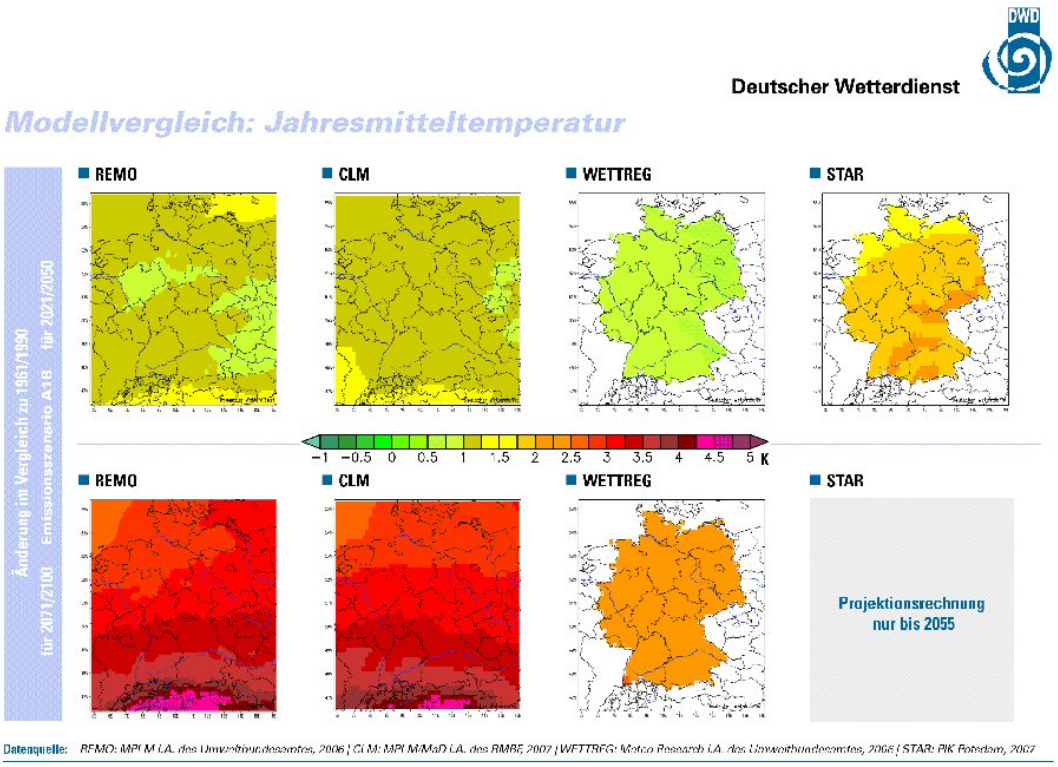
Figure 5 shows the expected change, over time, in the mean annual temperature for three different climate models (one global model and two regional models) and three emissions scenarios. The pertinent results indicate that, depending on trends in anthropogenic emissions of greenhouse-relevant gases, the mean annual temperature could increase by 0.5 to 1.5^{o} C for the period 2021-2050, and by 1.5 to 3.5^{o} C for the period 2071-2100, with respect to the current applicable climate normal period, 1961-1990. Spatially differentiated predictions regarding the possible future climate can be derived with the help of regional climate models.

At the same time, it must be remembered that the regional models magnify uncertainties in projection of temperatures and – especially – of precipitation. The reason for this is that such models contain global models' systematic errors for the relevant regions, in the form of parameters, and maintain such errors in their projections. The models' most speculative aspects are their predictions regarding extreme events, since such events are local events for which even regional models do not have sufficient resolution.

Findings obtained from four regional climate models available for Germany to date, REMO, CLM, WETTREG and STAR[3], show certain trends, with the results varying in accordance with the emissions scenario and, inter alia, the regional climate model chosen. For example, the dynamic climate models REMO and CLM and the statistical model STAR largely agree with regard to the spatial distribution of warming in a medium emissions scenario, with all showing a structure in which warming intensifies as one moves further south. STAR, the statistical model, carries out regionalisation with the help of temperature trends from the pertinent global model. For the period 2021-2050, it shows warming of 2^{o} C. The dynamic climate models show warming of about 1^{o} C, or only about half as much, for the same period. Also for the period 2021-2050, WETTREG, another statistical model, shows warming of about 0.5^{o} C that intensifies as one moves from east to west. For the period 2071-2100, that model shows the smallest degree of warming of all the models – about 2^{o} C. The dynamic climate models REMO and CLM predict warming of up to 3.5^{o} C – and even slightly higher in German Alpine regions – for the same period. All of the aforementioned models agree on the season in which warming will be most pronounced; all indicate that warming could be especially noticeable in winter months.

[3] Based on the ECHAM5 global model (which serves as a driver).

Figure 5: Changes in mean annual temperatures, as predicted by the regional climate models REMO, CLM, WETTREG and STAR, for the A1B emissions scenario in the period 2021-2050 (above) and 2071-2100 (below), in comparison to the corresponding figures for the model-specific control period, 1961-1990



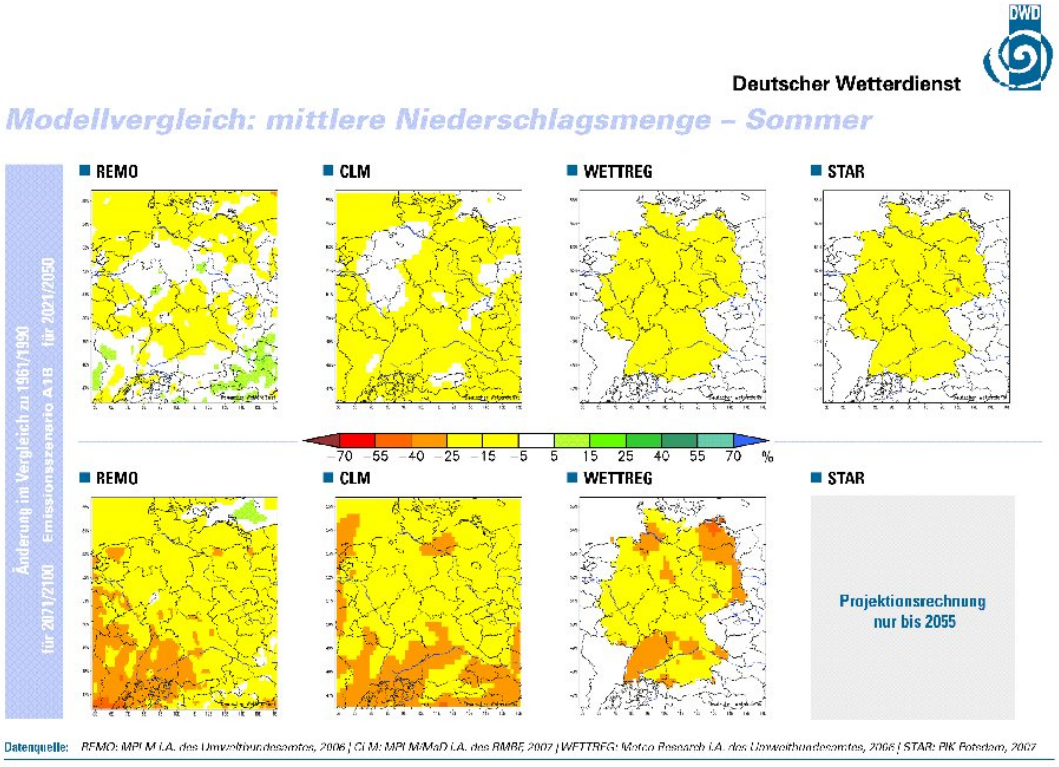
With regard to precipitation levels, the aforementioned climate models show that they remain nearly constant on a yearly basis, while changes in precipitation cycles could well occur in Germany (Figs. 4 - 6). All four models indicate, for example, that summer precipitation could decrease by up to 40 % nation-wide, and that the south-western part of Germany might be particularly strongly affected by such decreases. In winter months, precipitation levels could increase by up to 40%, depending on what model is chosen. In upland regions of the Länder Rhineland-Palatinate and Hesse, and in north-eastern parts of Bavaria, the statistical WETTREG procedure shows areas in which winter precipitation could increase by up to 70% in the period 2071-2100, with regard to the 1961-1990 control period. What is more, the dynamic climate models CLM and REMO point to an additional precipitation increase in spring, although that increase would be smaller than the winter increase.

Comparative studies of WETTREG and REMO[4] indicate that extreme events could grow in magnitude and frequency in future. For example, the numbers of summer days (T>25°C) could double by the end of the century, and the numbers of hot days (T>30°C) could even triple. Initial analyses indicate that the intensity of heavy precipitation events could increase. As to the frequency of storm days, these initial

[4] Cf. the final reports at http://www.umweltbundesamt.de/klimaschutz/index.htm

studies show no changes from current conditions. Additional detailed studies are required in this area.[5]

Figure 6: Changes in mean summer rainfall (JJA), as predicted by the regional climate models REMO, CLM, WETTREG and STAR, for the A1B emissions scenario in the period 2021-2050 (above) and 2071-2100 (below).



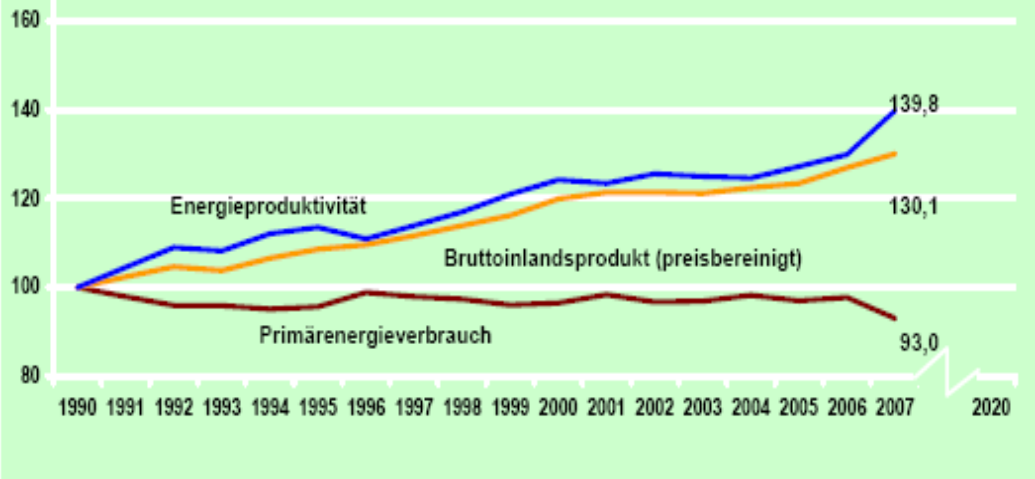
2.5 Economic development

In 2008, Germany's gross domestic product (GDP) increased to EUR 2,492 billion (cf. *Table 4*). This translates into a per-capita figure, i.e. for the population as a whole, of EUR 30,342. At the same, primary energy consumption (cf. also Chap. III 6) has been decreased slightly in recent years. The calculations clearly show that Germany has succeeded in decoupling economic growth and energy consumption, as is illustrated in *Table 4*. Energy productivity, i.e. gross domestic product in relation to primary energy consumption, increased by nearly 40% in Germany from 1990 to

[5] The four regional climate models considered only partially reflect current findings with regard to projected climate changes. The driving global model (ECHAM5-MPIOM) was not varied in the process, for example. The international research community has prepared additional regional climate models for Germany that take account of other global driver models. Those models are currently being evaluated in the framework of various projects (such as the KLIWAS research programme of the Federal Ministry of Transport, Building and Urban Affairs (BMVBS)).

2007. That amounts to an average annual improvement of 1.7 percent (cf. also Fig. 7[6])

Figure 7: Energy productivity and economic growth (1990 = 100); Source: Federal Government 2008 progress report on the national sustainability strategy.



[Energy productivity; Gross domestic product (inflation-adjusted); Primary energy consumption]

2.5.1 Overall economic indicators

The gross domestic product (GDP) of a country is the monetary result of the national economic production process, i.e. the summed value of all goods and services – less the value of the goods and services used as inputs in the production process – that are produced by residents or non-residents within the geographical boundaries of the country.

The GDP is the sum of the gross value added (GVA) of all economic sectors, adjusted to take account of assumed fees for bank services, plus non-deductible sales tax and import duties. The GVA measures the net result of production activities. As a rule, it is defined as the difference between the gross production values and the inputs of the individual economic sectors. Where it is necessary to establish a relationship between the environmental burdens arising from economic processes, the GDP is the suitable reference quantity, because it describes the overall economic activity of a national economy.

Table 3 shows the development of GVA for individual aggregated economic sectors. All figures are inflation-adjusted in accordance with the previous-year-price method, and all figures are "chain-linked" to provide comparable time series. The figure for the year 2000 has been chosen as the reference value (2000=100). In addition, for 2008, GVA is given in 2008 prices, and the various sectors' individual shares of GVA are shown. GVA for Germany amounted to a total of EUR 2,235.12 billion in 2008.

[6] Federal Government 2008 progress report on the national sustainability strategy.

The largest share of GVA was generated in services sectors and in the manufacturing sector (not including the construction sector). Since 2000, the construction sector has experienced a sharp reduction in GVA.

Table 3: Gross value added (GVA) by sectors – inflation-adjusted and chain-linked (2000=100)

Sector	**1991**	**1995**	**2000**	**2004**	**2005**	**2006**	**2007**	**2008**	**billions of €**	**Sectors' share of GVA in 2008**	**2000, in billions of €**
Agriculture and forestry; fisheries	97,11	88,10	100,00	118,01	98,99	95,84	99,81	103,75	19,57	0,9%	23,46
Manufacturing sector, excluding construction sector	97,12	90,14	100,00	104,76	107,58	113,95	119,86	120,35	579,96	25,9%	465,34
Construction	108,46	115,89	100,00	83,31	79,25	77,39	79,37	82,15	93,82	4,2%	96,21
Wholesale and retail trade, hotels and restaurants and transport	82,10	87,03	100,00	105,29	106,02	110,48	111,02	113,31	399,83	17,9%	337,27
Financial intermediation, renting and business activities	71,81	85,32	100,00	104,48	105,94	108,21	112,15	114,19	655,04	29,3%	510,94
Public and private services provision	82,57	91,40	100,00	102,41	102,99	103,74	105,10	106,18	486,90	21,8%	422,98
Total GVA									**2 235,12**	**100%**	**1 856,20**

Source: Federal Statistical Office, Fachserie 18, Reihe 1.4[i]

Table 4: Development of gross domestic product (GDP)

	1991	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008
GDP in relevant prices (in billions of €)	1534,6	1848,5	2062,5	2113,2	2143,2	2163,8	2210,9	2243,2	2321,5	2422,9	2492,0
GDP, inflation-adjusted (2000=100)	85,36	90,54	100,00	101,24	101,24	101,02	102,24	103,03	106,08	108,69	110,10
Primary energy consumption (in petajoules [PJ])	14.611	14 269	14 401	14 679	14 427	14 460	14 656	14465	14 756	13 993	14 003*

***Preliminary figures**

Source: Federal Statistical Office, Fachserie 18, Reihe 1.4[ii]; Federal Statistical Office, Statistisches Jahrbuch (Statistical Yearbook) 2008[iii]; Arbeitsgemeinschaft Energiebilanzen (AGEB; Working Group on Energy Balances)[iv] Auswertungstabellen zur Energiebilanz für die Bundesrepublik Deutschland 1990 bis 2007 (Evaluation tables for Energy Balance for FRG, 1990 to 2007), Last revision, Sept. 2008

Table 5 shows the development of real per-capita gross domestic product for Germany, from 1991 to 2008, in euros per capita (relevant prices) and inflation-adjusted (2000=100). The figures show that per-capita GDP has been growing again since 2005, after slight decreases in 2002 and 2003.

Table 5: Development of per-capita gross domestic product (GDP)

	1991	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Germany, in relevant prices (in € / per capita	19 186	22 636	25 095	25 664	25 984	26 222	26 798	27 202	28 185	29 453	30 342
Germany, inflation-adjusted (2000=100)	87,7	91,1	100,0	101,1	100,9	100,6	101,9	102,7	105,9	108,6	110,2

Source: Federal Statistical Office, Fachserie 18, Reihe 1.4

2.5.2 Gainful employment by economic sectors

Table 6 shows the development of gainful employment in Germany, in the various relevant economic sectors, from 1991 to 2008. Throughout that entire period, considerable reductions have occurred in the areas of agriculture, forestry and fisheries, the manufacturing industry and the construction industry. These reductions have been largely offset by steadily increasing employment in the service sectors, with the result that the employment level was higher in 2008 than it was in 1991.

Table 6: Gainfully employed persons in Germany, by economic sectors, 1991 - 2008 (in 1000s of persons)

	1991	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Agriculture, fisheries and forestry	1.515	1.079	936	925	904	880	873	853	826	845	856
Manu-facturing sector, (excluding construction sector)	11.331	9.005	8.534	8.544	8.355	8.140	8.020	7.890	7.822	7.910	8.024
Construction	2.805	3.236	2.769	2.598	2.439	2.322	2.254	2.185	2.177	2.212	2.197
Wholesale and retail trade, hotels and restaurants and transport	9.318	9.297	9.824	9.885	9.836	9.718	9.801	9.780	9.807	9.966	10.057
Financial intermedia-tion, renting and business activities	3.736	4.445	5.802	5.985	6.060	6.127	6.298	6.370	6.596	6.828	7.029
Public and private services provision	9.916	10.539	11.279	11.379	11.502	11.539	11.634	11.773	11.869	12.007	12.167
Total number of gainfully employed persons	38.621	37.601	39.144	39.316	39.096	38.726	38.880	38.851	39.097	39.768	40.330

Source: Federal Statistical Office, Fachserie 18, Reihe 1.4 (2008)

A major revision of the National Accounts in 2005 resulted in the following three changes in particular:

- Inflation adjustment of **GDP** or **GVA**, for example, is **no longer** performed on the **basis of prices for a fixed reference year** (most recently, 1995), but always **on the basis of prices for the relevant preceding year** (for example, figures for 2004 are adjusted on the basis of 2003 prices). This is in line with the binding European legal requirements and contributes to international harmonisation of price and volume measurements.
- The change in the calculation and allocation of imputed bank charges ("Financial Intermediation Services, Indirectly Measured"; FISIM) to users is also a consequence of a binding new legal requirement imposed by the EU Commission.
- In addition, new and hitherto unused initial data have been integrated in the calculations.

The new method always incorporates the latest price ratios in the accounts, and this ensures more accurate calculation of the "real" rates of change:

Most inflation-adjusted GDP figures have increased as a result of the 2005 revision. The annual rates of change for most years are higher than the previous corresponding figures. The annual average for the whole period from 1991 to 2004 shows only a slightly higher increase in the inflation-adjusted GDP figures.

Table 7: Gross domestic product, inflation-adjusted, chained (change from previous year in %)

	1992	1995	2000	2001	2002	2003	2004
New result	2,2	1,9	3,2	1,2	0,2	0,0	1,6
Previous result	2,2	1,7	2,9	0,8	0,1	-0,1	1,6
Difference in %-points	0,0	0,2	0,3	0,4	0,1	0,1	0,0

The number of **gainfully employed persons** was revised in connection with the introduction of internationally comparable labour market statistics by the Federal Statistical Office. Comparisons with previous publications are therefore of limited value.

2.6 Energy

2.6.1 Energy consumption by sectors and fuels

Consumption of energy, especially energy generated from fossil fuels, almost invariably creates burdens on the environment (e.g. emission of greenhouse and pollutant gases). The task of reducing or preventing energy-related environmental burdens necessitates obtaining a detailed overview of energy use.

In energy statistics, final energy consumption – i.e. energy consumption by end users – is broken down into the sectors "industry", "households", "commerce/trade/services" and "transport". The figures also show "non-energy-related consumption" – for example, petroleum for the production of plastics – and consumption and losses in the "energy transformation sector" – basically, consumption and losses in production of electricity, district heat and fuels. The energy consumption and losses of all sectors together, expressed in terms of the fuels used, make up primary energy consumption (Table 8).

Primary energy consumption in Germany has decreased slightly since 1990.

In addition, the sectoral structure of final energy consumption has changed since that year. To begin with, the industrial sector's importance within final energy sectors has diminished slightly. Its share of total final energy consumption decreased from 31.4 % in 1990 to 28 % in 2007. By contrast, increases have occurred in the relevant shares of private households (from 25 % in 1990 to 25.6 % in 2007) and transport (from 25.1 % in 1990 to 30.3 % in 2007).

In 2007, final energy sectors accounted for some 61 % of total primary energy consumption, while non-energy-related consumption accounted for some 7%. About 31 % of primary energy consumption consisted of losses and own consumption in production and supply of electricity and other secondary energy forms/sources, such as district heat and fuels.

Table 8: Structure of energy consumption in Germany, by sectors, 1990-2007 (in PJ)

	1990	***1991***	***1992***	***1993***	***1994***	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	***2004***	***2005***	***2006***	***2007****
Primary energy consumption[a)]	*14905*	*14610*	*14319*	*14309*	*14185*	*14269*	*14746*	*14614*	*14521*	*14323*	*14401*	*14679*	*14427*	*14460*	*14656*	*14465*	*14756*	*13993*
Transformation sector:																		
Losses and own consumption[d)]	*4475*	*4354*	*4281*	*4188*	*4111*	*3983*	*4107*	*4066*	*4017*	*3988*	*4098*	*4192*	*4156*	*4144*	*4294*	*4499*	*4564*	*4395*
Non-energy-related consumption[e)]	*958*	*890*	*911*	*887*	*964*	*963*	*953*	*1012*	*1046*	*1035*	*1068*	*1031*	*1046*	*1032*	*1040*	*1046*	*1043*	*1013*
Final energy sectors:																		
Industy[c)]	*2977*	*2694*	*2560*	*2432*	*2463*	*2474*	*2424*	*2440*	*2397*	*2384*	*2421*	*2365*	*2322*	*2437*	*2513*	*2424*	*2471*	*2444*
Transport	*2379*	*2428*	*2522*	*2596*	*2553*	*2614*	*2625*	*2643*	*2691*	*2781*	*2751*	*2698*	*2672*	*2601*	*2615*	*2586*	*2615*	*2598*
Households	*2383*	*2516*	*2436*	*2617*	*2558*	*2655*	*2890*	*2854*	*2782*	*2612*	*2584*	*2822*	*2689*	*2726*	*2661*	*2569*	*2601*	*2202*
Commerce/trade/services[b)]	*1733*	*1728*	*1609*	*1589*	*1535*	*1579*	*1747*	*1598*	*1588*	*1523*	*1478*	*1571*	*1544*	*1520*	*1533*	*1341*	*1461*	*1340*

a) Primary energy consumption calculated on the basis of the efficiency approach.

b) As of 1995, the sector is "commerce/trade/services and other consumers (including military)" rather than "small consumers and military". For the period 1990-1994, statistical differences in the electricity sector, as listed in the Energy Balances, are included.

c) The sector "other mining and manufacturing".

d) Losses in energy transformation – for example, in power stations, refineries and briquetting plants – and including line losses

e) For example, as a raw material in the chemical industry

*) Provisional figures

Source: Arbeitsgemeinschaft Energiebilanzen (Working Group on Energy Balances), Auswertungstabellen zur Energiebilanz für die Bundesrepublik Deutschland 1990 bis 2007 (Evaluation tables for the Energy Balance for the Federal Republic of Germany, 1990 to 2007), last revision: Sept. 2008.

Table 9: Primary energy consumption[1)] in Germany, by fuels / energy sources, 1990-2007 (in PJ)

Fuel / energy source	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007 ***
Hard coal	2306	2330	2196	2139	2140	2060	2090	2065	2059	1967	2021	1949	1927	2010	1909	1808	1964	1990
Lignite	3201	2507	2176	1983	1861	1734	1688	1595	1514	1473	1550	1633	1663	1639	1648	1596	1576	1612
Petroleum	5217	5525	5612	5731	5681	5689	5808	5753	5775	5599	5499	5577	5381	5286	5214	5166	5121	4701
Natural gas, petroleum gas	2293	2409	2382	2520	2567	2799	3132	2992	3019	3010	2985	3148	3143	3190	3250	3229	3261	3118
Nuclear energy	1668	1609	1733	1675	1650	1682	1764	1859	1764	1855	1851	1868	1798	1801	1822	1779	1826	1533
Hydroelectric power, wind power, photovoltaic energy [2)]	58	53	62	64	67	83	73	77	80	91	127	124	145	136	166	173	190	217
Other energy sources[3)] (biomass, waste, gases)	160	180	177	194	211	205	210	281	311	324	356	370	367	428	673	746	889	890
Foreign trade balance, electricity	3	-2	-19	3	8	17	-19	-8	-2	4	11	10	2	-29	-26	-31	-71	-68
Total	**14905**	**14610**	**14319**	**14309**	**14185**	**14269**	**14746**	**14614**	**14521**	**14323**	**14401**	**14679**	**14427**	**14460**	**14656**	**14465**	**14756**	**13993**
For reporting purposes: Share for renewable energies [in %]	***1,3***	***1,3***	***1,4***	***1,6***	***1,8***	***1,9***	***1,8***	***2,4***	***2,6***	***2,8***	***2,9***	***2,9***	***3,2***	***3,4***	***4,5***	***5,4***	***6,4***	***7,2***

[1)] Primary energy consumption calculated on the basis of the efficiency approach;
[2)] As of 1995, hydroelectric power and wind power include photovoltaic power;
[3)] 1990 to 1994: other gases. 1995 to 1999: other gases, waste and biomass and other renewable energies. As of 2000: pit gas, biomass and renewable energies, other renewable energy sources and non-renewable waste, waste heat and others; as of 2003, new surveys pursuant to the Act on Energy Statistics (Energiestatistikgesetz), which came into force in 2003. Since then, the relevant records for renewable energies and other energy sources have been more comprehensive.
*) Provisional figures; last revision: 2 September 2008

Source: Arbeitsgemeinschaft Energiebilanzen (Working Group on Energy Balances), Auswertungstabellen zur Energiebilanz für die Bundesrepublik Deutschland 1990 bis 2007 (Evaluation tables for the Energy Balance for the Federal Republic of Germany, 1990 to 2007), last revision: Sept. 2008

In 2007, a total of some 34 % of primary energy requirements were met with petroleum. The corresponding figures for other fuels included 22 % for natural gas, 14 % for hard coal and 11 % for lignite. Nuclear energy met 11% of primary energy requirements. The largest shifts in the pertinent shares for fuels since 1990 include a 50 % decrease in lignite consumption and a 36 % increase in natural gas consumption.

Renewable energies – including hydroelectric power, wind energy, biomass, solar power and geothermal energy – have rapidly multiplied their share of the primary energy supply, with growth from a 1.8 % share in 1996 to a 7.2 % share in 2007 (Table 9).

2.6.2 Electricity generation and consumption

From 1990 bis 2007, Germany's domestic net electricity consumption increased by 16 %, or 74 TWh. In absolute figures, this increase was nearly evenly distributed among the three most important final energy sectors, industry (+ 19 TWh), commerce/trade/services (+ 29 TWh) and households (+ 24 TWh) (Table 10).

Gross electricity production increased only slightly from 1990 to 1999. From 1999 to 2007, a marked increase occurred, however – 82 TWh, or 15 %. The reasons for this growth included higher domestic electricity demand and a growing export surplus in international electricity trade.

Hard coal and lignite account for the largest share, about 51 %, of primary energy inputs for electricity production. In this category, they rank ahead of nuclear energy (28 % in 2007) and natural gas (11% in 2007). Development of primary energy consumption for electricity production depends on a number of factors: electricity consumption, transformation efficiency in fossil-fired power stations and the primary energy mix, including renewable energies' share.

From 1990 to 1999, primary energy inputs for electricity production decreased overall. The reasons for this decrease included efficiency growth in power stations overall, decreasing lignite inputs and increasing natural gas inputs. In addition, domestic electricity production hardly increased, in spite of slight increases in electricity consumption.

Table 10: *Electricity production, electricity supply and electricity use in Germany from 1990 to 2007*

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007 ***
Primary energy inputs[1)] for electricity production (in PJ)																		
Hard coal	1270	1354	1285	1323	1308	1332	1370	1281	1365	1273	1268	1231	1200	1229	1177	1161	1234	1345
Lignite	1731	1634	1562	1484	1458	1455	1433	1392	1346	1335	1420	1507	1537	1507	1509	1462	1435	1480
Other solid fuels[2)]	64	62	61	61	70	60	65	70	86	84	96	85	76	106	81	121	120	131
Heating oil	108	125	112	80	78	84	79	68	69	65	71	78	73	78	84	92	76	79
Gases	435	416	368	362	414	431	454	477	490	489	481	489	505	528	527	607	670	694
Of which: natural gases [3)]	336	326	282	282	327	346	374	384	395	396	396	402	411	440	442	521	575	599
Hydroelectric power, wind power, photovoltaic power [4)]	58	53	62	64	67	104	94	98	99	110	149	146	168	163	198	207	222	228
Nuclear energy	1663	1608	1732	1674	1649	1681	1763	1858	1763	1855	1851	1868	1798	1800	1822	1779	1826	1533
Total	5329	5252	5183	5047	5045	5148	5258	5244	5218	5211	5335	5403	5357	5411	5398	5429	5582	5490
Electricity supply (in TWh)																		
Gross electricity production	550	540	538	527	528	537	553	552	557	556	577	586	587	607	615	621	637	638
Electricity imports	32	30	28	34	36	40	37	38	38	41	45	44	46	46	44	53	46	44
Electricity use (in TWh)																		
Electricity exports	31	31	34	33	34	35	43	40	39	40	42	45	46	54	52	62	66	63
Losses, own consumption, pumping-electricity consumption [56)]	96	91	88	87	85	84	82	81	82	80	85	95	87	93	92	94	93	90
Net electricity consumption [6]	455	449	445	441	446	458	465	469	475	477	494	494	500	505	516	518	524	529
-Of which: industry	208	194	189	180	185	190	188	195	199	201	208	208	209	219	225	229	229	227

Beginning in 2000, a marked increase in primary energy consumption occurred, however, with the result that primary energy inputs for electricity production were 3 % higher in 2007 than they were in 1990. That increase was due primarily to strong growth in domestic and international electricity demand. The increased demand was met in part through increased use, for electricity generation, of natural gas and lignite, both fossil fuels. A greater part of the demand, however, was met via electricity from renewable energies, especially wind power and biomass. Overall, renewable energies' coverage of gross electricity consumption increased from 6.3 % in 2000 to 14.0 % in 2007, i.e. more than doubled during that period (Table 11).

Table 11: Electricity production from renewable energies, 1998 to 2007 [in TWh]

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Hydroelectric power[1)] / geothermal energy	**19,0**	**21,3**	**24,9**	**23,4**	**23,8**	**20,4**	**21,0**	**21,5**	**20,0**	**21,2**
Wind power	**4,5**	**5,5**	**7,6**	**10,5**	**15,8**	**18,9**	**25,5**	**27,2**	**30,7**	**39,7**
Biomass	**1,6**	**1,8**	**2,3**	**3,2**	**4,0**	**7,0**	**8,3**	**10,5**	**15,6**	**18,6**
Biogenic fraction of waste[2)]	**1,8**	**1,9**	**1,9**	**1,9**	**1,9**	**2,2**	**2,1**	**3,0**	**3,7**	**4,1**
Photovoltaic power	**0,0**	**0,0**	**0,1**	**0,1**	**0,2**	**0,3**	**0,6**	**1,3**	**2,2**	**3,1**
Total	26,9	30,5	36,7	39,1	45,8	48,7	57,5	63,6	72,2	86,8
Share of gross electricity consumption [%]	**4,8**	**5,5**	**6,3**	**6,7**	**7,8**	**8,1**	**9,5**	**10,4**	**11,7**	**14,0**
Share of primary energy consumption (efficiency method) [%]	**0,8**	**0,9**	**1,1**	**1,1**	**1,4**	**1,5**	**1,6**	**2,1**	**2,5**	**3,1**

[1)] Electricity generation from renewable energies, including natural flow to pumped storage power plants

[2)] Biogenic waste fraction set at 50%

Source: BMU, Erneuerbare Energien in Zahlen ("Renewable energies in figures"), National and International Development, Internet update, Last revision: December 2008.

2.6.3 Energy prices

Import prices of crude oil, natural gas and hard coal have risen in recent years. The price of crude oil was some 350 % higher in December 2007 than it had been in 1991. In a short-term perspective, the factors responsible for the spiking of oil prices included conflicts in the Middle East – especially the war in Iraq – Hurricane Katrina (2005), which impaired oil production in the Gulf of Mexico and oil refining in the U.S., and speculation in oil futures markets. In the long term, decreases in technically and economically recoverable oil reserves, and increased oil demand, in both industrialized countries and developing countries, will lead to further increases in the price of this resource. Gas prices, which are tied to oil prices, have followed oil-price trends with a lag of about half a year.

Over the same period, import prices for coal fluctuated far less strongly than did import prices for oil. The reason for this is that coal supplies are more broadly distributed, geopolitically, than oil supplies are. At the same time, the Federal Statistical Office has observed considerable coal-price increases nonetheless: in May 2008, the price of hard coal was 41.5% higher than it was in the same month of the

previous year. The reasons for this included rapidly growing coal consumption – especially in China, India and the U.S. – and continual growth in steel production.

What is more, consumer prices for the various relevant fuels increased between 1991 and 2007. The reasons for this included higher import prices, a lack of competition in electricity and gas markets and tax policies (different taxation of oil products, gas and electricity for different consumer groups).

In 2007, the price for one kWh of electricity in the households sector (EUR 0.207) broke down as follows into cost components: production: 24 %; transport/distribution: 35 %; license fees: 9 %; electricity tax: 10 %; allocations pursuant to the Act on the Preservation, Modernisation and Development of Combined Heat and Power Generation (Combined Heat & Power Act; KWKG): 1 %; allocations pursuant to the Renewable Energy Sources Act (EEG): 5 %; and value-added tax: 16 %. In the main, increases in costs for production/transport/distribution (between 59 and 93 % per year) were responsible for the largest part of electricity-price increases since 2001[7].

[7] Federal Statistical Office, Daten zur Energiepreisentwicklung 2008 ("Data on development of energy prices", 2008)

BMU, 2008: Strom aus Erneuerbaren Energien, Was kostet uns das? ("Electricity from renewable energies – how much does it cost us?")

Table 12: *Import and consumer prices*

		Units	1991	1995	2000	2005	2006	2007
Import prices								
	Crude oil	Euros/t	129,20	94,92	227,22	298,22	379,01	382,96
	Natural gas	€/TJ	2 439,00	1 881,00	2 967,00	4 479,00	5 926,00	5 473,61
	Hard coal	Euros/t	46,05	40,63	41,54	57,27	61,76	63,31
Consumer prices								
	Heating oil, light, households[1)]	Euros/100 l	26,38	21,94	40,82	51,62	59,30	58,63
	Natural gas, households[1)]	Cents/kW h	3,55	3,48	3,94	5,34	6,33	6,51
	Electricity, households[1)]	Cents/kW h	14,80	16,36	14,92	18,22	18,91	20,15
	Heating oil, heavy, industry[2), 3)]	Euros/t	114,70	106,75	188,92	181,44	296,13	288,64
	Natural gas, industry[2), 4)]	Cents/m³	14,33	12,45	16,72	2,46	2,91	N. e.
	Electricity, industry[2)]	Cents/kW h	6,91	6,74	4,40	6,76	7,51	N. e.
	Regular petrol	Euros/l	0,65	0,77	0,99	1,10	1,27	1,33
	Diesel fuel	Euros/l	0,55	0,58	0,80	0,98	1,12	1,19

[1)] Including VAT, tariff customers (households' requirements), including compensatory levy, electricity tax and VAT

[2)] Not including VAT

[3)] Average price for purchase of 2001 t or more per month; as of 1993, for purchase of 15 t or more per month

[4)] average revenue

Source: Federal Ministry of Economics and Technology (BMWi) Federal Statistical Office, Eurostat, Federal Office of Economics and Export Control, Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry; taken from: Energiedaten ("Energy Data", BMWi) 2008, Last revision: 24 June 2008

2.7 Transport

2.7.1 Transport figures

In recent years, passenger transports have grown moderately, while goods transports have increased considerably[8].

From 1991 to 2007, total passenger transports increased by 26.4 %. Motorised individual transports grew by 24.1 %, thereby retaining their predominant role. Their share of total passenger transports decreased slightly, from 81.6 to 80.1 %.

[8] The "transport figures" considered here consist of total transports, measured in passenger-kilometres / tonne-kilometres.

Among all forms of passenger transports, air transports showed the largest growth rates. From 1991 to 2007, total air passenger transports in air traffic over Germany increased by some 160 %. At the same time, such transports' share of total passenger transports increased from 2.6 % to 5.3 %.

Total transports in local public transportation hardly changed at all over this period; in 2007, they were only slightly higher than the corresponding figure for 1991. At the same time, local public transportation's share of total passenger transports decreased from 9.3 to 7.4 %. Passenger transports in the railway sector increased sharply, by a total of 39.1 %. In addition, their share of total passenger transports increased from 6.5 % in 1991 to 7.2 % in 2007. Overall in the period under consideration, local public transportation and railways, which are relatively less-energy-intensive modes of transport, had a combined share of between 14 % and 16 % of total passenger transports.

Table 13: Total motorised passenger transports in Germany, measured in billions of passenger-kilometres (1991-2007)

Year	Railways	%	Local public transportation	%	Air transports	%	Motorised individual transports	%	**Total**
1991	57,0	6,5	81,6	9,3	22,6	2,6	713,5	81,6	**874,7**
1992	57,2	6,4	80,4	9,0	25,6	2,9	731,5	81,8	**894,8**
1993	63,4	7,0	79,6	8,7	27,7	3,0	740,8	81,3	**911,5**
1994	65,2	6,6	77,5	7,8	30,0	3,0	821,4	82,6	**994,0**
1995	71,0	7,0	77,0	7,6	32,5	3,2	830,5	82,2	**1011,0**
1996	71,7	7,1	76,7	7,6	33,6	3,3	831,8	82,0	**1013,8**
1997	72,4	7,1	76,2	7,5	35,8	3,5	833,4	81,9	**1017,9**
1998	72,7	7,0	75,7	7,3	37,5	3,6	845,3	82,0	**1031,2**
1999	73,8	7,0	76,2	7,2	39,9	3,8	866,7	82,0	**1056,5**
2000	75,4	7,2	77,3	7,4	42,7	4,1	849,6	81,3	**1045,1**
2001	75,8	7,1	77,0	7,2	41,9	3,9	872,0	81,8	**1066,7**
2002	70,8	6,6	75,7	7,1	40,8	3,8	880,3	82,4	**1068,1**
2003	71,3	6,7	75,8	7,1	43,3	4,1	875,6	82,1	**1066,1**
2004	72,9	6,7	82,8	7,6	48,4	4,4	887,1	81,3	**1091,1**
2005	76,8	7,1	82,5	7,6	52,6	4,8	875,7	80,5	**1087,6**
2006	79,0	7,2	81,8	7,4	55,6	5,1	882,6	80,3	**1099,0**
2007	79,3	7,2	82,2	7,4	58,8	5,3	885,4	80,1	**1105,8**

Source: Federal Ministry of Transport, Building and Urban Affairs (BMVBS)(Ed.)(2008): Verkehr in Zahlen 2008/2009 ("Transports in figures, 2008/2009"); Hamburg

Goods transports increased by a total of 66 % from 1991 to 2007. The largest growth – growth that began from an extremely low level – occurred in air transports, and amounted to 191 %.

During the same period, road transports increased by 90 %. The share of goods transports taking place on roads increased from 61.5 % in 1991 to 70.5 % in 2007. That growth came primarily at the expense of inland shipping and, until 2001, also at the expense of railway transports. Since 2004, the railway sector has increased its share of the total goods transport market.

Railways (not including local public transportation and ICE trains) and inland waterways, both of which are relatively energy-efficient modes of transport, lost shares of total goods transports, in a combined decrease from 34.6 % to 27.1 %.

Table 14: Total goods transports in Germany, measured in billions of tonne-kilometres (1991-2007)

Year	Railways	%	Inland water-ways	%	Roads	%	Long-distance pipelines	%	Air trans-ports	%	**Total**
1991	82,2	20,6	56,0	14,0	245,7	61,5	15,7	3,9	0,4	0,1	**400,0**
1992	72,8	18,3	57,2	14,4	252,3	63,4	15,7	3,9	0,4	0,1	**398,5**
1993	65,6	16,8	57,6	14,7	251,5	64,4	16,1	4,1	0,5	0,1	**391,2**
1994	70,7	16,8	61,8	14,6	272,5	64,6	16,8	4,0	0,5	0,1	**422,3**
1995	70,5	16,4	64,0	14,9	279,7	64,9	16,6	3,9	0,5	0,1	**431,3**
1996	70,0	16,4	61,3	14,4	280,7	65,8	14,5	3,4	0,5	0,1	**427,1**
1997	73,9	16,4	62,2	13,8	301,8	66,9	13,2	2,9	0,6	0,1	**451,5**
1998	74,2	15,8	64,3	13,7	315,9	67,3	14,8	3,2	0,7	0,1	**469,9**
1999	76,8	15,5	62,7	12,6	341,7	68,9	15,0	3,0	0,7	0,1	**469,9**
2000	82,7	16,2	66,5	13,0	346,3	67,8	15,0	2,9	0,8	0,2	**511,3**
2001	81,0	15,7	64,8	12,6	353,0	68,6	15,8	3,1	0,7	0,1	**515,3**
2002	81,1	15,7	64,2	12,5	354,5	68,8	15,2	3,0	0,8	0,2	**515,8**
2003	85,1	15,7	58,2	10,8	381,9	70,6	15,4	2,9	0,8	0,2	**541,4**
2004	91,9	16,1	63,7	11,2	398,4	69,9	16,2	2,8	1,0	0,2	**571,1**
2005	95,4	16,5	64,1	11,1	402,7	69,6	16,7	2,9	1,0	0,2	**580,0**
2006	107,0	17,1	64,0	10,2	439,1	70,1	15,8	2,5	1,2	0,2	**627,1**
2007	114,6	17,3	64,7	9,8	466,5	70,5	15,8	2,4	1,2	0,2	**662,9**

Source: Federal Ministry of Transport, Building and Urban Affairs (BMVBS)(Ed.)(2008): Verkehr in Zahlen 2008/2009 ("Transports in figures, 2008/2009"); Hamburg.

2.7.2 Motor-vehicle fleet

The total number of motor vehicles in service in Germany increased continually, with the increase from 1991 to 2007 amounting to 28 %. In 2007, a total of 46.6 million automobiles, 2.8 million trucks and 5.9 million motorised two-wheeled vehicles were in service in Germany.

The number of automobiles on the road grew by 27 % during that period. In 2007, a total of 23 % of all automobiles in Germany had diesel engines. The corresponding figures in 1991 was only 12 %. Diesel automobiles' share of the total automobile fleet will continue increasing in the coming years, since diesel vehicles' share of total new registrations has grown sharply (1991: 11 %, 2007: 48 %) and there are no signs of any reversal in this trend.

From 1991 to 2007, the total truck fleet in operation in Germany increased by 63 %. With their strong engines, trucks account for a disproportionate share of the emissions caused by motor vehicles. The total number of motorised two-wheeled vehicles registered the same percentage growth – 63 %.

Table 15: Growth of the motor-vehicle fleet, in millions of vehicles (1991-2007)

Year	Automobiles (including station wagons)	Motorised two-wheeled vehicles	Trucks and semi tractor-trailers	Other motor vehicles	**Total**
1991	36,8	3,7	1,8	2,6	**44,9**
1992	37,9	4,0	2,0	2,5	**46,4**
1993	38,9	3,9	2,1	2,4	**47,3**
1994	39,8	3,8	2,2	2,5	**48,3**
1995	40,4	3,9	2,3	2,5	**49,1**
1996	41,0	4,2	2,4	2,5	**50,1**
1997	41,4	4,4	2,5	2,5	**50,8**
1998	41,7	4,6	2,5	2,5	**51,3**
1999	42,3	4,9	2,6	2,5	**52,3**
2000	42,8	5,1	2,7	2,5	**53,1**
2001	43,8	5,0	2,8	2,5	**54,1**
2002	44,4	5,2	2,8	2,5	**54,9**
2003	44,7	5,2	2,8	2,5	**55,2**
2004	45,0	5,4	2,8	2,5	**55,7**
2005	45,4	5,6	2,8	2,6	**56,4**
2006	46,1	5,7	2,8	2,2	**56,8**
2007	46,6	5,9	2,8	2,2	**57,5**

Source: Federal Ministry of Transport, Building and Urban Affairs (BMVBS)(Ed.)(2008): Verkehr in Zahlen 2008/2009 ("Transports in figures, 2008/2009"); Hamburg.

2.7.3 Fuel consumption[9]

Until 1999, fuel consumption in the transport sector[10], in absolute figures, continued to grow with regard to the corresponding figures in 1991. Then, after sharp decreases until 2005, consumption stabilised at a level similar to that seen in 1991. The quantity of fuels sold in 2007 was 11.5 % lower than the corresponding figure for 1999.

Slight decreases in vehicles' specific fuel consumption have been offset by growing transport volumes – especially in road transports of goods – and by a trend toward larger and more powerful vehicles.

The most important reasons for the decreases in fuel consumption since 1999 include improved mileage in new automobiles, achieved via optimisation of engines and various vehicle technologies, and a sharp increase in the numbers of diesel automobiles, which are relatively fuel-efficient , as a share of newly registered automobiles (cf. Chap. 2 7.2). An ecologically oriented tax reform (Ökologische Steuerreform) has contributed centrally to the trend toward more fuel-efficient vehicles. In addition, trans-boundary refuelling has increased, and thus fuel sales in Germany have decreased.

The various different types of fuel concerned have differed in terms of their percentage participations in the overall decrease in sales. While sales of diesel fuel increased by 50 % from 1991 to 2007, petrol sales decreased sharply, by 31 %.

[9] Fuel-consumption figures are based on domestic fuel sales, including sales of biofuels (Sources: Arbeitsgemeinschaft Energiebilanzen (Working Group on Energy Balances; ed.) / Mineralölwirtschaftsverband e.V. Association of the German Petroleum Industry)

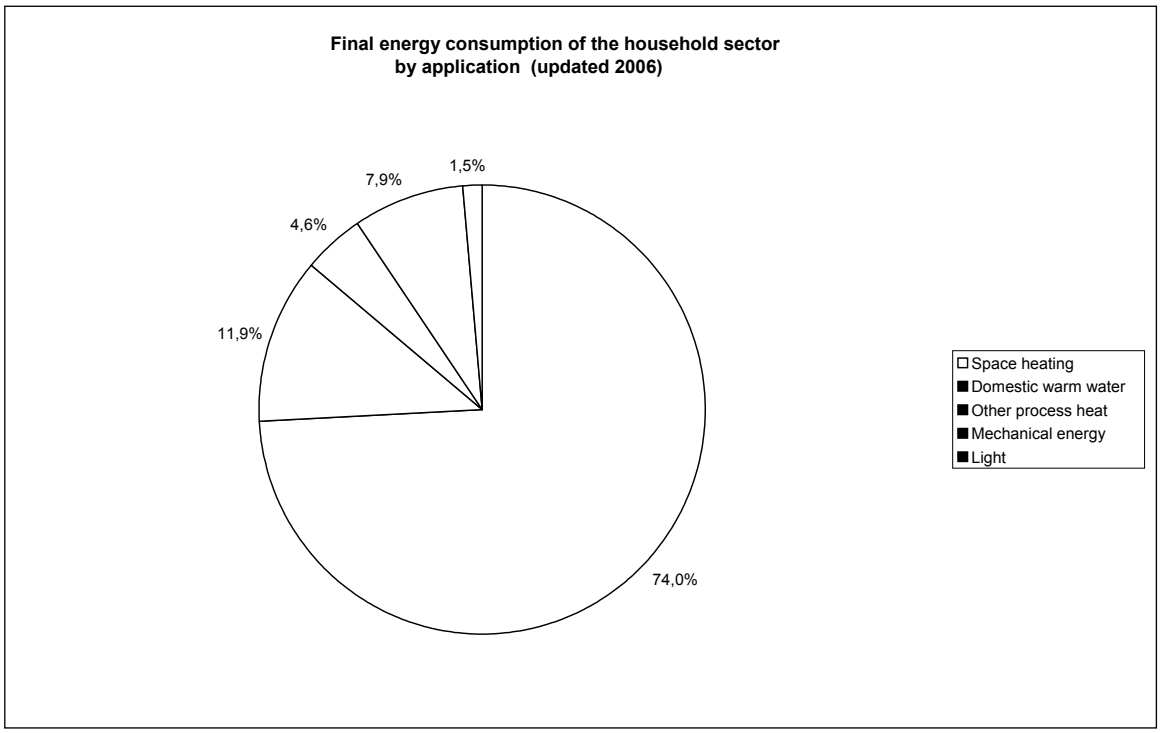
[10] Road transports, railway transports and inland shipping; not including air transports

In contrast to trends for fuels used for road, railway and inland-waterway transports, consumption of aircraft fuel (kerosine) increased by 34 % from 1999 to 2007. From 1991 to 2007, sales of kerosine nearly doubled (+95 %). This trend continues the growth in kerosine consumption that has been in progress for decades.

2.8 Private households

In final energy consumption of private households (last revision: 2006), structured by usage areas (*Figure 8*), energy inputs for space heating are highly predominant (74%), followed by those for hot water supply (11.9%), mechanical energy (7.9%), other process heat (4.6%) and lighting (1.5%). As a result, nearly three-fourths of final energy consumption in the private households sector is related to outdoor temperatures.

Figure 8: Final energy consumption in the private households sector, by usage areas (last revision: 2006)



Source: Federal Ministry of Economics and Technology (BMWi) 2008 Energiedaten ("Energy Data"), Table 7 [Space heating; Water heating; Other process heat; Mechanical energy; Lighting]

The final energy used for space heating (Table 16) continues to come primarily from natural gas (with a share of about 45%) and light heating oil (with a share of about 34%, or about 33 % when existing heating-oil stocks are deducted). Decreases in use of coal, a trend seen since the 1990s, have continued.

Table 16: Final energy consumption in the private households sector, by fuels / energy sources (last revision: 2006)

Heating oil	34,1%
Heating-oil stocks	-0,9%
Natural gas	45,1%
Electricity	3,7%
District heat	6,8%
Coal	1,8%
Other	9,4%

Quelle: BMWi 2008 Energiedaten Table 7

The average residence size, in terms of floor space per residence and inhabitant, has increased contnually since 1990 (Table 17). Similarly, the total numbers of households has grown, especially the numbers of households with one or two persons. The trend toward single-person households has continued.

Table 18 **(**last revision: 2005) provides an overview of average household floor space, per residence and inhabitant, and of numbers of various sizes of residences in Germany.

Table 17: Developments in the housing sector

	1990	**1996**	**2000**	**2005**
Residence size, in m^2				
Per residence	81,9	83,7	84,6	85,8
Per resident	34,8	37,2	39,5	41,2
Number of rooms				
Per residence	4,3	4,4	4,4	4,4
Per resident	1,8	1,9	2,0	2,1

Source: Statistisches Jahrbuch 2007 ("Statistical Yearbook, 2007"); figures for 1990 from Statistical Yearbook for 2000

Table 18: *Numbers of residential buildings and residences (last revision: 2005)*

	Number of buildings (in millions)	**Floor space (in millions of m^2)**	**Number of residences (in millions)**
Total	17,6	3 326	38,8
of which:			
With 1 residence	11,0	1 323	11,0
With 2 residences	3,5	626	7,0
With 3 residences or more	3,0	1 377	20,7

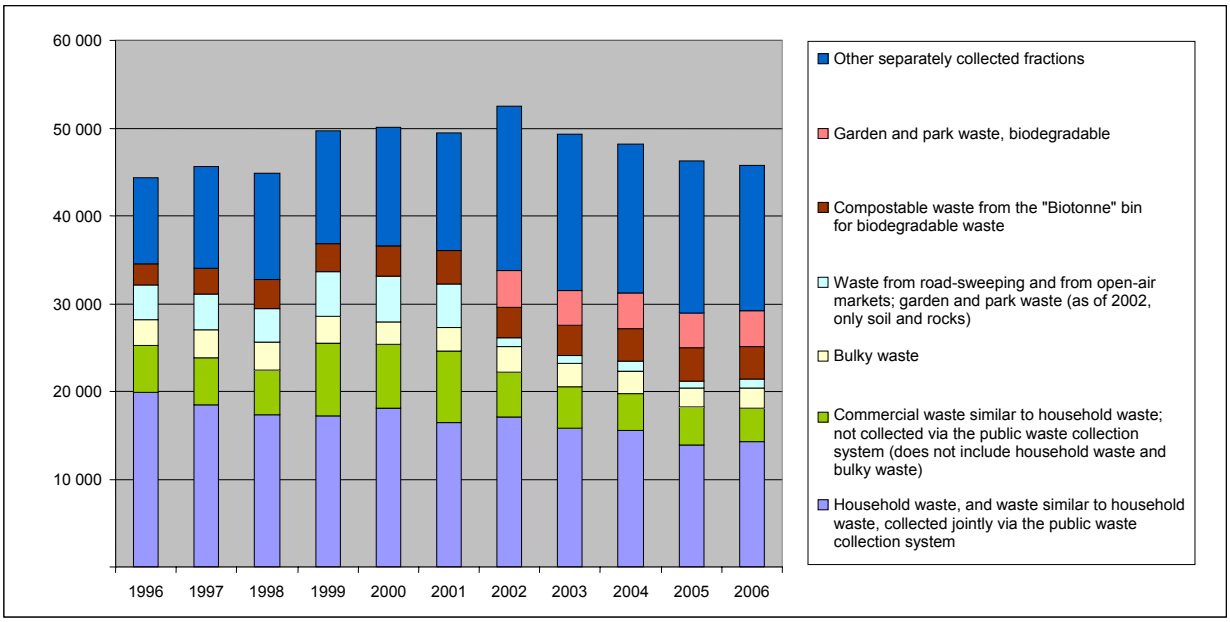
Source: Statistisches Jahrbuch 2007 ("Statistical Yearbook, 2007")

2.9 Waste management

2.9.1 Waste quantities

In 2006, about 46.5 million tonnes of municipal waste was produced in Germany (Federal Statistical Office, 2008). As used here, the municipal-waste category includes household waste, commercial waste similar to household waste and bulky waste. It also includes separately collected recyclable waste, such as used paper, used glass, organic waste and packaging. Such materials are recycled, or otherwise used, via a wide range of different procedures. Figure 9 provides an overview of development of municipal-waste quantities in Germany. The quantities of waste to be managed have continually decreased since 1999. In 2006, they amounted to about 13.7 million tonnes. The total quantities of recycled waste have increased sharply in recent years. In 2006, they amounted to over 32.7 million tonnes, or about 70% of the total quantity of municipal waste.

Figure 9: Municipal-waste production in Germany



In addition to municipal waste, the following additional waste was produced in 2006: some 56 million tonnes of waste from the manufacturing sector, about 42 million tonnes of mining waste and some 196 million tonnes of construction and demolition waste, including road rubble and excavated material (Federal Statistical Office 2008).

2.9.2 Legal basis and objectives of waste management

The basic law governing the waste-management sector is the Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal (KrW-/AbfG), last amended by Art. 5 of the Act of 22 December 2008 (Federal Law Gazette I p. 2986). Art. 4 (1) of that Act sets forth the following hierarchy of objectives: First and foremost, waste production should be avoided. Secondly, waste should be recycled or used for energy recovery wherever possible. Thirdly, waste is to be disposed of in an ecologically compatible manner whenever the aforementioned two options are not feasible. A number of ordinances mandating acceptance of returned products (of various groups) and materials (packaging or electrical devices) have been issued with the aim of promoting recycling of certain waste fractions.

The Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV) of 20 February 2001 and the Technical Instructions on Municipal Waste (TA Siedlungsabfall) of 14 May 1993 have played key roles in governing waste-management structures. As a result of provisions in these two regulations, all landfilling of untreated municipal waste was terminated as of 31 May 2005, with the aim of preventing further emissions (landfill gas, polluted leachate) from landfills. Similarly, landfilling of biologically degradable waste and of high-calorific waste has been prohibited since 1 June 2005. Such waste must be incinerated in waste-incineration facilities or treated in mechanical-biological waste-treatment facilities.

2.9.3 Waste incineration

In 2008, a total of about 70 waste-incineration facilities for municipal waste, with a total capacity of about 18 million tonnes per year, were in operation in Germany. In all likelihood, the incineration capacity of the country's waste-incineration facilities will increase to 19.5 million tonnes per year by 2010. Table 19 provides an overview of the development of incineration of municipal waste.

Table 19: Development of incineration of household waste, 1990–2008

	Number of facilities	**Waste-throughput capacity in thousands of tonnes per year**	**Average throughput per facility in thousands of tonnes per year**
1990	48	9 200	191
1992	50	9 500	190
1993	49	9 420	192
1995	52	10 870	202
1998	53	11 900	225
2000	61	13 999	230
2005	67	16 900	252
2008*)	70	18 000	257

*) estimated figures

In recent years, use of procedures for using municipal waste, or high-calorific fractions derived from such waste, as a substitute fuel has intensified. Such substitute fuels supplant regular fuels in co-combustion in existing power stations and industrial facilities. In addition, they are used as fuels in substitute-fuel power stations designed especially to burn them.

In 2008, for example, some 0.7 million tonnes of municipal waste and commercial waste were incinerated in coal-fired power stations, and about 0.9 million tonnes were burned in the cement industry. No significant changes in the waste quantities used in co-combustion in such facilities are expected in the coming years. As of the end of 2008, a total of 15 power stations fired with substitute fuels, with total capacity of about 1.8 million tonnes per year, were in operation. An additional 13 power stations fired with substitute fuels, with planned capacity of about 2.6 million tonnes per year, were under construction as of that time. In 2010, when those facilities have been completed, the country's power stations fired completely with substitute fuels will likely have a total capacity of about 4.4 million tonnes.

All facilities in which waste is thermally treated are subject to the Ordinance on Incineration and Co-incineration of Waste (17th Ordinance on the Execution of the Federal Immission Control Act (BimSchV)) and must comply with stringent emissions standards. All waste-incineration facilities in Germany use the energy they release from waste. Most of these facilities produce both electricity and heat or supply steam to power stations or industrial plants. The average efficiency of all the facilities in question amounts to about 47 percent.

2.9.4 Mechanical-biological waste treatment

In 2007, a total of 46 facilities for mechanical-biological waste treatment, with a total treatment capacity of about 5.0 million tonnes per year, were in operation in Germany. In that same year (2007), some 2.3 million tonnes of municipal waste were treated in a total of 30 mechanical waste-treatment facilities. In treatment of a total of 7.3 million tonnes of waste in mechanical-biological and mechanical waste-treatment facilities, some 3.0 million tonnes of high-calorific fractions were separated out for use as substitute fuels and some 0.2 million tonnes of metals were separated out for recycling. Some two million tonnes of waste pretreated in those facilities were placed in landfills.

In the process, mechanical-biological waste-treatment facilities have been subject to the strict provisions of the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV) (which expired when landfill laws were amended), the Ordinance on Facilities for Biological Treatment of Waste (30th BImSchV) and Annex 23 of the Wastewater Ordinance (AbwV). Those provisions provide for low-emissions waste treatment in mechanical-biological waste-treatment facilities and environmentally compatible behaviour of treatment residues in landfills.

2.9.5 Waste storage in landfills

In 2008, a total of 130 former municipal-waste landfills were in operation as Class II landfills. To remain in operation, the landfills had to comply with certain technical requirements relative to sealing systems and to collection and treatment of landfill gas and leachate.

Since the early 1990s, the quantities of biodegradable waste placed in landfills – waste which is responsible for landfills' methane emissions – have been decreasing, as a result of introduction of systems for collecting recyclable waste (such as organic waste, paper, packaging) and of expansion of capacities for treating residual waste. Pursuant to the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV), landfill storage of high-calorific or biodegradable waste is no longer permissible as of 1 June 2005. Consequently, waste stored in landfills after that date no longer contributes to landfill-gas emissions. Together, the two factors – i.e. collection systems and the aforementioned ordinance – have led to a considerable reduction, in recent years, of methane emissions from landfills.

Methane emissions from landfills are expected to end gradually, over the coming decades, as waste stored prior to 2005 decomposes.

Table 20: Time series for numbers of municipal-waste landfills operated in Germany, and for the waste quantities stored in them

	1990	**1993**	**1999**	**2003**	***2008***
New Länder	7 983	292	137	N. e.	N. e.
Old Länder	290	270	239	N. e.	N. e.
Total for Germany as a whole	8 273	562	376	302	130
Stored waste quantity that contributes to landfill-gas formation, in millions of tonnes*	44,3	27,8	15,5	11,0	0
Methane emissions from landfills, in millions of tonnes per year	1;72	1,66	0,99	0,62	0,36

* Residual municipal waste, and waste of similar composition (with biogenic-organic components)

2.9.6 The waste-management sector's contributions to climate protection and resources conservation

The measures described in section 3.9.5 reduced methane emissions from landfills by about 80 %, from a level of 1.72 million tonnes in 1990 to 0.36 million tonnes in 2008. That reduction amounts to about 28.5 million tonnes of CO_2 equivalents.

As landfill-gas formation decreases, annual methane emissions from landfills will decrease by an additional 0.10 million tonnes by 2012 (about 2.1 million tonnes of CO_2 equivalents) and by 0.11 million tonnes from 2012 to 2020 (about 2.3 million tonnes of CO_2 equivalents).

Energy production from waste earns carbon credits for substitution for fossil fuels; some 50 % of the energy content of residual municipal waste results from the waste's biogenic fractions and is thus proportionally assessed as CO_2-neutral.

The largest share, by quantity, of residual municipal waste – some 17.4 million tonnes in 2006 – is managed in waste-incineration facilities. The energy produced with such waste amounts to about 6.3 terawatt-hours (TWh) of electricity and 17.2 TWh of heat. The fossil-fuel substitution achieved with that energy represents about 9.75 million tonnes of avoided CO_2 emissions per year. The net relevant quantity of avoided CO_2 emissions, taking account of the fossil fraction in waste and of waste-incineration facilities' requirements for external energy, amounts to about 4 million tonnes. Additional CO_2-emissions reductions could be achieved by optimising the facilities' energy use.

CO_2-emissions avoidance could also be enhanced by increasing rates of recycling of metals and non-ferrous metals in slags of waste-incineration plants.

Additional substitutions of primary fuels – and, thus, additional CO_2-emissions reductions – can be achieved by increasing use of substitute fuels from waste, and from waste wood and sewage sludge, in power stations and industrial processes.

Fermentation of organic waste from households also reduces CO_2 emissions:

A total of 85 to 90 % of the some 6 million tonnes of organic waste produced by German households is treated in composting facilities and then used as compost. The energy released as the organic material decomposes is lost as unused heat. Currently, only 10 to 15 percent of organic waste goes to fermentation systems that use biogas as a fuel. Use of fermentation, rather than composting, in treatment of organic waste, or use of a combination of the two processes, could yield considerable CO_2 reductions in arrangements whereby biogas is burned to produce useful electricity and heat. Optimised fermentation of an assumed quantity of about 68 percent of existing organic waste, with efficient use of the energy contained in the relevant biogas, could provide net savings of about 0.8 million tonnes of CO_2 equivalents by comparison to composting.

3 Inventories of anthropogenic emissions of greenhouse gases

As a Party to the United Nations Framework on Climate Change (UNFCCC), since 1994 Germany has been obliged to prepare, publish and regularly update national emission inventories of greenhouse gases.

In February 2005, the Kyoto Protocol entered into force. As a result, for the first time ever the international community of nations is required to implement binding action objectives and instruments for global climate protection. This leads to extensive obligations vis-à-vis the preparation, reporting and review of emissions inventories. As a result of Europe's own implementation of the Kyoto Protocol, via the adoption of EU Decision 280/2004/EC[11], these requirements became legally binding for Germany in spring 2004.

Pursuant to Decision 3/CP.5, all Parties listed in ANNEX I of the UNFCCC are required to prepare and submit annual National Inventory Reports (NIRs) containing detailed and complete information on the entire process of preparation of such greenhouse-gas inventories. The purpose of such reports is to ensure the transparency, consistency and comparability of inventories and to facilitate and support an independent review process. The Secretariat of the Framework Convention on Climate Change has made submission of the inventory report a pre-requisite for performance of the agreed inventory reviews.

In 2009, Germany presented its seventh National Inventory Report (NIR 2009), which follows upon the country's inventories for the years 1990 to 2007. That latest report describes the methods and the data sources on which the calculations are based. With regard to explanation of additional relevant details, and to survey and calculation procedures for emissions inventories, the reader's attention is called to that National Inventory Report[12] (NIR).

The following section presents a compilation of data on the direct greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (laughing gas, N_2O), hydrofluorocarbons (HFCs)), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

3.1 Presentation, determination and structuring of emissions data

Data on greenhouse-gas emissions in Germany for the years 1990 to 2007 are presented in summary overview tables and substance-specific trend tables. For highlighting purposes, emissions trends are also shown in graph form.

In this context, it is important to note that detailed statements regarding annual emissions are available in the inventories published annually in the Common

[11] Decision No. 280/2004/EC of the European Parliament and the Council of 11 February 2004 on a system for monitoring greenhouse-gas emissions in the Community and for implementing the Kyoto Protocol (OJ. L 49 of 19 February 2004, p. 1)

[12] The National Inventory Report has been published at:

http://www.umweltbundesamt.de/emissionen/publikationen.htm

Reporting Format (CRF). The data used in the present report agree with the data submitted as of 15 April 2009 to the UNFCCC Secretariat.[13]

3.2 Accuracy of emissions data

The IPCC Good Practice Guidance (GPG, 2000) characterises determination of uncertainties as a key element of any complete inventory. Uncertainties information is used primarily as an aid for improving the precision of inventories, as well as for selecting methods and carrying out recalculations for inventories. The declared aim is to minimise uncertainties to the greatest possible degree, in order to maximise the inventories' accuracy. To that end, all Annex I countries (pursuant to the Kyoto Protocol) must first quantify the uncertainties for all pertinent source categories and sinks, i.e. must first enhance their understanding of the quality of their inventories.

Uncertainties are quantified separately, and by source categories, for emission factors and activity data. They are also quantified for emissions with regard to the locations / sources at which they are directly measured or on the basis of which they are estimated.

method combines, in a simple way, the uncertainties in activity rates and emission factors, for each source category and greenhouse gas, and then aggregates these uncertainties, for all source categories and greenhouse-gas components, to obtain the total uncertainty for the inventory. The Tier 2 method for uncertainties determination is the same, in principle, but it also considers the distribution function for uncertainties and carries out aggregation using Monte Carlo simulation. Before the Tier 2 method can be carried out, a probability density function for both parameters must be determined. Ideally, these functions can be determined via statistical evaluation of individual data items (such as measurements for a large number of facilities). In many cases, only a few such values are available, and uncertainties are determined on the basis of expert assessments.

Currently, Germany reports only uncertainties that have been calculated pursuant to the Tier 1 method. Tier 2 uncertainties calculation is carried out only every 3 years. The uncertainties data for the activity rates, emission factors and emissions figures used have been taken from the Federal Environment Agency's "Central System on Emissions (CSE)" database. They are based on expert assessments carried out by the Federal Environment Agency's specialised units and by relevant external institutions.

Pursuant to Tier 1, the inventory's total uncertainty for 2007 is +/-9.7 % (level). Nitrous oxide emissions data account for a central share – somewhat more than 50 % – of that uncertainty. And within that data category, the predominant uncertainty is that in the sector Agriculture: Agricultural soils (4.D), which accounts for some 35 % of the uncertainty. CO_2 sinks within the LULUCF sector also contribute significantly to the total uncertainty: Forests (5.A) account for about 25 %; CO_2 emissions from LULUCF: Cropland (5.B) account for nearly 10 %. CO_2 emissions from the sector Fuel combustion (1.A) also contribute an important share – about 9 % – to the total uncertainty. Within that sector, solid fuel combustion within the sub-sectors Public electricity and heat production (1.A.1.a) and Commercial/institutional/residential (1.A.4.a/b) predominates with regard to uncertainty. Additional noteworthy individual

[13] The National Inventory Report has been published at:

http://www.umweltbundesamt.de/emissionen/publikationen.htm

contributions are provided by the LULUCF source categories Grassland (5.C), at 4.4 % (CO_2), and Settlements (5.E), at 3.7 % (CO_2); by Fugitive emissions from fuels (1.B); at nearly 3 % (CH_4); and by the category Chemical industry (2.B), at 2.1 % (N_2O). The inventory's trend uncertainty amounts to 13 %. In this area as well, nitrous oxide emissions from agricultural soils (4.D) and CO_2 sinks (5.A) provide the major contributions.

The large uncertainties for N_2O, for both experts' assessments and the reference values from the IPCC Guidelines, have a large impact on the maximum uncertainty figure for the inventory as a whole. As a result, in the next report rounds, it will continue to be necessary to improve the data for this pollutant in the sectors agriculture, LULUCF and industrial processes.

Detailed data on the existing uncertainties are available in the NIR 2009 (Chapters 1.7.2 und 18).

3.3 Emissions of greenhouse gases, 1990-2007

In the framework of burden-sharing agreed internally within the EU, the Federal Republic of Germany has made a commitment to reduce its emissions of all six Kyoto gases by 21 % in comparison to the base year (1990 and 1995[14]), by the end of the first commitment period, which runs from 2008 to 2012. The development of greenhouse-gas emissions in Germany since 1990 is shown in Table 21 for the various individual greenhouse gases and graphically in Fig. 10 for all emissions, represented as CO_2-equivalent emissions.

[14] For HFC, PFC and SF_6

Table 21: Development of greenhouse-gas emissions in Germany since 1990 [in CO_2 equivalents]

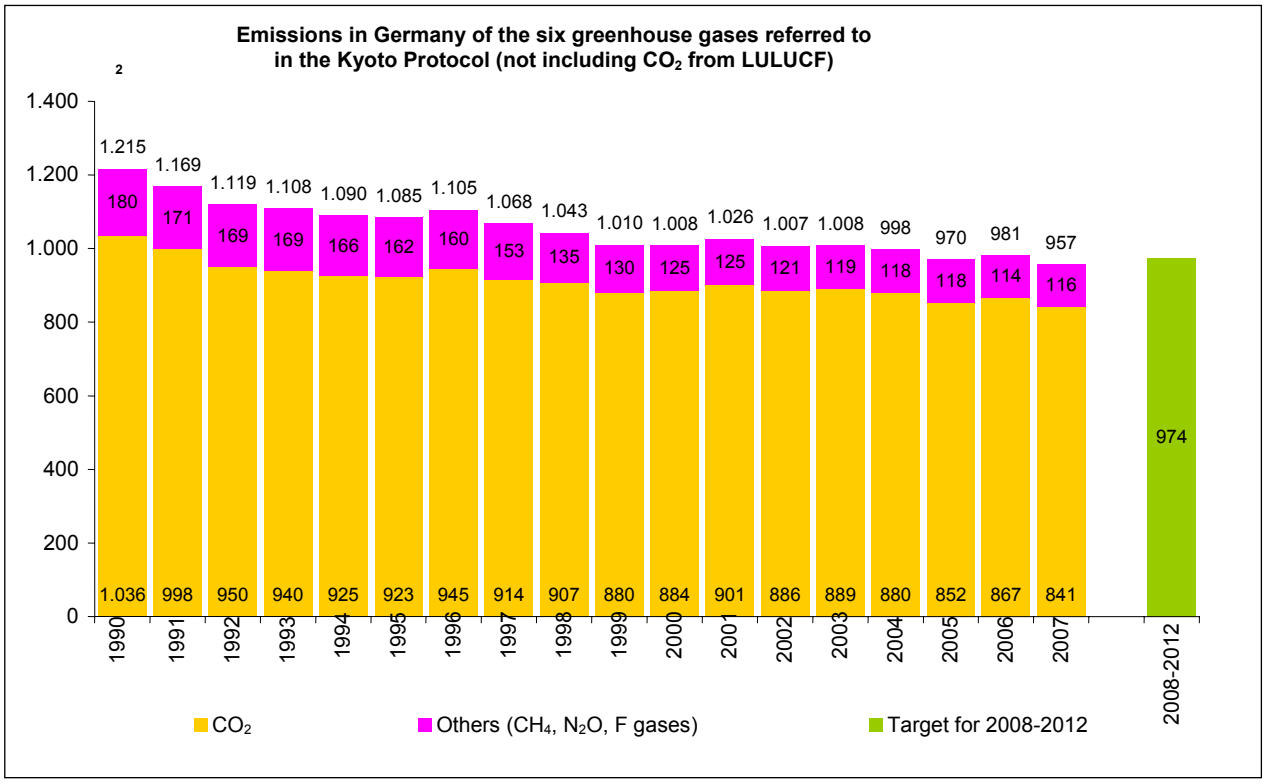
Emissions trends	Base year[1]	1990	1995	2000	2005	2006	2007
	[Gg CO_2 equivalent]						
Net CO_2 emissions / storage[2]	1.007.274	1.007.274	891.748	851.528	829.106	850.787	824.362
CO_2 emissions (not including LULUCF)[2]	1.035.580	1.035.580	922.660	883.683	851.708	867.021	841.152
CH_4	4.657	4.657	3.809	3.040	2.201	2.100	2.026
N_2O	226	226	216	156	181	171	180
HFCs (CO_2 equivalent)	6.463	4.369	6.463	6.471	9.978	10.516	11.098
PFCs (CO_2 equivalent)	1.750	2.708	1.750	781	707	569	528
SF_6 (CO_2 equivalent)	7.220	4.785	7.220	5.082	4.898	5.510	5.567
Total emissions / storage, including LULUCF[2]	1.190.530	1.186.959	1.054.041	976.065	947.043	964.433	939.985
Total emissions, not including CO_2 from LULUCF[2]	1.218.837	1.215.265	1.084.954	1.008.220	969.645	980.667	956.775

[1] The base year is 1990 for CO_2, CH_4, and N_2O; it is 1995 for HFC, PFC and SF_6

[2] The information in these series makes it possible to compare data of Parties with different emissions structures.

Source: National Inventory Report 2009

Figure 10: Overall development of greenhouse gases in Germany, in CO_2 equivalents (without CO_2 from LULUCF)



Source: German greenhouse-gas inventory, 2009

As of 2007, the decrease in greenhouse-gas emissions in Germany, with regard to the base-year emissions defined in the framework of the Kyoto Protocol[15], amounted to 22.4 %. Consequently, Germany's emissions are below the annual volume level defined for the commitment period (2008-2012; cf. Figure 10), and they are at a level at which a 21 % reduction obligation, within the framework of EU burden sharing, is feasible.

The individual greenhouse gases contributed to this development to varying degrees (see Fig. 11). Emissions of the direct greenhouse gases that predominate by amount were considerably reduced; CO_2 emissions decreased by 18.8 % and CH_4 emissions were reduced by 56.5 %. In the main, the reasons for these reductions are found in five areas, as described in the following section:

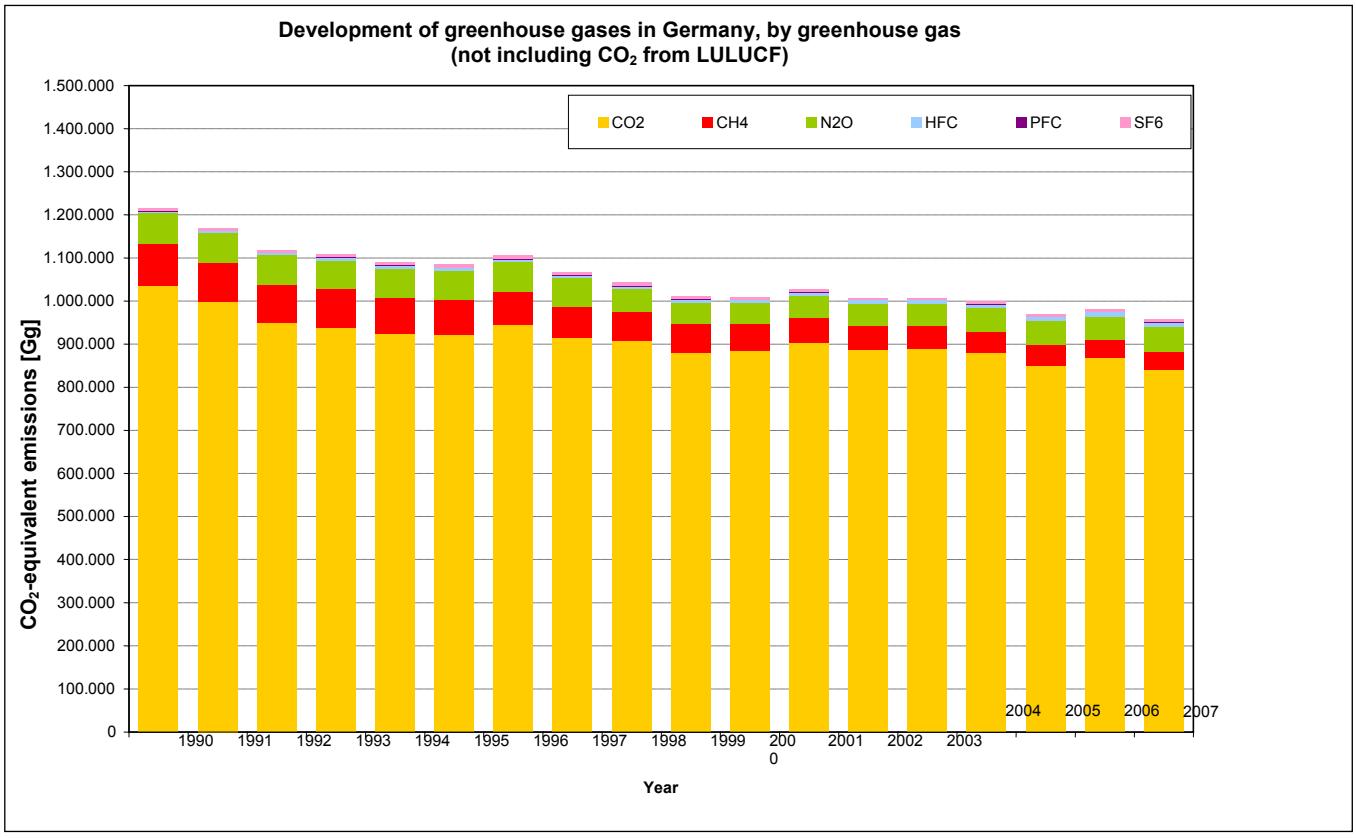
1. The climatological winter of 2006/2007 was unusually mild. As a result, heating-energy consumption was considerably reduced during that period. In addition, December 2007 was, on average, somewhat milder than the corresponding temperatures during the international climatological reference period, 1961-1990 (Müller-Westemeier et.al., 2008: p. 35).
2. The value-added-tax (VAT) increase, from 16 % to 19 %, that was introduced as of 1 January 2007 had a similarly significant impact. It prompted consumers to make planned fuel purchases early, still within 2006. On the other hand, that fact (as well as the preceding one) must be seen as a one-time effect that will not occur in subsequent years.

[15] The base-year emissions for 2006 amount to 1,232,429.543 Gg CO_2 equivalent

3. What is more, expansion of use of renewable energies, the sole both lasting and influenceable factor among those in question, clearly has contributed significantly to fulfillment of Germany's emissions-reduction obligations.
4. Changes in methods used for the areas of agriculture and air transports are another significant factor. In the area of agriculture, this year's inventory makes the first transition to complete use of the IPCC 2006 Guidelines. In another first, in the air-transports sector, this year's report now uses an improved split factor for differentiation between national and international air transports. Both of these changes have led to methods-related emissions reductions. On the other hand, indirect CO_2 emissions from solvents production are being reported for the first time, and this has tended to increase trends.
5. As well as being a result of the aforementioned effects, the reductions are also due to a package of measures: expansion of use of renewable energies; fuel conversions; improvement of economic effectiveness; changes in the ways in which livestock are kept; and reductions in the sizes of animal populations.

The aforemented causal factors are discussed in detail in the discussion below of trends for the various individual greenhouse gases.

Figure 11: Greenhouse-gas emissions in Germany – annual contributions of the various greenhouse gases, in Gg

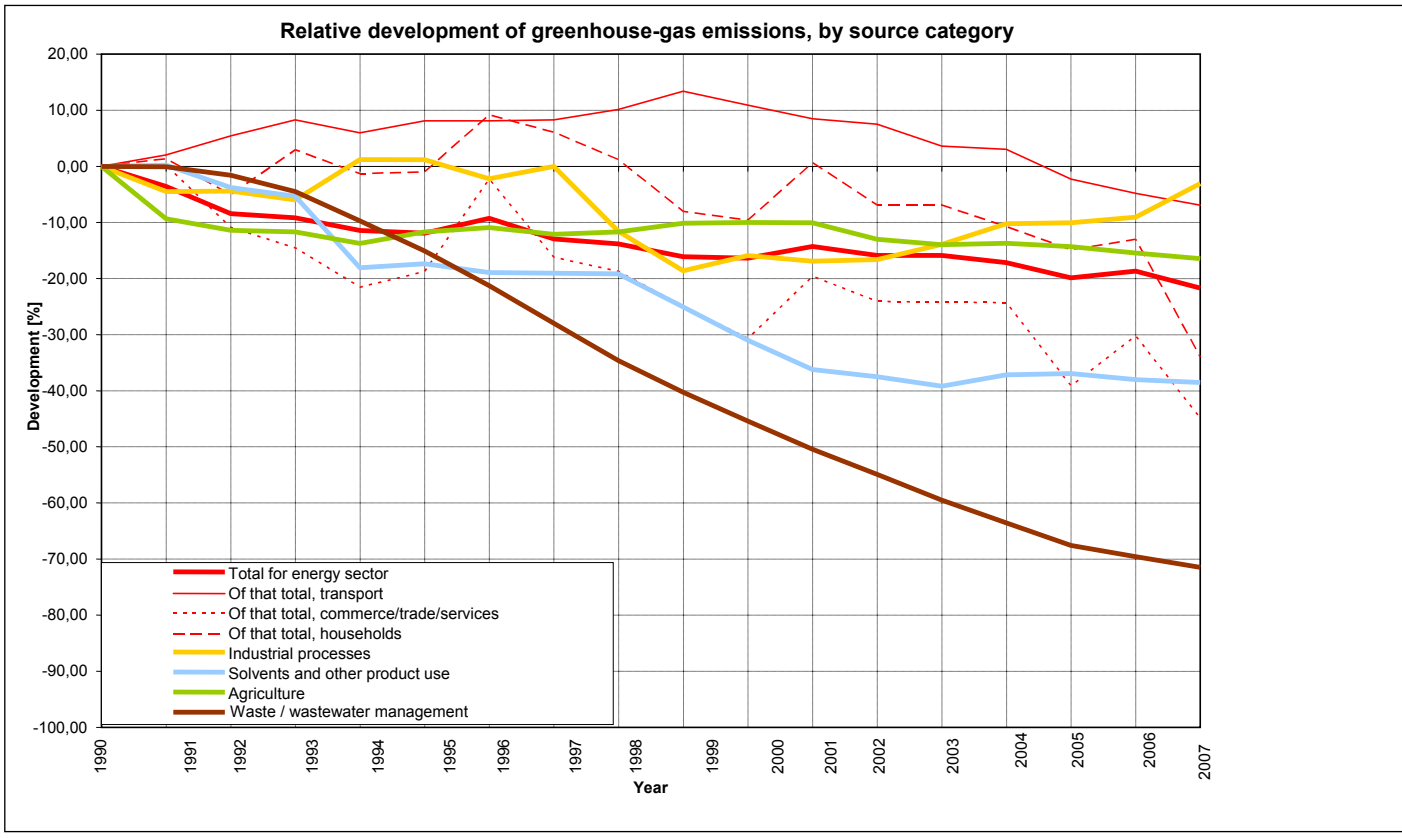


Source: German greenhouse-gas inventory, 2009

Release of carbon dioxide from stationary and mobile combustion processes is far and away the principal cause of emissions, accounting for 87.9 % of greenhouse gas emissions. Due to a disproportionately large decrease in emissions of the other greenhouse gases, the proportion of total greenhouse gases attributable to CO_2 emissions has increased by nearly 3 percentage points since 1990. Emissions of methane, which are caused primarily by animal husbandry, fuel distribution and landfills, accounted for a share of 4.4 % in 2007. Emissions of N_2O, caused primarily by agriculture, industrial processes and transport, accounted for 5.8 % of greenhouse gas releases. The other relevant gases, the so-called "Kyoto" or "F" gases, together accounted for about 1.8 % of total greenhouse-gas emissions. This spectrum of distribution of greenhouse-gas emissions is typical for a highly developed and industrialised country.

The figure below shows the courses of these trends with regard to the year 1990. Emissions of the quantitatively important direct greenhouse gases have been considerably reduced in the period under consideration.

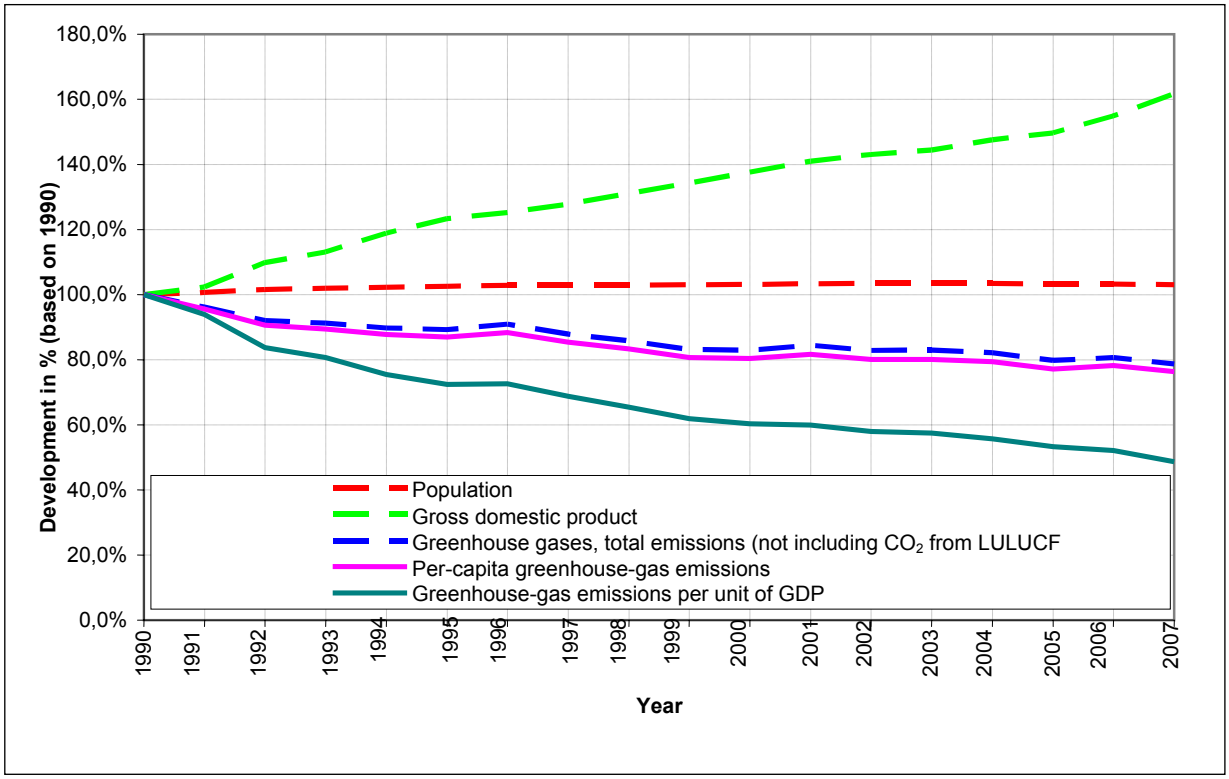
Figure 12: Relative development of emissions from selected source categories since 1990



Source: German greenhouse-gas inventory, 2009

The following figure shows how, in the period from 1990 to 2007, economic growth (+41.7 %) and population growth (+3.1 %) were markedly decoupled from trends for greenhouse-gas emissions (-21.3 %). This success is even more apparent when the relevant per-capita emissions reduction (-23.6 %) is compared to the emissions reduction with regard to economic growth (- 51.3 %).

Figure 13 Relative development of emissions indicators since 1990



Sources: DESTATIS[16], greenhouse-gas inventory, 2009

Nearly similar developments are seen in trends for total greenhouse gases (given as **CO_2-equivalent emissions**: - 21.3 % since 1990) and emissions of **CO_2** (-18.8 % since 1990). The reason for this is the quantitative predominance of carbon dioxide – in the period under consideration, CO_2 emissions' share of total greenhouse-gas emissions increased from 81 % to 87.9 %.

Methane emissions were reduced by over 56.5 % between 1990 and 2007, with per-capita emissions decreasing from nearly 58.4 to 24.6 kg per inhabitant. This trend has been the result of environmental protection measures ("green dot" on recyclable products, "yellow sacks" for recycling pickups, increased recycling overall and increasing energy recovery from waste) that have reduced amounts of waste for landfilling. A second key reason is that use of pit gas from coal mining, for energy recovery, has increased. Emissions in this area have decreased by nearly 78 % since 1990. Yet another reason for the emissions reductions is that livestock populations in the new Federal Länder were reduced, especially in the first half of the 1990s. Repairs and modernisations of outdated gas-distribution networks in that part of

[16]Source for population:

http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Statistiken/Zeitreihen/LangeReihen/Bevoelkerung/Content100/lrbev01ga,templateId=renderPrint.psml (link as of 9 March 2009)

Source for GDP, 1991-2007: http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Statistiken/VolkswirtschaftlicheGesamtrechnungen/Inlandsprodukt/Tabellen/Volkseinkommen1950,property=file.xls (link as of 9 March 2009), GDP 1990: Assessment by experts of the Federal Environment Agency

Germany, along with introduction of vapour recovery in fuel distribution, have brought about further reductions of total emissions.

In comparison to the previous year, methane emissions decreased by 3.5 %. This trend is due to further increases in use of pit gas for energy recovery, as well as to further decreases in landfill emissions.

Nitrous oxide emissions in 2007 were 20 % lower than the corresponding emissions in 1990. This reduced the relevant per-capita emissions from 2.8 kg per inhabitant to 2.2 kg per inhabitant. At the same time, the emissions reductions achieved in the agriculture sector (via reduction of animal populations) were offset by growth in emissions from road transports. As of 1997, technically based reduction measures in the area of adipic acid production led to sharp reductions of total emissions.

3.4 Emissions of fluorinated greenhouse gases

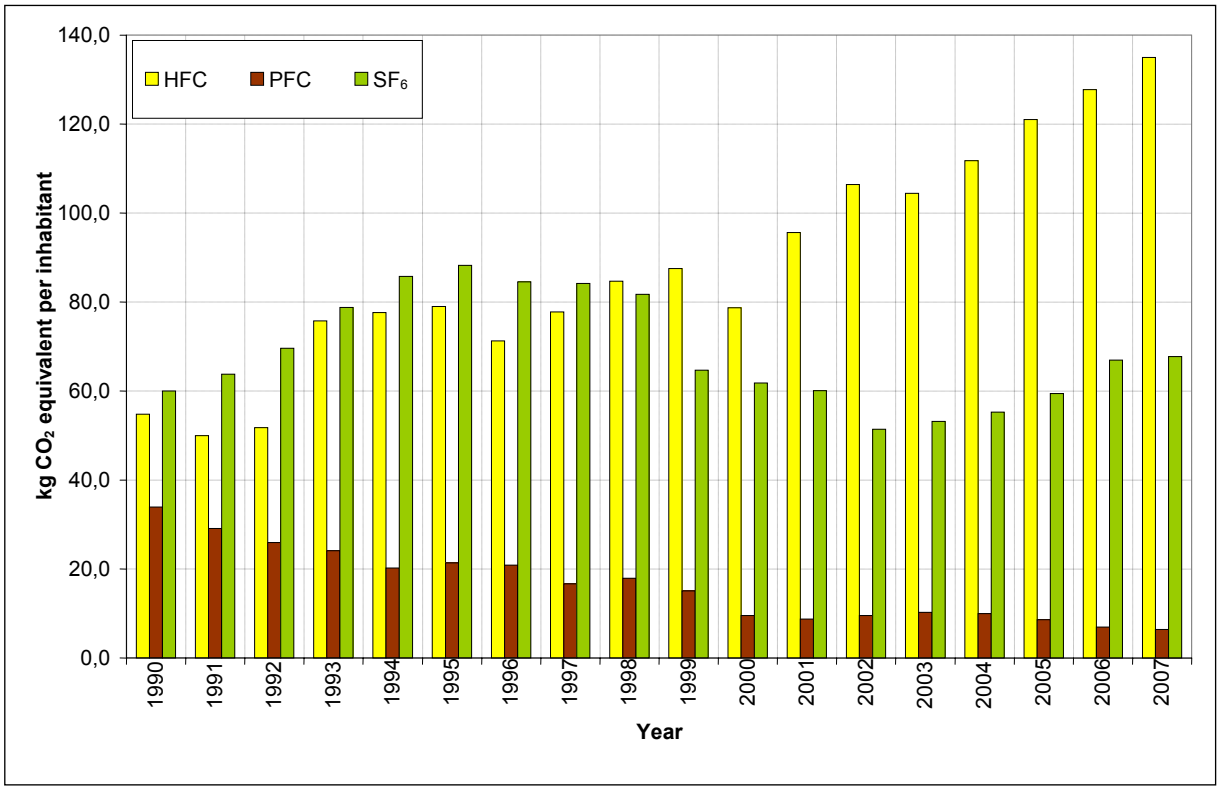
Different trends also emerged in emissions of so-called "**F gases"** (PFC, HFC and SF_6) in the period between 1990 and 2007. In total, emissions in 2007 amounted to about 17 million tonnes of CO_2 equivalents. As a result of increased use of HFCs as substitutes for CFCs, **HFC** emissions in this period rose by about 154 %. Growth of such emissions since the base year 1995 thus amounted to about 70 %. All in all, somewhat more than 11.1 million tonnes of CO_2 equivalents of HFCs were emitted in 2007. In contrast to other pertinent emissions sources, air conditioning and refrigeration systems, along with a number of rigid foams, store large quantities of HFCs. Germany reports such stored quantities as potential emissions.

Emissions of **PFC** compounds have been considerably reduced since 1990. With respect to the corresponding level in 1990, they decreased by about 80 %, mainly as a result of reduction of CF_4 emissions in the aluminium industry. The decrease in those emissions since the base year 1995 was about 70 %. PFC emissions in 2007 amounted to a total of 0.5 million tonnes of CO_2 equivalents.

SF_6 emissions increased by 16 % from 1990 to 2007, although since the base year 1995 they have decreased by over 23 %, or 1.6 million tonnes of CO_2 equivalents, as a result of enacted reduction measures. The situation for SF_6 is similar to that for HFC in that large quantities of SF_6 are stored in a number of relevant applications, as well as in electrical transmission equipment and soundproof windows. Germany reports such stored quantities as potential emissions. SF_6 emissions in 2007 amounted to a total of 5.6 million tonnes of CO_2 equivalents.

In the following section, the three substance groups / gases are considered separately, to take account of the differences in development of the groups / gases.

Figure 14 Population-normed development of emissions of HFCs, PFCs and SF_6 in Germany



Sources: DESTATIS[17], greenhouse-gas inventory, 2009

3.5 Emissions of perfluorocarbons (PFCs)

Only some of the relevant PFC emissions originate from direct use of such substances in products and processes. In this regard, PFCs differ significantly from HFCs and SF_6. In the past, a majority of PFC emissions originated in aluminium smelting, in which CF_4 and C_2F_6 are produced as a side effect of aluminium electrolysis (anode effect). Other emissions sources include the semiconductor industry (CF_4, C_2F_6, C_3F_8, C_4F_8) and circuit board production (CF_4). In those sources, PFCs are used as etching gases. Until 1994, CF_4 was also emitted as a by-product of CFC production.

In Germany, relatively small amounts of PFC emissions are produced in applications in which PFCs are used as substitutes for CFCs. The reason for this is that most of the applications in question in Germany use other substitute substances. Only the country's air conditioning and refrigeration sectors still use PFCs to some degree

[17] Source for population: http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Statistiken/Zeitreihen/LangeReihen/Bevoelkerung/Content100/lrbev01ga,templateId=renderPrint.psml (checked on 9 March 2009)

Source for GDP 1991-2007: http://www.destatis.de/jetspeed/portal/cms/Sites/destatis/Internet/DE/Content/Statistiken/VolkswirtschaftlicheGesamtrechnungen/Inlandsprodukt/Tabellen/Volkseinkommen1950,property=file.xls (checked on 9 March 2009); GDP 1990: UBA experts' assessment

(since about 1995). One maker of athletic shoes briefly used PFCs as a cushioning gas in shoe soles.

Since 1990, aluminium smelting has been the largest source of PFC emissions. Via a range of measures, including emissions reductions, the aluminium industry has considerably reduced its PFC emissions. From 1995 to 2007, the aluminium-smelting sector's share of total PFC emissions decreased from about 90 % to about 37 %. In 2007, the semiconductor industry accounted for about 36 % of all PFC emissions (1995: about 10 %), while the air conditioning and refrigeration sectors accounted for about 24 % (1995: about 0.5 %).

3.6 Emissions of hydrofluorocarbons (HFCs)

Since the early 1990s, HFCs have been used as substitutes for chlorofluorocarbons and hydrochlorofluorocarbons (CFCs and HCFCs), which are greenhouse gases that deplete the earth's ozone layer. HFC emissions thus originate primarily from products and processes in which they are used as refrigerants, blowing agents, propellants, etchng gases or fire retardants. In addition, HFC emissions (HFC-23) occur as a by-product of production of HCFC-22.

Because the global warming potential (GWP) of these substances varies widely, emitted quantities of HFCs are given in CO_2 equivalents. In 2007, mobile (32 %) and commercial (32 %) refrigeration systems were the largest sources of HFC emissions. Other relevant sources included polyurethane (PUR) one-component foams, XPS and PUR hard foams (12 %) and industrial refrigeration systems (11 %). Emissions from air conditioning and refrigeration systems have increased continually since 1995, and they played a predominant role in 2007, accounting for over 70 % of HFC emissions in that year. On the other hand, emissions from PUR one-component foams have been significantly decreased. The reason for this is that HFC components in blowing agents have been reduced, HFCs with lower GWP are being used and halogen-free substances are being phased in. In the area of hard foams, emissions have remained virtually unchanged ever since HFC began to be used as substitutes for (H)CFCs (PUR since 1996; XPS since 2001). Reductions of HFC emissions from F-gas production have had a particularly strong impact on development of overall emissions. Via treatment of some of the gases in cracking plants, as well as through other measures, those emissions have been reduced by over 90 % with regard to the corresponding level in 1990.

3.7 Emissions of sulphur hexafluoride (SF_6)

All SF_6 emissions result from direct use of this substance. In 2007, sulphur hexafluoride emissions originated primarily from non-ferrous foundries (43 %), soundproof-window production (29 %), electrical transmission systems and other electrical systems (13 %) and solar-cell production (5 %). In addition, numerous smaller applications contributed a total of about 10 % to total emissions.

Automobile tyres, which were the main source of SF_6 emissions in 1995, are now an insignificant source. In addition, emissions from electrical transmission systems and from soundproof windows have decreased continually since 1995. On the other hand, emissions from the latter source have increased again in recent years, and they are expected to increase further in future as soundproof windows containing SF_6 are disposed of. Emissions from non-ferrous foundries have also increased markedly, with emissions from aluminium foundries making the largest contribution to this category since 1999. Emissions from magnesium foundries have also increased.

Emissions from thin-film cell production in the solar power sector have been reported since 2002. In 2007, that source already accounted for a total of 5 % of SF_6 emissions.

3.8 Description of the National System of Emissions Inventories

Article 5.1 of the Kyoto Protocol mandates the establishment of National Systems for preparation of greenhouse-gas emissions inventories. The National System for Germany fulfils the requirements of the Guidelines for National Systems (UNFCCC Decision 19/CMP.1), requirements which are binding under the Kyoto Protocol and Decision No 280/2004/EC.

The National System provides for the preparation of inventories conforming to the principles of transparency, consistency, comparability, completeness and accuracy. Such conformance is achieved through extensive use of the methodological regulations from the IPCC Guidelines and the IPCC Good Practice Guidance, through ongoing quality management and through continuous inventory improvement.

In Germany, the National System has been established at the ministerial level, under the leadership of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). The System now incorporates other German ministries, including the Federal Ministry of the Interior (BMI), the Federal Ministry of Defence (BMVg); the Federal Ministry of Finance (BMF), the Federal Ministry of Economics and Technology (BMWi), the Federal Ministry of Transport, Building and Urban Construction (BMVBS) and the Federal Ministry for Food, Agriculture and Consumer Protection (BMELV). As a result, the process of emissions-inventory preparation now includes all of the key institutions that are in a position to make high-quality specialised contributions to it.

A policy paper, "National Emissions Reporting System" of 5 June 2007, based on an agreement between the state secretaries of the aforementioned ministries, defines the relevant responsibilities of the Federal Government's various departments. That policy paper is provided in the NIR 2009. The Federal Environment Agency (UBA) has been assigned the task of serving as the "Single National Entity", or national co-ordinating agency, for Germany (cf. NIR 2009, Chapters 1.2.4.5 and 1.2.4.7). The Single National Entity's tasks include planning, preparing and archiving of inventories, describing inventories in the inventory reports and carrying out quality control and assurance for all important process steps. It also serves as a central point of contact for all participants in the National System.

To support its work in this regard, the Single National Entity has developed the database "Central System on Emissions (CSE), a central, national database for emissions calculation and reporting and for central storage of all information required for emissions calculation.

Within the Federal Environment Agency, a "Quality System for Emissions Inventories" (QSE) provides the framework required for good inventory practice and for routine quality assurance. The tools used by the Single National Entity are described in detail in the NIR 2009, Chapter 1.2.3.

Since 2005, decisive progress has been made in institutionalising the National System.

In the interest of supporting the inventory-preparation process, and to provide a forum for discussion of all issues relative to the National System, the state secretaries' pertinent resolution also provides for the establishment of a co-ordinating committee that includes representatives of all Federal ministries involved in emissions reporting. The National Co-ordinating Committee has the tasks of supporting the emissions-reporting process and clarifying all open issues pertaining to the National System. In addition, the National Co-ordinating Committee is responsible for deciding when to release inventories.

Via agreements between the Single National Entity, other Federal institutions and non-governmental organisations, relevant data-provision channels are safeguarded for the long term, new data sources are developed and the National System is placed on a more and more solid institutional footing. In efforts to fulfil mandatory quality criteria, a need is seen, within the EU, to use data from the EU Emission Trading Scheme (EU ETS) to improve greenhouse-gas emissions inventories. The Single National Entity has addressed this need by developing an institutionalised procedure for using monitoring data from the ETS. Details relative to the institutional determinations within the National System are described in the NIR 2009, Chapter 1.2.4.

Additional details relative to the National System are provided in the National Inventory Report 2009, Chapter 1.2ff.

4 Policies and measures

4.1 General and political frameworks

The Federal Government was early in developing a comprehensive climate-protection strategy. By resolution of 13 June 1990, the "CO_2-Reduction" Interministerial Working Group (IWG) was established, under the direction of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). This working group's tasks include developing guidelines for policies and actions relative to climate protection, identifying needed action, highlighting potential for reducing greenhouse-gas emissions and proposing, to the Federal Cabinet, comprehensive packages of measures for reducing greenhouse-gas emissions in Germany.

The "CO_2-Reduction" IWG has submitted a number of reports to the Federal Cabinet on Germany's national climate-protection strategy. It made such submissions in November 1990, December 1991, September 1994, November 1997, October 2000 and July 2005. And it has been continuing its work in this area.

The main pillars of Germany's national climate-protection strategy include saving energy, improving energy efficiency, achieving a balanced mix of energy sources and expanding use of renewable energies. These emphases are contributing to the achievement of a sustainable energy supply. Germany's national climate-protection programme (like the Integrated Energy and Climate Programme (IECP) that has been implemented since 2007; cf. Chap. 5.2) has a sectoral approach. This means that it considers climate-protection requirements, and the impacts of climate-protection measures, in terms of separate economic sectors: industry, the energy sector, commerce/trade/services, private households and transport. At the same time, sector-overarching instruments, such as the European Union's emissions trading scheme, have been playing an increasingly important role in such efforts.

In the framework of burden sharing within the European Union (EU), and on the basis of obligations arising from the Kyoto Protocol, Germany has committed to reducing its greenhouse-gas emissions by 21 percent by 2008-2012, with respect to the relevant emissions levels in 1990, the base year. The Federal Government plans to achieve this target by implementing, and increasing use of, climate-policy instruments and measures. There are no plans to use public-sector purchases of emissions certificates as a means of achieving the Kyoto target. In the framework of the European Union's unilateral emissions-reduction target for the year 2020, 20% with respect to 1990, installations in Germany covered by emissions trading as of 2013 are subject to an EU-wide emissions cap of 21 % with respect to 2005. Sectors in Germany not subject to emissions trading have to reduce their emissions by 14% in the period 2005-2020. If the European Union, acting within the framework of an international climate protection agreement, commits to greater emissions reductions (30 %), the aforementioned emissions-reduction targets would be suitably tightened.

The current relevant calculations are based on model calculations from the project "Policy Scenarios V" ("Politikszenarien V"), which is being carried out by a consortium of German research institutes under commission to the Federal Environment Agency (UBA) and the BMU.[18] Those model calculations draw to some extent on emissions projections from other research projects of the Federal Environment Agency or the BMU or of other departments.

As noted above (page 15), the Federal Government has not endorsed the results of the presented scenarios for trends in greenhouse-gas emissions in Germany for the period 2005 through 2020.

4.2 Climate-protection measures and instruments since 1990

The National Climate-Protection Programme of 13 July 2005 has been supplanted by the Integrated Energy and Climate Programme (IECP), which was approved in 2007 in Meseberg. The IECP is aimed at helping to reduce the Federal Republic of Germany's greenhouse-gas emissions by 40% by 2020, with regard to the relevant levels in 1990. It includes pertinent legislation and provides for specific measures aimed at enhancing energy efficiency and intensifying use of renewable energies.

The following table provides an overview of the IECP's components and their implementation status:

[18] Öko-Institut e.V. Institute for Applied Ecology, Forschungszentrum Jülich, German Institute for Economic Research (DIW), Fraunhofer Institute for System and Innovation Research, Dr. Hans-Joachim Ziesing: Improvement of the methodological basis, and preparation of a greenhouse-gas-emissions scenario, as a basis for the 2009 Projection Report in the framework of EU greenhouse-gas monitoring ("Verbesserung der methodischen Grundlagen und Erstellung eines Treibhausgasemissionsszenarios als Grundlage für den Projektionsbericht 2009 im Rahmen des EU Treibhaus-gasmonitorings"). UFOPLAN project FKZ 206 42 106.

Table 22 *Status of implementation of proposals within the Federal Government's Integrated Energy and Climate Programme (IECP)*

Key IECP proposals	**Implementation status**
Reductions of electricity consumption: -40 million tonnes CO_2 eq/a[19] by 2020	
Intelligent processes for measuring electricity consumption	A relevant amendment of the Energy Industry Act (Energiewirtschaftsgesetz – EnWG) came into force in September; a complementary ordinance came into force in October
Support programme for climate protection and energy efficiency (outside of buildings)	A new support programme, "Climate-Protection Initiative of the Federal Government" ("Klimaschutzinitiative der Bundesregierung") (Volume for 2008: about EUR 290 million)
Energy-efficient products	"Ecodesign Directive" of the EU: Currently, groups of experts are preparing relevant execution provisions that will define minimum technical standards for individual groups of energy-using products. Following a transition period, all devices introduced to the market must meet certain minimum energy-efficiency standards.[20]
Replacement of night-current-storage heating systems	Cf. the Energy Saving Ordinance (Energieeinsparverordnung)
Procurement of energy-efficient products and services	With a General Administrative Regulation for Procurement of Energy-efficient Products and Services ("Allgemeine Verwaltungsvorschrift zur Beschaffung energieeffizienter Produkte und Dienstleistungen") of 17 January 2008, the Federal Government has made binding the guidelines for procurement of energy-efficient products and services that were introduced on 10 December 2007. The guidelines, which have been in force since 24 January 2008, apply to all of the Federal Government's agencies that award public contracts. The country's Länder and municipalities have been requested to review the possibility of adopting this regulation.
Modernisation of fossil-fired power stations: -30 million tonnes CO_2 eq/a by 2020	
Low-CO_2 power-station technologies	An EU directive on CO_2 capture and storage in power stations was approved at the EU Council Summit held on 11/12 December 2008. The European Parliament approved the directive on 21 December 2008. The directive has since been promulgated.
Clean power-station technologies	The 37th Ordinance on the Execution of the Federal Immission Control Act (BImSchV), which would establish new upper limits on nitrous oxide emissions of new power stations (as of 2012), was not introduced, but its provisions were "divided" among the 13th BimSchV and the 17th BimSchV.
Electricity generation from renewable energies: -55 million tonnes CO_2 eq/a by 2020	

[19] CO_2(eq)/a: carbon dioxide equivalent per year: The "carbon dioxide equivalent" is a measure that is used to compare the climate impacts of the various greenhouse gases. The "global warming potential" (GWP) of a substance is determined by calculating the quantity of carbon dioxide that would have the same greenhouse effects as a unit quantity of the substance.

[20] Devices placed on the market prior to the defined cut-off date may continue to be sold.

Expansion of use of renewable energies in the electricity sector	The amended Renewable Energy Sources Act (EEG) was promulgated in the Federal Law Gazette of 31 October 2008 and entered into force on 1 January 2009. An Act for acceleration of expansion of the extra-high voltage grid ("Gesetz zur Beschleunigung des Ausbaus der Höchstspannungsnetze") was approved by the Bundestag and the Bundesrat, in May and June 2009, respectively, and will soon enter into force.
Combined heat & power generation: -20 million tonnes CO_2 eq/a by 2020	
Act on the Preservation, Modernisation and Development of Combined Heat and Power Generation (Combined Heat & Power Act; KWKG)	The amended Act on the Preservation, Modernisation and Development of Combined Heat and Power Generation (Combined Heat & Power Act; KWKG) was promulgated in the Federal Law Gazette of 31 October 2008, after which it immediately entered into force. The amended Act establishes new rates of support for power from CHP installations, and it opens the way to state subsidies for expansion of heat networks.
Building modernisations and heating systems: -41 million tonnes CO_2 eq/a by 2020	
Energy Saving Ordinance (Energieeinsparverordnung)	An ordinance for amendment of the Energy Saving Ordinance (Energieeinsparverordnung) was approved by the Federal Government on 18 March 2009, in a form that includes changes imposed by the Bundesrat. The amended ordinance entered into force on 1 October 2009. The new ordinance's key elements, which take account of the requirement of cost-effectiveness, include a tightening of energy-efficiency requirements for new buildings and a tightening of such requirements by an average of 30 percent for cases involving major changes in existing buildings; an expansion of individual requirements pertaining to retrofits; gradual phasing-out – supported by financial incentives – of night-current-storage heating systems; measures for strengthening implementation of the Energy Saving Ordinance (Energieeinsparverordnung); and incentives for intensified use of renewable energies.
Operational costs for rented apartments	On 5 November 2008, the Federal Cabinet approved an amendment of the Ordinance on Heating Costs (Heizkostenverordnung). That amendment, which entered into force on 1 January 2009, increases the consumption-dependent shares of invoiced heating costs in certain older buildings. A report on the potential for energy-saving via contracting in construction of rental housing has been completed. The pertinent final report is to become available at the end of August 2009.
KfW support programmes relative to the Federal Government's programme for energy-efficient construction and modernisation (CO_2-oriented building-modernisation programme)	Continuation of support programmes for energy-efficient construction and modernisation (CO_2-oriented building-modernisation programme), including energy-oriented modernisation of municipal and social infrastructures, has been approved until 2011, with a volume of some EUR 2.25 billion in 2009 and about EUR 1.1 billion in each of the years 2010 and 2011.
Energy-oriented modernisation of municipal and social infrastructures	*KfW support programmes relative to the Federal Government's programme for energy-efficient construction and modernisation (CO_2-oriented building-modernisation programme)*
Programme for energy-oriented modernisation of federal buildings	From 2006 to 2009, EUR 120 million per year will be provided for energy-oriented modernisation of civil and military federal buildings (support totaling EUR 480 million). The IECP provides for the programme to be continued beyond 2009 – until 2011 – at its existing level (EUR 120 million / year).
Heat saving in production processes	

	Introduction of modern energy-management systems	No relevant supporting measures have been implemented to date. A government-industry agreement is being sought on use of energy-management systems as a prerequisite for granting of reduced energy-taxation rates.

Use of renewable energies in heat production; -14 million tonnes CO_2 eq/a by 2020

	Regulation on feed-in of biogas into natural gas networks	An Ordinance on Amendment of the Gas Network Access Ordinance (Gasnetzzugangsverordnung), the Ordinance on Gas Network Tariffs (Gasnetzentgeltverordnung), the Ordinance on Incentive Regulation (Anreizregulierungsverordnung) and the Ordinance on Electricity Grid-use Fees (Stromnetzentgeltverordnung) entered into force on 12 April 2008.
	Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG)	The Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG) entered into force on 1 January 2009. The Act is aimed at increasing renewable energies' share of final energy consumption for heating / air conditioning in buildings to a level of 14%, from a current level of about 6 %, by 2020.

Transport: -30 million tonnes CO_2 eq/a by 2020

	CO_2 strategy for automobiles	The EU has been discussing standards for limitation of CO_2 emissions of motor vehicles. It is not clear at present when relevant binding regulations will be issued.
	Expansion of use of biofuels	An Act for amendment of support for biofuels ("Gesetz zur Änderung der Förderung von Biokraftstoffen") entered into force on 15 July 2009. The act's provisions include a reduction of the energy-based overall biofuel quota to 6.25 %, in the years 2010 to 2015, and an authorisation basis for a Biofuel Sustainability Ordinance. In addition, as of 2015 biofuels' net contribution to greenhouse-gas-emissions reduction, instead of the currently applied energy-based quota, is to be used as a basis for determining the blending quota for biofuels.
	Conversion of motor-vehicle tax to CO_2 basis	The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) is seeking to amend the assessment basis for motor-vehicle tax as of 1 January 2010.
	Labelling of automobiles to show fuel consumption	The Ordinance on Energy-Consumption Labelling of Automobiles (Pkw-Energieverbrauchskennzeichnungsverordnung) is currently being revised, with the aim of including information on CO_2 emissions, and on fuel consumption, in the form of an efficiency scale.
	Improved guidance impacts of truck road tolls	In June 2008, the Federal Cabinet approved an amendment of the Toll Rate Ordinance (Mauthöheverordnung). The Bundesrat's approval is still pending. The amendment entered into force on 1 January 2009.
	Air transports	Inclusion of air transports in EU emissions trading as of 2012 has been approved. The directive for inclusion of air transports in the emissions trading scheme is in force!!
	Ship transports	Negotiations are currently underway, in the IMO framework, on inclusion of ship transports in emissions trading. The EU plans to act if the IMO does not approve a pertinent regulation by 2011.
	Electromobility	A National Electromobility Development Plan is being prepared. Key elements of the plan were presented to the public on 25/26 November 2008, at a National Electromobility Strategy Conference.

Other GHG: -40 million tonnes CO_2 eq/a by 2020

Sum of the government's declared aimed-for emissions reductions: -270 million tonnes CO_2 eq/a by 2020

4.3 Cross-cutting measures

The key relevant cross-cutting policies and measures include the **introduction of the EU Emission Trading Scheme** (EU ETS) as of 2005.

- Since January 2005, operators of electricity-generation installations, and of a number of energy-intensive energy-generation installations, have been required to submit CO_2 certificates (emission allowances) in the amount of their installations' relevant previous-year emissions. For a number of reasons, in the pilot phase of the EU ETS, the number of emission allowances available overall corresponded to total emissions that were considerably higher than current emissions levels. In the EU ETS pilot phase, that caused the certificates' prices to fall to nearly zero. For the second period (2008-2012), the emissions target for the EU-27 countries is about 126 million tonnes CO_2 below the 2005 emissions level of the installations included as of 2008. As of 2008, the resulting shortage led to a significant increase in the price for CO_2 certificates. In the third phase of EU ETS, the range of installations subject to the system will be expanded. This will especially affect selected N_2O-emitting installations in the chemical and primary-aluminium industries.
- In the period 2005 to 2007, the majority of emission allowances were issued free of charge to the emitting installations. At the same time, in operation of the installations from an economically rational standpoint, installation operators will take full account of the price for CO_2-emission allowances, via the opportunity costs for the certificates issued free of charge. For new investments, this applies only to a limited extent, since issuance of free certificates for new installations is tantamount to subsidising of new installations – subsidising which, depending on the design of regulations for issuing certificates for new installations, can considerably distort the relevant CO_2-price signals.
- In decisions taken for revision of the EU Emission Trading Scheme, an emissions target (cap) has been established for the EU ETS that is to apply by the year 2020. In the event that an international climate protection agreement comes into being, the EU ETS cap will be tightened. That, in turn, is likely to lead to higher prices for EU emission allowances.

As of 2013, the EU ETS will apply fundamentally revised rules for allocation of emission allowances. Those rules will change both a) the economic incentives for operation of installations in key areas (such as electricity production) and b) the criteria applying to investments. Introduction of the EU Emission Trading Scheme is being taken into account in the following sectors and source-category areas:

- In the electricity production and industry sectors (energy-related and process-related emissions), the EU ETS's CO_2-price signals are having direct impacts on installation operation and on investment decisions (with the latter impacts possibly distorted, via allocation rules).
- For electricity-using sectors, indirect emissions impacts can occur through transfer of CO_2 costs to electricity rates (impacts on electricity consumption).

- At the same time, the electricity-market impacts of CO_2-certificate prices will not change the economic situation of CO_2-free energy sources that – in the framework of enacted support instruments – are not exposed to competition. The necessary support volume (difference between a) special compensation for electricity production from renewable energies and b) market prices) will decrease accordingly, however. In this light, the EU ETS should also be used to properly assess support instruments for renewable energies in electricity production.

In the "with-measures scenario", the EU ETS is taken into account in the following sectors, in the manners described:

- For electricity-production installations, the existing allocation rules for the two periods 2005-2007 and 2008-2012, and the allocation rules expected to apply as of 2013 as a result of decisions for revision of the EU ETS, are used as a basis.
- For all installations subject to the EU ETS (electricity production, energy-related and (where applicable) process-related emissions of industry) the certificate price from the reference variant is applied.
- For all electricity-consuming devices and installations, an electricity price is applied that reflects the CO_2 price.

4.4 Sector-oriented measures

The measures described in the following section have already been implemented and are taken into account in emissions estimates, for the various relevant individual sectors, in the "with-measures scenarios". (The scenario descriptions have been taken from the 2009 Projection Report.)

4.4.1 Electricity production from fossil fuels

4.4.1.1 "With additional measures" scenario

Assessment of measures in the "with-measures" scenario, in the sector of electricity production with fossil fuels, covers all measures of relevance for the German electricity sector that were approved, or that took effect, between 2000 and 2007. The relevant effects have been calculated with the help of the Electricity Investment Analysis (ELIAS) investment model of the Öko-Institut e.V. Institute for Applied Ecology, and with inclusion of feedback from a power-station-usage model.

The measures described in this section apply to fossil-fuel electricity production in condensing power stations and cogeneration (CHP) installations. Measures in the area of electricity production from renewable energies are described in Section 5.4.2. The following policies and measures in the area of fossil-fuel electricity production were taken into account in modelling of the effects of the "with-measures" scenario:

- Elimination of the natural gas tax for electricity production in condensing power stations;
- Introduction of the EU Emission Trading Scheme;
- Act on the Preservation, Modernisation and Development of Combined Heat and Power Generation (Combined Heat & Power Act; KWKG) of 2002, and its amendment of 2008; CHP support in the Renewable Energy Sources Act (EEG);

- Compensation for avoided network utilisation.

In addition, in quantification of the measures with impacts on the electricity sector, the effects of electricity production from renewable energies (Section 5.4.2) and of electricity demand (composed of demand in the end-consumer sectors of transport, space heating and water heating, commerce-trade-services, industry and private households, as well as electricity consumption in the transformation sectors) have been taken into account and listed.

Elimination of the natural gas tax: Taxation of fuel inputs for electricity production, and for cogeneration of electricity and heat, was modified in the framework of the Act for the Reorganisation of Taxation of Energy Products and for Amendment of the Electricity Tax Act (Gesetz zur Neuregelung der Besteuerung von Energieerzeugnissen und zur Änderung des Stromsteuergesetzes) of 15 July 2006 (Federal Law Gazette I No 33, p. 1534 – 1561). As a result, as of 1 August 2006, natural gas is generally exempt from taxes if it is used for electricity generation in stationary installations with a rated electrical generating capacity of more than 2 megawatts or in stationary CHP installations with a monthly or annual usage efficiency of at least 70 %. Engine-based or gas-turbine-based CHP installations for which the monthly usage efficiency applies must have an annual usage efficiency of at least 60 %. As a result, natural gas used for electricity production, in condensing power stations or in CHP installations, is exempted from taxation (until July 2006, such exemption applied only to CHP installations with the aforementioned minimum efficiencies). Elimination of the natural gas tax for condensing power stations increases the attractiveness of natural-gas-based electricity production, which has low emissions compared to coal-fired electricity production.

Introduction of the EU Emission Trading Scheme: Emissions trading in the power station sector, with regard to new investments, is shaped by the basic structure of the allocation rules for new installations, as provided for by the 2007 Allocation Act (ZuG 2007) and by the National Allocation Plan for the years 2008 through 2012 (ZuG 2012). For the period until 2012, free allocation, on the basis of fuel-specific benchmarks for new installations, is especially relevant. For CHP installations, allocation is assumed to be based on a double benchmark that covers both electricity production and heat production. For the period 2013 to 2020, complete auctioning of emission allowances for condensing power stations is assumed. For CHP installations, emission allowances are allocated free of charge for heat production and auctioned for electricity production.

Act on the Preservation, Modernisation and Development of Combined Heat and Power Generation (Combined Heat & Power Act; KWKG) of 2002, and its amendment of 2008; CHP support in the Renewable Energy Sources Act (EEG): The Act on the Preservation, Modernisation and Development of Combined Heat and Power Generation (Combined Heat & Power Act; KWKG) of 2002 (KWKG 2002) supplanted the CHP preliminary act (KWK-Vorschaltgesetz) of 12 May 2000, which was primarily oriented to protection of existing CHP installations. The KWKG 2002 was designed to contribute to efforts toward the Federal Government's climate protection objectives. Such contribution was to occur via term-limited protection of, and promotion of modernisation of, existing CHP installations; via expansion of electricity production in small CHP installations; and via market launch of fuel cells. As a result of the 2008 amendment of the KWKG, large new power stations in the industrial CHP sector, and in the district-heat sector, are also eligible for support if they are commissioned by 2016. All in all, this amended Combined Heat & Power Act

(KWKG) is the most important measure for supporting CHP installations. Operators of such installations receive supplementary payments for CHP electricity, with the amounts of such payments tied to installation categories. In addition, combined heat & power generation is being supported in the framework of electricity production from renewable energies.

Entgelte für vermiedene Netznutzung: Via the Energy Industry Act (Energiewirtschaftsgesetz – EnWG), which was amended in summer 2005, and the pertinent Electricity Grid Access Charges Ordinance (Strom-Netzentgeltverordnung; StromNEV), a first-ever legal claim to reimbursement of network utilisation charges avoided via non-central feed-in of electricity to the grid was created. In a network or transformation level with non-central feeding of electricity into the grid, the network operator's network charges payable to the next-higher network level are reduced in that smaller amounts of electric power have to be removed from such network or transformation level. For his so-provided network services, the party carrying out such non-central feed-in receives the difference (i.e. amount) compared to the situation without non-central feed/-in. That difference is referred to as "avoided network-utilisation charges". In future, avoided network-utilisation charges will be calculated for each network level – i.e. also for transformation. As a result, for example, for an installation that feeds electricity into the medium-voltage network, the charge for removal from high-voltage / medium-voltage transformation, and not (as was previously the case) the charge for removal from the high-voltage network, serves as the basis for calculating the avoided network utilisation. The procedure for charge calculation is set forth in the "Association agreement of 13 December 2001 on criteria for determination of network-utilisation charges for electrical energy and on network-utilisation principles" ("Verbändevereinbarung über Kriterien zur Bestimmung von Netznutzungsentgelten für elektrische Energie und über Prinzipien der Netznutzung vom 13. Dezember 2001"; VV II plus).

4.4.2 Electricity generation from renewable energies

4.4.2.1 Preliminary remarks

In recent years, more and more electricity has been generated from renewable energies. That growth is due in large measure to support via the Renewable Energy Sources Act (EEG), which was amended in 2004 and 2008. The EEG from 2008 is aimed at expanding electricity generation from renewable energies to a level of at least 30 % of electricity consumption by 2020 and to promote continuous growth of such generation thereafter.

4.4.2.2 "With- measures" scenario

The "with-measures" scenario is based on the current terms of support provided under the EEG and on relevant additional support, such as that provided via loan programmes. Development of electricity generation from renewable energies in the "with-measures" scenario is obtained via calculations with the "PowerACE ResInvest" model and via cross-checking against the current 2008 lead study[21]. The original minimum political goal, whereby renewable energies would account for 12.5 % of electricity generation by 2010, was already surpassed in 2007[22]. Under the "with-

[21] Nitsch 2008

[22] BMU 2008a

measures" scenario, the political goal whereby renewable energies account for at least 30 % of electricity generation will be reached in 2020. Renewable energies' share of electricity generation reaches about 33 % in 2020, thereby exceeding the level predicted by a scenario based on the 2004 amendment of the EEG[23] by 54 TWh in 2020. In comparison to the scenario calculated on the basis of the EEG compensation rates under the amended version of the EEG from 2004, electricity generation from renewable energies thus increases by 54 TWh in 2020.

4.4.3 Other transformation sectors

In the area of the other transformation sectors, the most important installation types are as follows:

- Heating stations
- Refineries
- Coking plants

All such installations are subject to the EU emissions trading scheme. Consequently, prices for EU emissions allowances – and, possibly, the pertinent allocation rules – have to be taken into account in connection with them.

4.5 Transport

4.5.1 Framework data

The special framework data for transport are presented in Table 23 and Table 24. The figures for passenger transport volume have been taken from the "Policy Scenarios IV" ("Politikszenarien IV") (Öko-Institut et al. 2007). For goods transport volumes, forecasts of the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) (BMVBS 2007) have been used. This has resulted in a considerable increase in goods transport volumes, in comparison to the corresponding figures in "Policy Scenarios IV", and, consequently, in somewhat higher energy demand and (thus) higher emissions than in the reference scenario.

Table 23 Passenger transport volumes

	2000	2004 / 2005	2010	2020	2025	2030
	Billions of pkm					
PSz-IV						
Autos,station wagons	838		894	948		940
Railway transports	89		95	104		104
Bus transports	84		87	89		90
Total	1.011		1.076	1.141		1.134

Source: Öko-Institut et al. (2007), ITP/BVU (2007)

[23] The comparison scenario is based on the support terms provided by the amended version of the EEG from 2004. It should be noted that support of renewable energies through 2007 accounted for electricity generation of 87.5 TWh. The projection on the basis of the support terms provided under the amended version of the EEG from 2004 shows electricity generation of 135 TWh in 2020.

Table 24 Goods transport volumes

	2000	2004 / 2005	2010	2020	2025	2030
	Billions of tkm					
PSz-IV						
Road	346		437	540		604
Railway	81		90	99		110
Inland waterway	67		77	92		103
Total	494		604	731		817
BMVBS intermodal forecast for 2025						
Road		393			704	
Railway		92			152	
Inland waterway		64			80	
Total		549			936	

Source: Öko-Institut et al. (2007), ITP/BVU (2007), Progtrans (2007)

4.5.1.1 "With-measures" scenario

The "with-measures" scenario includes the measures that have already been implemented or for which implementation has been approved or will take place in the near future. The following measures are taken into account in the analyses for the "with-measures" scenario:

Ecological tax reform, 1999-2003: Ecological tax reform for the period 1999 to 2003, with an increase of 3.07 cents per litre and year (totalling 15.34 cents/l as of 2003).

Spreading of truck road tolls: Greater spreading of truck road-use toll rates on federal autobahns, for trucks with more than 12 t permissible total weight, as of January 2009 (for three-axle vehicles: 0.106-0.127-0.159-0.207 €/km, depending on emissions class; for vehicles with four or more axles: 0.116-0.138-0.169-0.217 €/km, depending on emissions class)[24].

Biofuel Quota Act (BioKraftQuG): Implementation of the Biofuel Quota Act of December 2006, which establishes requirements for mixing of biofuels with petrol (ethanol) and diesel (RME, BTL). The defined targets to be achieved call for biofuels to account for 6.75 % of total fuel demand (fossil and bio) by 2010; 8 % of such demand by 2015; and, by 2020, 17 % of such demand by volume and 14 % of such demand by energy fraction. At the same time, graduated taxation of biofuels, as called for by the Biofuel Quota Act, is to be introduced[25].

CO_2-oriented strategy for automobiles (CO_2-emissions targets): Expansion of the ACEA agreement: Implementation of the European CO_2-oriented strategy for automobiles, via introduction of CO_2-emissions targets that, in keeping with the recently approved relevant EU regulation and its updates, are expected to lead to an average CO_2-emissions level, for all new automobiles registered in Germany (including all domestic and foreign automobiles), of 143 g CO_2/km in 2015 and 105 g CO_2/km in 2020. Those reductions are to be achieved via measures oriented to engines / power plants. What is more, implementation of non-engine-related

[24] The higher toll rates in force since 01/2009 were not known at the time the contract was issued, and thus it was not possible to take them into account in modelling.

[25] An Act for amendment of support for biofuels (Gesetz zur Änderung der Förderung von Biokraftstoffen) entered into force on 15 July 2009. As a result, the bases mentioned above must be considered outdated.

measures, such as use of low-viscosity oils and low-resistance tyres, more careful control of tyre pressures and use of biofuels, is expected to cut average emissions by an additional 10 g CO_2/km.

CO_2-based motor-vehicle tax: In motor-vehicle tax, use of an emissions-oriented and CO_2-oriented calculation basis as of 1 January 2009. That change will apply only to automobiles newly registered as of 1 January 2009. The tax is structured to take account of the following / includes the following: (a) typical CO_2 emissions for vehicles or individual vehicles; (b) the measure has been designed to have a neutral effect on costs, so that no changes in tax collection are required; (c) the lump-sum compensation for the energy-taxation advantages (formerly, mineral-oil-taxation advantages) enjoyed by automobiles with diesel engines is to be supplanted by CO_2-oriented compensation; (d) lower rates apply for automobiles that have especially low emissions and that already comply with all future emissions standards; (e) for vehicles in service as of 31 December 2008, tax-rate increases for automobiles in the Euro 2, Euro 3 and (possibly) Euro 4 emissions categories, with such increases reasonable in terms of their amounts and their comparison to emissions-dependent taxation of other vehicles; (f) for vehicles in service as of 31 December 2008, retention of today's already considerably higher tax rates for older vehicles in the Euro 1 emissions category and the "Euro 0" emissions level.

CO_2-based labelling for automobiles: Introduction of non-ambiguous emissions labelling, based on fuel consumption and CO_2 emissions, for new automobiles as of 1 July 2008. Colour codes are to be used to show efficiency classifications. A pertinent draft of the Federal Ministry of Economics and Technology (BMWi) calls for efficiency class A to allow less than 111.5 g CO_2/km for automobiles with 1,000 kg empty weight, less than 143.5 g CO_2/km for automobiles with 1,500 kg empty weight and less than 171.5 g CO_2/km for automobiles with 2,000 kg empty weight.

4.5.2 Private households

4.5.2.1 Space heating and water heating

Preliminary remarks and framework data

Trends for building floor space are a key parameter in analyses of the building sector. Total building floor space consists of floor space in both old and new buildings. The total inhabited residential floor space is obtained by adding old-building floor space, which is listed without taking account of vacancies, and the new-building floor space. Pursuant to demographic framework data for development of the residential population and of household structures, the entire inhabited residential floor space and the new-building floor space are listed separately for the a) reference development (the "trend" variant) and b) the "status quo" variant of the Federal Statistical Office's 11th co-ordinated population projection survey. The "status quo" variant is used in the "low population growth" sensitivity analysis.

The following

Table 25 and Table 26 present the framework assumptions relative to development of residential floor space in the building sector through 2020.

Table 25 Determinants for energy-consumption trends in the space-heating sector, 2005-2020

inbillions of m²	2005	2006	2010	2015	2020
Old buildings (net; not including vacancies)	3,06	3,06	3,05	3,03	3,00
New construction, reference		0,03	0,14	0,24	0,34
New construction, variant		0,03	0,14	0,23	0,30
Occupied residential space, reference V1-W2	3,06	3,09	3,19	3,27	3,34
Occupied residential space, variants V1 - W1	3,06	3,09	3,14	3,17	3,19

Sources: StBa 2006, StBa 2007a; own calculations of Jülich Research Centre, IEF-STE

Table 26 Annual new residential floor space, 2005-2020

in millions of m^2/a	2005	2006	2010	2015	2020
Reference	25,0	25,5	22,9	20,0	20,0
Variant: status quo	25,0	25,5	22,9	17,0	15,0

Sources: Öko-Institut et al. 2007; own calculations of Jülich Research Centre, IEF-STE

For private households, the IKARUS space-heat model is used, in the "with-measures" scenario, to take account of those measures that have already taken effect or that were approved in 2008 in the framework of the Integrated Energy and Climate Programme (Meseberg 2007) (cf. the following Table 27).

Table 27: *Analysed instruments and measures*

"With measures" scenario	
Quantifiable instruments	
KfW CO_2 building rehabilitation programme	
Modernisation of residential space	
Ecological construction	
KfW programme for residential property	
"City conversion East"	
Support for social housing	
Market incentives programme oriented to EE	
Amendment of the EnEV 2007	
Renewable Energies Heat Act	
Amendment of the Ordinance on Heating Costs	
On-site energy consultation	
"Soft" and non-quantifiable instruments	
Dena	
Information and motivation	
Campaigns for further training and quality	
R&D in the buildings and heating sectors	
Other impetus for modernisation	

Source: Jülich Research Centre, IEF-STE

4.5.2.2 Developments for instruments in the "with-measures" scenario

KfW support programmes for energy-efficient construction and modernisation

This group of programmes includes a *CO_2 Building Rehabilitation Programme (CO_2-Gebäudesanierungsprogramm)*; the programme *"Modernising living space – Eco-plus version" ("Wohnraum Modernisieren – Öko-Plus Variante")* for modernisation of existing buildings; and the *"Ecological Construction"* ("*Ökologisch Bauen*") programme for construction of energy-efficient new buildings. As of 1 April 2009, the two programmes for modernisation of existing buildings were combined within the programme "*Energy-Efficient Rehabilitation*" ("*Energieeffizient Sanieren*"), which includes both a loan-based variant and a grant-based variant, while relevant efforts in the area of new construction are being continued under the heading "*Energy-efficient Construction*" ("*Energieeffizient Bauen*"). [26]

[26] Some of the support programmes presented have been extensively restructured since the surveys for the 2009 Projecton Report.

The support programmes for energy-efficient construction and rehabilitation are part of the Federal Government's National Climate Protection Programme (which appears under the budget heading "CO_2 Building Modernisation Programme" ("CO_2-Gebäudesanierungsprogramm") as well as part of the KfW Bank Group's (KfW's) programmes for energy-efficient construction and rehabilitation. The Federal Ministry of Transport, Building and Urban Affairs (BMVBS) is providing some EUR 2.25 billion to the KfW Bank Group for loan-interest reductions and for investment subsidies. In each of the years 2010 and 2011, it will provide about EUR 1.5 billion for these purposes.

KfW CO_2-based building-rehabilitation programme: The *KfW CO_2 Building Rehabilitation Programme* is part of the National Climate Protection Programme and of the KfW Bank Group's programmes for energy-efficient construction and rehabilitation. The programme provides long-term financing, via low-interest loans and investment grants, of investments for energy-saving and CO_2-emissions reductions in buildings. It was established in 2001 as a complement to the KfW programmes for CO_2-emissions reductions and for modernisations. The KfW CO_2 Building Rehabilitation Programme especially supports extensive CO_2-emissions-reduction measures that enable residential buildings constructed before 1984 to achieve the new-building standards called for under the Ordinance on Energy Saving (Energieeinsparverordnung – EnEV). In 2007, the programme was expanded to include all residential buildings constructed before 1995. Under the programme, investors have the option of either using predefined packages of measures or compiling measures packages from a measures catalogue. In each case, such packages consist of a combination of individual measures that support improvements in buildings' thermal insulation, window replacements, replacements of heating systems and heating-fuel conversions. For buildings built between 1983 and 1995, individual support is provided, via measures packages for CO_2-emissions reductions. In each case, modernised buildings must comply with at least the requirements set forth in Annex 3 of the 2007 Ordinance on Energy Saving (EnEV 2007).

In 2009, soon after amendment of the EnEV 2007, the group's programmes for energy-efficient construction and modernisation are to be suitably adapted. According to KfW (2008a), the changes will include introduction of a common KfW "efficient-house" standard ("Effizienzhaus-Standard") for new buildings and for complete modernisations.

And plans call for investors to be able to freely choose individual measures, instead of having to use fixed packages of measures. An expected increase in the maximum support available for complete modernisations, from the current level of EUR 50,000 per residential unit to a level of EUR 75,000 per residential unit, has been taken into account.

From 2001 to 2007, loan commitments in the framework of the KfW CO_2 Building Rehabilitation Programme totalled EUR 10 billion and supported energy-efficiency modernisations of some 43.5 million m^2 of residential housing, or 540,000 residential units. From the relevant total federal funding provided in 2007, investment grants totalling EUR 15 million were paid out. The pertinent annual effects, from 2001 to 2007, are shown in Table 28.

Table 28: Effects of the KfW CO_2 Building Rehabilitation Programme (2001-2007)

		2001	2002	2003	2004	2005	2006	2007
Federal funding	Millions of EUR (Pro. funding	200	200	280	360	360	1.150	850
Loan volume	Millions of EUR	507	725	1.146	1.435	1.136	3.230	1.861
Grants	Millions of EUR							15
Modernised residential units	1,000s	31,5	43,2	69,0	90,1	69,9	149,2	88,6
Modernised living space	Millions of. m^2	2,6	3,6	4,9	5,2	6,4	13,0	7,8

Sources: Hansen & Kleemann 2005; BEI/IWU 2007; BEI/IWU 2008; BMVBS 2008; KfW 2008b, Calculations of the Jülich Research Centre, IEF-STE

The CO_2-reduction calculations are based on analyses by Kleemann (2003), according to which pertinent loan applications led to average reductions of at least 40 kg/m^2. That average reduction differs only slightly from the programme's emissions reductions, for the period 2005 to 2007, as determined by the Bremer Energie Institut.[27] In such analysis, residential buildings that have been modernised in terms of energy efficiency, with the help of KfW loans, are seen as representative samples of existing buildings of defined standard types. The reductions calculated for the standard building types, with the help of a space-heating model, are applied to the entirety of buildings modernised with KfW funding.

The programme has been receiving added funding, above and beyond the federal funding originally slated for the programme for the years 2008 to 2011. For example, programmes in support of energy-efficient construction and modernisation, run via KfW Bankengruppe, profit from planned increases from the Federal Government's first economic stimulus package (Konjunkturpaket I; package of measures for protecting employment by strengthening growth), amounting to a total of over EUR 2 billion in added programme funding. As a result, in the period 2009 to 2011, programme funding of about EUR 1.5 billion per year will be available for relevant interest reductions and investment grants.

[27] (BEI 2007; BEI/IWU 2007; BEI/IWU 2008

As part of calculations, it has been assumed that as of 2009 the programme's required minimum reductions will be tightened by 30 %, in an approach similar to that applied for amendment of the 2007 Energy Saving Ordinance (EnEV 2007). As it continues, the programme is expected to have loan resources as follows: a total of EUR 3.8 billion in 2008, about EUR 4.1 billion in 2009, and EUR 4.35 billion in each of the years 2010 and 2011. In each of the years in the period 2012 to 2030, federal funding amounting to EUR 1.0 billion, and a loan volume of EUR 2.7 billion, are assumed. As Table 29 shows, these resources could support emissions reductions totalling 7.1 million t CO_2 by 2020.

Table 29: *Loan volumes and CO_2 reductions achieved by the KfW CO_2 Building Rehabilitation Programme, 2006 to 2020*

		2006	2007	2008	2009	2010	2020	
Federal funding	Millions of EUR (Pro. funding)	1.150	850	1.395	1.480	1.470	1.150	
Loan volume / grants	Millions of EUR	3.230	1.876	3.805	4.077	4.349	2.700	
CO_2 reduction	Millions of t.	0,52	0,31	0,61	0,66	0,70	0,40	
Total CO_2. reduction	Millions of t..	0,52	0,83	1,44	2,10	2,80	7,10	

Sources: BMVBS 2008; calculations of the Jülich Research Centre, IEF-STE

KfW Housing Modernisation Programme: The KfW "Housing Modernisation" programme has been underway since 2005. It was formed as a combination of KfW's modernisation programme and CO_2-reduction programme. The programme provides low-interest financing for CO_2-reduction and modernisation measures in existing residential buildings. In its standard framework, the programme supports non-energy-related standard measures, including modernisation and refurbishment of residential buildings, landscaping improvements for apartment buildings, and measures for removal of vacant rental properties (apartment buildings) for which no demand is expected, in the long term, in the new Länder and in Berlin (east). In the "ÖKO PLUS" ("ECO PLUS") framework, thermal insulation measures, of relevance to climate protection, are supported via particularly favourable interest rates. ÖKO-PLUS measures include enhancements of buildings' outer thermal insulation and replacements of heating systems with renewable-energy systems, combined heat/power (CHP) systems or local-heat and district-heat systems.

Since the programme's cost structure is similar to that of the KfW CO_2 Building Rehabilitation Programme, the emissions reductions that can be achieved via the ÖKO-PLUS framework can be determined with sufficient precision. According to KfW, 20 % of programme funding goes toward emissions-reduction measures.

In 2006 and 2007, loan funding of EUR 3.8 and 3.3 billion, respectively, was committed within the "Housing Modernisation" programme (German Bundestag 2008; KfW 2008b). In the same period, the ÖKO-PLUS variant led to emissions reductions of some 0.08 million t CO_2.

In the model, assuming that the programme continues with annual loan funding of EUR 3.0 billion, through 2020, and that EUR 200 million of that sum are allotted annually to the ÖKO-PLUS variant, the programme could achieve CO_2 reductions totalling 0.6 million t by 2020 (Table 30).

Table 30: Loan volumes and emissions reductions via the KfW "Housing Modernisation" programme, 2006 to 2020

		2006	2007	2008	2010	2020
Loan volume - ÖKO PLUS	Millions of EUR	1.318	740	675	675	675
Loan volume - total	Millions of EUR	3.864	3.279	3.000	3.000	3.000
Funding for reduction measures	Millions of EUR	330	185	200	200	200
CO_2 reduction	Millions of t	0,05	0,03	0,04	0,04	0,04
Total CO_2 reduction	Millions of t	0,05	0,08	0,12	0,20	0,60

Sources: German Bundestag 2008; KfW 2008b; calculations of the Jülich Research Centre, IEF-STE

Energy Efficient Construction: The "Energy Efficient Construction" programme, which was established in 2005 (originally as "Ecological Construction"), provides long-term, low-interest financing for construction and first acquisition of "efficiency houses". To be eligible for support under the programme, as a "KfW Efficiency House 40", a house's annual, specific primary energy consumption must not exceed 40 kWh/(m^2 a), a standard that is 45 % more stringent than that required by the current EnEV Energy Saving Ordinance for new houses. Similarly, to be eligible for support as a "KfW Efficiency House 60", a house's annual, specific primary energy consumption must not exceed 60 kWh/(m^2 a), a 30 % more stringent standard than that required by the EnEV 2007 Energy Saving Ordinance for new houses. In each case as a one-time measure, this programme also supports installation of heating systems, in new houses, that use renewable energy, combined heat/power (CHP) arrangements or local/district heat.

In 2006 and 2007, with funding totalling EUR 2.2 and EUR 2.1 billion, respectively, this programme supported measures for some 106,000 residential units. A breakdown of funding by building types shows that in 2006 and 2007, some two-thirds of available loan funding was provided for KfW "Efficiency Houses 60 ". As of 2009, the EnEV 2007 Energy Saving Ordinance tightens thermal insulation requirements by 30 %. For this reason, the "Efficiency House 60" programme variant was terminated in 2008.

As the model indicates, and as the following Table 31 shows, continuation of the "Efficiency House 40" variant of the programme, with loan volumes averaging EUR 2.0 billion through 2020, could achieve CO_2-emissions reductions totalling some 1.1 million t.

Table 31: Loan volume and emissions reductions under the "Energy Efficient Construction" programme, 2006 to 2020

		2006	2007	2008	2010	2020
Energy Efficient Construction - EH 40	Millions of EUR	740	655	1.000	2.000	2.000
Energy Efficient Construction - ESH 60	Millions of EUR	1.469	1.446	1.000	0	0
Total loan volume	Millions of EUR	2.209	2.101	2.000	2.000	2.000
CO_2 reduction	Millions of t	0,09	0,09	0,09	0,07	0,07
Total CO_2 reduction	Millions of t	0,09	0,18	0,27	0,40	1,08

Sources: German Bundestag 2008; KfW 2008b; calculations of the Jülich Research Centre, IEF-STE

KfW Home Ownership Programme: The KfW "Home Ownership Programme", which has been in place since 1996, is designed to finance construction of new homes, as well as purchase and modernisation of owner-used homes and condominiums. Per supported property, the programme provides up to 30 % of total costs, up to a maximum loan amount of EUR 100,000. Since February 2008, borrowers can apply for home-ownership loans with terms of up to 20 and up to 35 years. For the first time, fixed-interest periods of 15 years are now available. Previously, the loans had a maximum term of 30 years, and borrowers could choose fixed-interest periods of either 5 or 10 years.

According to KfW (2008c), only 30.6 % of all borrowers apply their loans toward construction or purchase of a new home. Accordingly, some 70 % of the total loan volume goes toward purchases and modernisations of non-new homes. In light of decreasing new-home construction, that percentage can be expected to grow. From 2005 to 2007, the total loan volume varied between EUR 4.4 and 5.6 billion (Table 32).

In pertinent calculations, costs for modernisation are considered to amount to 20 % of the loan volume applied to existing (non-new) structures. The pertinent share of funding for reduction measures has been assumed on the basis of information for the KfW "Housing Modernisation" programme. With these assumptions, energy-efficiency oriented modernisations of existing buildings via this programme are likely to have produced emissions reductions amounting to some 0.06 million t CO_2 from 2006 to 2007. On the other hand, emissions increased by some 0.27 million t CO_2, during the same period, via construction and heating of new housing. The resulting added emissions can thus be estimated as 0.21 million t. In calculations for the period until 2020, new construction is assumed to decrease to a share of 24 % of all efforts under the programme, and annual support funding of EUR 4.5 billion is assumed. The calculations take account of the EnEV Energy Savingt Ordinance's 30 % tightening of relevant requirements as of mid-2009. Balancing of the additional emissions resulting from new construction with the CO_2 reductions resulting from modernisation shows a total pertinent emissions increase of some 0.5 million t.

Table 32: Loan volume, added emissions via new construction and emissions reductions via modernisation, 2006-2020

		2006	2007	2008	2010	2020
Total loan volume	Millions of EUR	4.397	5.262	4.500	4.500	4.500
Share for new-home purchases	%	36	31	29	27	24
Share for non-new-home purchases	%	64	69	71	73	76
Added emissions via new construction	Millions of. t	0,11	0,15	0,10	0,06	0,05
CO_2 reduction via modernisation	Millions of. t	0,03	0,03	0,03	0,03	0,03
Annual total CO_2 reduction	Millions of. t	-0,09	-0,12	-0,07	-0,03	-0,01
Cumul. total CO_2 reduction	Millions of. t	-0,09	-0,21	-0,28	-0,34	-0,50

Source: German Bundestag 2008; KfW 2008b; calculations of the Jülich Research Centre, IEF-STE

City-reconstruction programme "East" (Stadtumbauprogramm Ost): The Federal-Länder programme "City Reconstruction "East"" ("Stadtumbau Ost"), launched in 2002, is an initiative aimed at improving urban development and housing markets in the new German Länder. In particular, the programme is designed to help improve the housing-sector framework and safeguard the proper functioning of housing markets. It does this by providing targeted support for necessary investments for dismantling, refurbishment and modernisation (Lenkungsgruppe 2008).

Pursuant to the pertinent report of the Expert commission on structural change in the housing market in the new Länder (Expertenkommission zum wohnungswirtschaftlichen Strukturwandel in den neuen Ländern) (Pfeiffer, Simons et al. 2000), this programme for promoting urban development will remove some 350,000 residential units from the market in the period 2002 to 2009. As of the end of 2007, dismantling of some 221,000 residential units had been supported via the "City Reconstruction "East"" programme. Assuming that the current dismantling rate, 30,000 to 40,000 residential units per year, is maintained, the programme's target of removing 350,000 residential units will be achieved by about 2011. In addition, dismantling of an additional 225,000 residential units is to be supported through 2016, to prevent vacancy rates from increasing again (Beckmann, Meyer et al. 2008).

From the outset, the programme's key aims have included renewal of city centres and viable city districts. Pursuant to a programme evaluation, as of the end of 2007 the Federal Government and the Länder had provided a total of some EUR 950 million for dismantling and nearly EUR 870 million for renewal measures. Currently, the programme is scheduled to run from 2002 to 2009, and it calls for use of some EUR 1.1 million of federal programme funding. With that funding, along with additional funding from Länder and municipalities, the programme's total funding resources amount to about EUR 2.5 billion.

The average annual support provided under the programme amounts to about EUR 300 million. In calculations, it is assumed that half of that funding will go toward dismantling measures and half will be allocated to renewal/upgrade measures. In addition, in calculations current funding levels are assumed to continue until 2020.

In estimation of the applicable CO_2 reductions resulting from energy efficiency optimisations to existing buildings, it is assumed that support will be provided each year for some 2,000 residential units, with a total annual financial volume of about EUR 50 million. Assuming that urban residential units have average floor space of 70 m², and that specific CO_2 reductions amount to 40 kg/m² (by analogy to the CO_2 Building Rehabilitation Programme, which has been suitably studied), reductions through 2020 would amount to 0.1 million t CO_2.

Support for social housing: For the public sector, support for social housing is an important housing-policy instrument. The purpose of such support is to make housing available especially for households that cannot afford suitable housing. Pursuant to the Housing Allowance Act (Wohnraumförderungsgesetz; WoFG), the focuses of relevant support include modernising existing housing. By analogy to the modernisation concept used by the German Civil Code (BGB), in the present context modernisation comprises structural measures that enhance utility value in a lasting way, that improve general living conditions and that provide lasting energy and water savings (WoFG 2006). The Act for Amendment of the German Basic Law (Gesetz zur Änderung des Grundgesetzes (GG)) of 1 September 2006 (Federalism Reform I 2006) revises Art. 74 (1) No 18 GG and places promotion of social housing within the exclusive legislative competence of the Länder (Act on the disentanglement of joint tasks and financial assistance (Disentanglement Act; EntflechtG 2006). This shift of task responsibility is designed to take account of the great regional differences seen in development of housing requirements. In 2006, the Federal Government provided a final package of financial aid, amounting to EUR 202.4 million, for investments to promote social housing. Upon termination of federal funding for housing promotion, the Länder will receive annual compensation of EUR 518.2 million from the federal budget, for the period 2007 to 2013, in order to perform such tasks. That funding, which is more than double the financial assistance that the Länder would have received in the coming years under previous financial planning, also meets the financing requirements for relevant obligations the Federal Government entered into through 2006. After 2013, the need and suitability of such payments, with regard to fulfillment of the tasks of the Länder, will be reviewed (EntflechtG 2006).

Market Incentive Programme: The Market Incentive Programme (MAP) focuses especially on promoting use of renewable energies for heat production. The programme is aimed at facilitating broad-based market introduction of renewable-energy technologies for heat production, as well as at triggering relevant cost reductions and technological development. The Market Incentive Programme, which was launched in 1999, helps enhance heating resources in the building sector by supporting installation of solar-thermal systems and both small and large biomass systems. Since 2008, the programme has also provided financial support for installation of heat pumps in buildings. The MAP is managed by the Federal Office of Economics and Export Control (BAFA) and KfW (Kreditanstalt für Wiederaufbau).

From the time it was launched until the end of 2007, the programme has provided some EUR 1 billion of support, thereby triggering investments amounting to EUR 8.2 billion. In 2006 and 2007, the programme provided support for investments totalling EUR 1.5 billion and EUR 1.7 billion, respectively. In 2008, total funding support was

increased to up to EUR 350 million. As of 2009, funding support is to grow to EUR 500 million (per year).

Solar-thermal systems: The MAP provides support for systems with flat, vacuum or air collectors. In terms of the collector area installed to date, air collectors play a subordinate role in comparison to the other collector types. Some 90 % of all relevant installed systems use flat collectors. The installed solar thermal systems are used for water heating and/or heating-system support. Data from programme evaluation indicate that in 2006 and 2007 1.1 and 1.2 million m^2, respectively, of collector area were installed (ZSW/ISI 2004; ZSW/TFZ 2006; ZSW 2007; ZSW 2008).

The efficiency of an entire solar-energy system, including pathways to points of consumption and thermal losses, which all system components incur, is referred to as the system's "system efficiency". The system efficiency of an average flat-collector system is about 35 %. The corresponding figure for vacuum-collector systems is about 45 %.

Under Germany's specific climatic conditions, the average solar radiation may be assumed to be about 1,000 kWh/m². For calculation of the applicable emissions reductions, data of (EWI/Prognos 2006) for the average efficiency levels of conventional water-heating systems, and of existing fuel structures, have been used.

Furthermore, in calculations it was assumed that, pursuant to (ZSW 2007; ZSW 2008), 90.0 % of all collector systems have areas of no more than 20 m^2. In keeping with that assumption, commercially installed collector systems are assumed to account for 10 % of all collector area, and refurbishment of existing systems is assumed to apply to 5 % of the area in question. For these two percentage shares, no CO_2 reductions in the housing sector are applied.

In light of the MAP programme's increasing funding-support volumes, the calculations also take account of increases in pertinent investment volumes. If the programme is assumed to continue until 2020 with the parameters it had in 2007, the relevant emissions reductions could amount to about 1.7 million t CO_2.

Table 33: Emissions reductions via solar-energy systems, 2006 to 2020

		2006	2007	2008	2010	2020
Annual investment volume	Millions of EUR	825	1.020	1.261	1.559	1.559
Installed collector area	1,000s of m^2	1.140	1.220	1.306	1.397	1.480
Annual CO_2 reduction	Millions of t	0,11	0,11	0,11	0,11	0,11
Cumulative CO_2 reduction	Millions of t	0,11	0,23	0,34	0,56	1,66

Sources: ZSW/ISI 2004; ZSW/TFZ 2006; ZSW 2007; ZSW 2008; calculations of the Jülich Research Centre, IEF-STE

Biomass systems: In support for energy generation from biomass, the MAP differentiates between systems with less than 100 kW output and those with more than 100 kW output. Small biomass systems are supported via subsidies from the Federal Office of Economics and Export Control, while large systems are supported via low-interest loans from KfW. From the programme's inception until the end of 2006, the programme has provided financial grants for installation of over 95,300 small biomass boilers. The investments triggered as a result, for small biomass systems, have amounted to EUR 1.5 billion[28]. Over 95 % of the pertinent applications for small systems are submitted by private households, while commercial applicants predominate in the area of large systems.

From 2004 to 2007, support for installation of small biomass systems led to installation of systems with total output of 2.6 GW. The numbers of applications submitted annually vary – also as a result of variances in funding rates – between levels representing 15,000 to 40,000 systems. A breakdown by performance classes shows that, on average, 48 % of all applications were submitted for the system groups "up to 20 kW" and "21 to 50 kW", while an additional 4 % were submitted for the group "51 to 100 kW". In 2006, a total of 1 GW of new thermal output was installed. Of that figure, 46 % correlates with manually fed wood-chip furnaces, while 44 % correlates with pellet furnaces. Some 10 % of all relevant installed output is produced by systems that burn cord firewood.

The relevant supplied energy is calculated from the number of supported systems in the housing sector, the average output per system and the average lifetime per system. The resulting CO_2 reduction is obtained by combining those figures with structural data for the substituted fuels.

From 2004 to 2006, the annual investments triggered by the support programme varied between EUR 199 and 658 million. With continuation of the programme, providing annual added installed output of 1 GW, reductions of 2.7 million t CO_2 could be achieved by 2020.

[28] BMU 2007 a

Table 34: Emissions reductions via biomass systems

		2006	2007	2008	2010	2020
Annual investment volume	Millions of EUR	658		350	500	500
Installed output	MW	1.000	454	700	1.000	1.000
Annual CO_2 reduction	Millions of t	0,21	0,09	0,14	0,19	0,19
Cumulative CO_2 reduction	Millions of t	0,21	0,30	0,43	0,82	2,74

Sources: ZSW/ISI 2004; ZSW/TFZ 2006; ZSW 2007; ZSW 2008; calculations of the Jülich Research Centre, IEF-STE

Heat pumps: Since early 2008, efficient heat-pump systems are also eligible for support from the Market Incentive Programme (cf. Table 36). The amounts of available support depend on the heat-pump system in question, the type of building in question and the building's floor space. For buildings with up to two residential units, support levels depend on buildings' living space. For buildings with more than two residential units, or for non-residential buildings, support is calculated on the basis of the net investment for the heat pump (10 % for new buildings and 15 % for existing buildings). Support is also available for combinations involving a heat pump and a solar-energy system. Additional support, amounting to 50 % above the basic support level, is available for particularly efficient heat pumps, on an innovation-promotion basis. To be eligible, heat-pump systems have to achieve the annual performance coefficients specified in No 9 of the support guideline (BMU 2007b). For electrically driven heat pumps, the annual performance coefficient is calculated by dividing the pertinent heat output by the pertinent electrical input. The pertinent electrical input includes that for operation of peripheral consuming devices, such as a groundwater pump. Pursuant to the VDI 4650 standard, the required COP value (ratio of thermal output (kW) to consumed pertinent electrical drive power, including auxiliary energy, under test conditions) is to be determined by analogy to DIN EN 255 and DIN EN 14511. In the process, the heating flow temperature is 55 °C and the boundary heating temperature is 15 °C.

Table 35: Basic support for heat pumps as of 2008

	Existing buildings Basic support	New buildings Basic support	Existing buildings Basic support	New buildings Basic support	Existing buildings Annual COP	New buildings Annual COP
	€/m²	€/m²	€ max.	€ max.	min.	min.
Air/water	10	5	1.500	850	3,3	3,5
Water/water	20	10	3.000	2.000	3,7	4,0
Brine/water	20	10	3.000	2.000	3,7	4,0

Source: BMU 2007a

According to the Federal Office of Economics and Export Control, between 30,000 and 50,000 applications were expected, in this MAP framework, in 2008 (BAFA 2008). In the calculations, some 30,000 applications for residential buildings were assumed for 2008, and some 40,000 applications were assumed as of 2009. About half of all applications are for systems in new buildings. For estimation of the savings in new buildings, in calculations the relevant residential buildings are assumed to have an average floor space of 140 square meters, since over 80 % of all new residential buildings are single-family homes. Existing buildings are assumed to have average living space of 86 m^2 per residential unit. The relevant emissions reductions could amount to 0.4 million t CO_2 by 2020.

Table 36: Emissions reductions via heat pumps

		2008	2009	2010	2020
Annual investment volume	Millions of EUR	300	400	400	400
Support volume	Millions of EUR	55	73	73	73
Annual CO_2 reduction	Millions of t	0,04	0,03	0,03	0,03
Cumulative CO_2 reduction	Millions of t	0,04	0,07	0,10	0,39

Sources: BMU 2007, BAFA 2008, BWP 2008; calculations of the Jülich Research Centre, IEF-STE

In summary, calculations indicate that the MAP programme could lead to emissions reductions totalling 4.2 million t CO_2 by 2020.

Promotion of energy consulting (on-site consulting): On-site consulting with regard to thrifty, efficient energy use in residential buildings is an important tool for outlining needed energy-related investments in the building sector. The demand for energy-related consultations within the Federal Ministry of Economics and Technology (BMWi) support programme "On-site energy-related consulting in residential buildings" ("Energieberatung in Wohngebäuden vor Ort") has grown considerably since 1998, when 1,034 consultations per year were carried out. The highest annual number of energy-related consultations to date was reached in 2006, when over 22,000 consultations were carried out. In 2007, 15,800 consultations were carried out. From 2006 to 2008, EUR 500,000 from the Building Rehabilitation Programme were provided annually for support of on-site consulting. On-site consultations are eligible for support if they focus comprehensively on structural thermal insulation, heat production and distribution (including water heating) and use of renewable energies. Pursuant to the applicable support guideline of May 2008, the subsidy for an on-site consultation with regard to a single-family or semi-detached house amounts to EUR 300, while the consultation subsidy with regard to a residential building with more than two residential units is EUR 360. The subsidy for a separate thermographic report is EUR 150, and no more than 50 % of the relevant costs (VOB 2008). By analogy to the evaluation carried out by (Ifeu/TNS-Emnid 2008), the subsidy rate for one-family and semi-detached houses is assumed to be about 50 %, while for apartment buildings it is assumed to be 40 %. Under the aforementioned guideline, a lower subsidy rate of 25 % applied, during the period from September 2006 to April 2008, for all residential buildings. In 2007 in particular,

that lower rate contributed to a decrease in the numbers of energy-related consultations carried out.

The estimated expenditures for the programme amounted to EUR 3.7 million in 2005 (for about 12,000 consultations), while in 2006 they were EUR 6.0 million (22,300 consultations) and in 2007 they were EUR 3.1 million (15,800 consultations).

Not all proposals provided in consultations are actually implemented. A survey conducted by the Federal Office of Economics and Export Control (BAFA 2000) found, for example, that 64 % of all persons surveyed felt that their consultation had strongly influenced their decision to carry out investments oriented to energy efficiency. Pursuant to a programme analysis carried out by Ifeu/TNS-Emnid (2008), persons receiving consultations in 2005 implemented relevant proposals at the following rates:

- (Proposals related to) heating systems 80 %
- Thermal insulation 74 %
- Windows 60 %
- Average 70 %.

The following estimate of CO_2 reductions is based on the more optimistic value, 70 %.

In the calculations, it has been assumed that consultations are carried out throughout a representative sample (i.e. a "cross-cutting" sample) of all existing buildings. In addition, a mean heated living space of 200 m² is assumed, for the entirety of all existing buildings, as a result of evaluation of on-site consultations. In keeping with procedures for the Federal Government's KfW promotional programmes, the resulting reductions per square metre, 40 kg CO_2, are credited to this programme. In this light, the 12,000 consultations carried out in 2005 would lead to annual reductions of about 0.07 million t CO_2. For 2006, the estimated reductions amount to nearly 0.13 million t, while for 2007 they amount to 0.09 million t CO_2.

For the programme's continuation through 2020, a total of 15,000 energy-related consultations are assumed to be carried out annually, providing a cumulative gross reduction of about 2.15 million t CO_2 through 2020.

Many persons who receive consultation make use of financial support for their resulting modernisations. As a result, there is some overlapping with the calculated savings resulting via support measures. The percentage share allotted to support, in keeping with Hansen & Kleemann (2005), is set at 62 %. The net CO_2-reduction effects resulting from on-site energy-related consultations, as shown in Table 37, could amount to 0.5 million t CO_2 for the period 2006 to 2020.

Table 37: On-site energy-related consultations, and CO_2-emissions reductions

		2006	2007	2008	2010	2020
Support volume	Millions of EUR	6,0	3,1	4,7	4,7	4,7
Consultations	Number	22.327	15.810	15.000	15.000	15.000
CO_2 reduction	Millions of t	0,13	0,21	0,30	0,47	1,31
Non-overlapping CO_2 reduction	Millions of t	0,05	0,08	0,11	0,18	0,50

Sources: German Bundestag 2008; calculations of the Jülich Research Centre, IEF-STE

Energy Saving Ordinance (Energieeinsparverordnung – EnEV)

EnEV 2002/2004

The Energy Saving Ordinance (Energieeinsparverordnung), which supplanted the "Ordinance on Heat Protection" (Wärmeschutzverordnung; WSchV95) and the Ordinance on Heating Systems (Heizungsanlagenverordnung; HeizAnlV) in 2002, takes a combined view of building services and all related equipment.

In the Energy Saving Ordinance (Energieeinsparverordnung) 2002, requirements with regard to annual primary energy requirements in new buildings were formulated as a function of the ratio A/V_e. New buildings' annual primary energy requirements were to be calculated ("proof procedure") on the basis of the standards DIN V 4108-6 and DIN V 4701-10. Pursuant to the official reasons for the Energy Saving Ordinance (EnEV 2002, Bundesratsdrucksache (Bundesrat printed document) 194/01, p. 35/36), the ordinance tightened requirements for new buildings by an average of about 30 % in comparison to pertinent requirements under the WSchV95. The ordinance also introduced an "energy requirements certificate" (Energiebedarfsausweis) for the purpose of recording calculation results.

For existing buildings, the Energy Saving Ordinance 2002 imposed maximum permissible heat-transfer coefficients in connection with structural measures, as well as individual requirements for heating and water-heating systems. The standards for maximum U values for new and modified parts of skins of existing buildings were tightened in part, over those imposed by the WSchV95, by 10 to 15 %.

EnEV 2007

An amended version of the Energy Saving Ordinance, the EnEV 2007, which transposed the EC Directive on the Energy Performance of Buildings, mandated the gradual phasing-in of energy requirements certificates for all residential buildings (and for non-residential buildings) in connection with building sales or rentals. Since January 2009, such certificates have been required for all residential buildings; since July 2009, they have also been required for non-residential buildings. This amendment of the Ordinance did not tighten requirements pertaining to primary energy requirements and to applicable U values.

EnEV 2009

This amendment of the Energy Saving Ordinance (EnEV 2009), which entered into force on 1 October 2009, implements the following changes:

In the interest of enhancing energy efficiency, while remaining within reasonable economic limits, the Ordinance tightens requirements pertaining to annual primary energy requirements and maximum permissible U values, for new buildings and in connection with significant changes to existing buildings, by an average of 30 %. For existing buildings, the Ordinance mandates conformance with component requirements in connection with all modernisations that cover more than 10 % of a component's area.

- Under the EnEV 2009, the "reference building procedure" for obtaining annual primary energy requirements is also required for residential buildings. That procedure had been introduced by the EnEV 2007 for non-residential buildings. For any given building, the applicable requirements are determined individually, on the basis of a reference building with the same geometry, orientation and floor space, as well as with standardised components and building services systems. The reference building's building services systems reflect requirements under the Act on the Promotion of Renewable Energies in the Heat Sector (Erneuerbare-Energien-Wärmegesetz) in that they include solar water heating in energy accounting.
- This ordinance introduces a new calculation procedure for residential buildings, which is based on the DIN V 18599 standard and which may be used as an alternative to the existing procedure for energy accounting. The ordinance also expands individual requirements for insulation retrofits by specifying requirements pertaining to insulation quality. It also extends insulation requirements to include walkable – and previously non-insulated – top-floor ceilings. Previous such requirements called only for insulation of non-insulated top-floor ceilings that were accessible but non-walkable.
- Electric storage heating systems may no longer be operated in residential buildings with more than 5 residential units if they are the only source of space heat in such buildings. If installed prior to 1990, such heating systems must be decommissioned by the end of 2019. Electric storage heating systems installed after 1990 may not be operated after the end of a 30-year operation period. The same rules apply for non-residential buildings with floor space of at least 500 m^2.
- In the interest of improving enforcement of the EnEV, the latest version of the ordinance tightens private parties' obligations to provide proof – for example, entrepreneurs' obligations to provide pertinent declarations. The ordinance also assigns to district chimney sweeps the task of carrying out testing of heating systems (for example, in connection with decommissioning of boilers, addition of thermal insulation to heating systems).

Table 38 provides a comparison of U values in requirements pertaining to various components in connection with energy-efficiency-oriented modernisations of existing buildings.

Table 38: Comparison of maximum permissible heat transfer coefficients

WSVo		**EnEV 2002-2007**		**EnEV 2009**	
Component	**W/m²K**	**Component**	**W/m²K**	**Component**	**W/m²K**
Exterior walls	0,50 / 0,40	Exterior walls, in general	0,45 / 0,35	Exterior walls	0,24
Windows, window doors and roof windows	1,8	Windows, window doors, windows in roof areas	1,7	Windows, window doors	1,3
				Roof windows	1,4
Roofs and ceilings, with respect to outside air	0,30	Roofs, ceilings and sloping roofs, with respect to outside air	0,30	Roofs, ceilings and sloping roofs, with respect to outside air	0,24
		Flat roofs, with respect to outside air	0,25	Flat roofs, with respect to outside air	0,20
Cellar floors, walls and ceilings, with respect to unheated rooms or surrounding soil	0,50	Walls and ceilings, with respect to unheated rooms or surrounding soil	0,40 / 0,50	Walls and ceilings, with respect to unheated rooms or surrounding soil	0,30

Sources: Hansen & Kleemann 2005; EnEV 2009

For the current EnEV, relevant reductions are calculated with respect to the level mandated by the WSchV95. As of July 2009, the difference between the EnEV 2007 standard and the EnEV 2009 standard is used. The resulting cumulative reduction could amount to 3.7 million t CO_2 for the period 2006 to 2020.

Table 39: CO_2 reductions via the EnEV

CO_2 emissions		2006	2007	2009	2010	2020
Reductions in new buildings	Millions of t	0,00	0,00	0,10	0,29	1,92
Reduction in existing buildings	Millions of t	0,00	0,00	0,07	0,20	1,77
Total additional reductions	Millions of t	0,00	0,00	0,17	0,50	3,68

Source: Calculations of the Jülich Research Centre, IEF-STE

Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG): With the EEWärmeG (approved 2008), the Federal Government is seeking to increase renewable energies' share of the required heat supply from 6.6 % in 2007 to 14 % in 2020. The Act requires owners of new buildings, as of 2009, to meet specific percentages of their heat-energy requirements via renewable energies.

Under the Act, the requirement for use of renewable energies is deemed fulfilled if solar-thermal systems meet 15 % of a relevant building's heat requirements, or if systems using solid or liquid biomass, geothermal energy or environmental heat meet 50 % of the building's heat requirements. Where the heating system uses gaseous

biomass, that system must meet at least 30 % of the building's heat requirements. Requirements also apply with regard to the size of systems using solar radiation energy; such systems must have a collector area of at least 3 m^2 per 100 m^2 of the relevant building's floor space.

Owners may also fulfill their obligations in this area by means of alternative measures. For example, owners may rely on waste heat or highly efficient CHP systems, if such heat or systems meet at least 50 % of their buildings' heat energy requirements; or they may take measures to have their buildings' annual primary energy requirements be at least 15 % lower than the pertinent level imposed by the applicable EnEV. In addition, all building owners who rely on local or district heating networks for their heat supply are exempted from the requirements. The Act also permits combinations of individual renewable energies and substitute measures.

The EEWärmeG does not require use of renewable energies for existing residential buildings. For such buildings, use of renewable energies is to be promoted via an enlarged Market Incentive Programme. To provide the necessary investment incentives, the Federal Government plans to increase the relevant support funding to EUR 500 million per year in the period 2009 to 2012.

For calculation of the reductions achieved via the EEWärmeG, only the new living space constructed in the period 2009 to 2020 is used. Taking account of the current fuel / energy source structures in the area of new buildings – which in 2006 showed renewable energies with a share of about 10 % and district heating with a share of 9 % – district heating's share is assumed to grow to 10.5 % in this area by 2020, while renewable energies' share is assumed to grow to 27 % by that year. The resulting reductions could reach about 1.5 million t CO_2 by 2020 (cf. Table 40)

Table 40: *Reductions in the area of new buildings, via the EEWärmeG*

		2006	2008	2009	2010	2020
Emissions from new buildings	Millions of t	0,75	0,70	0,57	0,45	0,34
Reductions via the EEWärmeG	Millions of t	0,00	0,00	0,17	0,14	0,11
Total reductions	Millions of t	0,00	0,00	0,17	0,31	1,46

Source: Calculations of the Jülich Research Centre, IEF-STE

The EEWärmeG is an overarching measure. Its effects overlap with those of other measures and thus cannot simply be added to the reductions calculated for monetary support measures; that would entail double-counting.

Amendment of the Ordinance on Heating Costs: The amendment of the Ordinance on Heating Costs (Verordnung über Heizkostenabrechnung) entered into force on 1 January 2009. For certain older buildings, it increases consumption-dependent shares of heating costs. In buildings that do not comply with requirements of the Ordinance on Heat Protection (Wärmeschutzverordnung) of 16 August 1994, and that are equipped with oil-fired or gas-fired heating systems, in general, 70 % of the costs of operation of a central heating system are to be distributed in keeping with the measured heat consumption of relevant heat users. That provision of the ordinance applies for buildings in which the majority of exposed heat-distribution lines

are insulated. The provision's purpose is to provide incentives for users to be more thrifty in their usage. The ordinance also exempts so-called "passive houses" from consumption-measurement obligations, in order to provide incentives for compliance with the "passive house" standard in construction of buildings and in modernisation of apartment buildings.

Table 41: *Estimation of CO_2 reductions resulting via "saver" usage patterns, in comparison to standard usage patterns, through 2020*

CO_2 emissions		2006	2008	2009	2010	2020
Annual emissions reductions	Millions of t	0,00	0,00	0,02	0,02	0,02
Total reductions	Millions of t	0,00	0,00	0,02	0,03	0,23

Sources: Richter, Bolsius et al. 2008; own calculations of Jülich Research Centre, IEF-STE

German Energy Agency (Deutsche Energie Agentur – dena): The German Energy Agency (dena), a nation-wide centre of excellence for energy efficiency, has been in operation since September 2000. It develops relevant projects, programmes and campaigns, and it provides impetus for use of forward-looking technologies and services. Via co-operation and topic-oriented networks, it also brings societal stakeholders in the energy sector together. Its current central projects include efforts related to heat from renewable energies, energy performance certificates for buildings and the "Future House" ("Zukunft Haus") and "Efficient Homes " ("Niedrigenergiehaus im Bestand") projects.

Its information campaigns "Heat from Renewable Energies" and "Future House" inform builders and owners about energy-efficient construction and modernisation and provide relevant practical advice. The organisation also engages in intensive public relations efforts, throughout a wide spectrum of media, and it aims specific information directly at architects, technical planners, crafts companies and end users.

A current project, "dena seal of quality for energy performance certificates", is aimed at establishing a quality assurance system for energy performance certificates, on the basis of common quality standards for certificate issuers. In the interest of quality, only requirements-based certificates are eligible for the seal of quality. Furthermore, a controlled quality standard is to be achieved via automated data checking and spot checks of certificate issuers.

dena, with support from the Federal Ministry of Transport, Building and Urban Affairs (BMVBS), has developed the model project "Efficient Homes " ("Niedrigenergiehaus im Bestand"), a project for both residential and non-residential buildings. This project is aimed at using best-practice projects to establish forward-looking standards, in the market, for modernisations oriented to energy efficiency.

The additional reduction effects that dena model projects trigger in other projects cannot be quantified in their entirety.

Additional "soft" measures: Other relevant "soft" measures, apart from the activities of dena, include provision of information and encouragement, training and quality campaigns, R&D in the building and heating-system sectors and replacement of defective components. In light of the manner in which relevant measures are

defined, such measures' potential reductions cannot be separately quantified at present.

4.5.3 Electricity consumption of private households

4.5.3.1 Framework data

The key framework data governing electricity requirements of private households include demographic trends and trends in structure of private households. The relevant assumptions are comprehensively described in Section 6.3.1.

4.5.3.2 Measures under the "with-measures" scenario

Electrical appliances and electronic devices represent the second-most important area of energy consumption – after the area of space heating and water heating – in the household sector. In this area, in contrast to that of space heating, a major part of the already implemented measures for enhancing energy efficiency and reducing CO_2 emissions have originated at the EU level. This applies especially to the two measures that must be considered the main factors driving energy-efficiency improvements in large electrical household appliances: **the Energy Consumption Labelling Ordinance (Energieverbrauchskennzeichnungsverordnung - EnVKV) and the Ordinance on Maximum Energy Consumption (Energieverbrauchshöchstwerteverordnung – EnVHV).**

Both ordinances entered into force in Germany at the end of the 1990s, i.e. prior to the basic time period, as defined in the present context, for the "with-measures" scenario (2000 to the end of 2007). Since during that period the pertinent labelling requirements have been tightened, and labelling requirements have been extended to additional device groups[29], these measures have to be taken into account in the "with-measures" scenario, however.

Voluntary product labelling and **voluntary commitments:** Such efforts – which have originated primarily at the EU level – are currently of relevance especially for consumer-electronics and office-electronics devices. They include the following:

- Voluntarily applied labels, such as Energy Star, GEEA Label, Blauer Engel ("blue angel"), EU Ecolabel, Energy+.
- Negotiated agreement, dating from 2000, between the EU Commission and EACEM on standby losses from audio devices.
- Code of Conduct, dating from 2000, on the energy efficiency of external power supplies.
- Code of Conduct, dating from 2003, on the energy efficiency of digital TV systems (Version 2).
- Industry Self-Commitment to Improve the Energy performance of Household Consumer Electronic Products sold in the EU, dating from 2003.

Such measures' influence on the electricity consumption of household appliances and devices is difficult to quantify, however, since it is virtually impossible to separate

[29] The EnVKV currently covers the following device groups: household refrigerators and freezers, washing machines, dryers, dishwashers, certain types of lights and fluorescent lamps, electric ovens and room air conditioners.

the measures' impacts from general progress in the energy sector. Such measures are thus best characterised as "soft" measures. The same applies to the various **information and consultation programmes and campaigns oriented to the energy efficiency** of electrical devices, and to reduction of stand-by losses, that have been carried out by various institutions (energy agencies, consumer advice centres, municipal utilities, etc.). Such efforts include the " Initiative EnergieEffizienz " ("Energy Efficiency Initiative"), launched in October 2003, which is being carried out by the German Energy Agency (dena) in co-operation with energy-sector companies.

4.5.4 Industry and commerce-trade-services; electricity and process heat / steam

4.5.4.1 Measures under the "with-measures" scenario

In modelling of energy consumption and CO_2 emissions in the industry and commerce-trade-services sectors, the following measures are taken into account in the **"with-measures" scenario**:

Introduction of the EU Emission Trading Scheme in the industry sector: Emission trading has been applied solely to energy-intensive sectors, including especially iron and steel production, cement production and glass and paper production.

KfW programmes for promoting energy efficiency in industry and in commerce-trade-services: KfW Environmental Programme, ERP Energy Efficiency Programme, ERP Environmental and Energy Efficiency Programme, BMU Programme for Promotion of Demonstration Projects (does not apply to buildings). In this context, the ERP Energy Efficiency Programme deserves special mention. Initiated in conjunction with the "Special Fund for Energy Efficiency in SMEs", which is described in Point 4, since 2008 it has awarded low-interest loans to small and medium-sized enterprises (SMEs) for energy-efficiency investments. For SMUs, the Energy Efficiency Programme functions as a substitute for the ERP Environmental and Energy Efficiency Programme. Both instruments function primarily via low-interest loans for investments (cf. also KfW Förderbank (promotional bank) 2008a).

"InitiativeEnergieeffizienz": This includes both the German Energy Agency's (dena's) "Initiative Energieeffizienz" ("Energy Efficiency Initiative"), which in 2005 was expanded to include the industry and commerce-trade-services sectors, and additional dena information campaigns. In the commerce-trade-services sector, the initiative "Energy Efficiency in the Services Sector" ("Energieeffizienz im Dienstleistungssektor") is worthy of special mention. It provides comprehensive information on ways of enhancing energy efficiency in office environments. Along with energy-efficient IT systems, that effort focuses especially on ventilation, air conditioning and lighting in office buildings. In the area of industry, the initiative "Energy Efficiency in Industry and Trade" ("Energieeffizienz in Industrie und Gewerbe") is worthy of special mention. That effort provides information with the aim of improving energy efficiency in cross-cutting technology areas such as pump systems, compressed-air systems, refrigeration and ventilation (cf. also dena 2008).

Voluntary labelling for office equipment; in particular, the EU's "Energy Star" programme: In Europe, the "Energy Star" programme, which originated in the U.S., currently covers the areas of computers, monitors, fax machines, printers, scanners, copiers and multi-function devices. The programme, which does not divide devices

into efficiency classes, awards the "Energy Star" label to all devices that fulfill defined minimum standards.

Special Fund for Energy Efficiency in SMEs: The *"Special Fund for Energy Efficiency in SME"* was initiated by the Federal Ministry of Economics and Technology (BMWi) and KfW at the end of 2007 (BMWi 2007; KfW 2007) and commenced operating in early 2008. Aimed at small and medium-sized enterprises (SMEs), it is designed to provide incentives for investments oriented to energy efficiency. The Special Fund consists of two coupled instruments. Firstly, it supports energy-efficiency consultations in companies, i.e. consultations in which qualified experts identify potential for saving energy. In each case, such support provides fee subsidies for both a short initial consultation and a more comprehensive detailed consultation. Secondly, the Special Fund provides low-interest loans in the framework of the "ERP Energy Efficiency Programme" (cf. also KfW Förderbank 2008a).

Procurement of energy-efficient products and services in the federal sector (Bundesanzeiger (Federal Gazette) 2008): The effects of this measure are taken into account in the "with-measures" scenario. The measure, which entered into force in January 2008, in the framework of an administrative regulation, includes a catalogue of procurement guidelines.

4.5.5 Fugitive emissions of energy sectors

A significant share of fugitive CH_4 emissions from the energy sector originate in hard-coal mining. The so-called "coal-policy understanding" ("kohlepolitische Verständigung") of 7 February 2007 includes a range of agreements relative to phasing-out of German hard-coal mining. The following points from those agreements are significant with regard to development of German greenhouse-gas emissions[30]:

- Reduction of German hard-coal production to 12 million t in 2012;
- Probable termination of German hard-coal mining by 2018;
- Review of the agreement on termination of hard-coal mining in Germany on the basis of a report to be provided in 2012.

In light of this understanding, the "with-measures" scenario works from the assumptions that German hard-coal production will decrease to 12 million tonnes/year in 2012 and will terminate completely in 2018, developments that will affect trends for fugitive CH_4 emissions from the active hard-coal mining sector.

4.5.6 Industrial processes and product use

4.5.6.1 CH4 and N2O emissions from industrial processes

The area of industrial processes that produce CH_4 and N_2O emissions comprises two different source categories:

- Process-related CO_2 emissions that depend largely on the relevant chemical and technical processes and for which no waste-management technologies

[30] Key points of a coal-policy understanding between the Federal Government, the states of North Rhine – Westphalia (NRW) and the Saarland, RAG AG and the Mining, Chemical and Energy Industrial Union (IGBCE); 7 February 2007.

are (yet) available (such as CO_2 capture and storage). These emissions can be changed only via use of substitutes or via changes in production levels.

- Process-related greenhouse-gas emissions that can be reduced via suitable reduction technologies.

The second of these categories includes only two chemical-industry processes that cause significant greenhouse-gas emissions and thus require analysis in the following section:

- Adipic acid production, and its relevant N_2O emissions;
- Nitric acid production, and its relevant N_2O emissions.

Inclusion within the EU-ETS: As of 2013, both production processes are subject to the EU Emission Trading Scheme. As of 2013, therefore, a price for greenhouse-gas emissions must be taken into account as an additional production factor. In addition, the benchmark for new installations that the EU ETS will define will provide incentives for N_2O reductions in new installations.

Amendment of the Technical Instructions on Air Quality Control (TA Luft): For a transition period lasting until 2013, it must also be taken into account that the amended Technical Instructions on Air Quality Control (TA Luft 2002) impose an emissions standard of 800 mg N_2O/m^3 as of 2010.

Both such inclusion within the EU ETS and the amendment of the TA Luft must be taken into account in the "with-measures" scenario.

4.5.6.2 Emissions from production and use of PFCs, HFCs and SF_6

"With measures" scenario

In the "with-measures" scenario, the following measures are taken into account in the area of the fluorinated greenhouse gases PFCs, HFCs and SF_6:

Measures to reduce emissions of PFCs, HFCs and SF_6

- Obligations to service stationary refrigeration systems and check their leaktightness
- Establishment of standards for maximum rates of leakage from stationary refrigeration systems (Meseberg resolution No 23)
- Reduction of fluorinated greenhouse gases in semiconductor production
- Self-commitment of the German primary aluminium industry
- Ban on use of synthetic greenhouse gases (in new types of aerosols, disposable containers, automobile tyres, shoes)

Measures for reduction of HFC emissions

- Promotion of substitution of HFCs in commercial refrigeration systems (about 30% of newly built refrigeration systems in the food-retailing sector per year; about 540 systems per year)
- Substitution of HFCs with refrigerants with GWPs of less than 150, and improvement of leaktightness of mobile air conditioning systems, for selected vehicle classes

- Substitution of HFCs, with refrigerants with GWPs considerably below 150, in mobile air conditioning systems
- Extensive substitution of HFCs in use as blowing agents in PU installation foams

Measures for reduction of SF_6 emissions

- Substitution of SF_6 in its use as a protective gas in large magnesium-production sites
- In soundproof windows for residential buildings, substitution of SF_6 (as an insulating gas) via changes in window designs
- Self-commitment on the part of German producers and users of switchgear, and of SF_6 producers, to take measures to limit SF_6 emissions from electrical operating equipment

4.5.7 Agriculture[31]

Policies for the agricultural sector are decided largely at the EU level, in the framework of the Common Agricultural Policy (CAP). While to date the CAP does not contain specific measures and instruments for reducing greenhouse-gas emissions, reform of the CAP is promoting measures that will help reduce such emissions. Such measures especially include promotion of organic farming and agricultural environmental measures aimed at encouraging extensivication, smaller animal populations and smaller amounts of nitrogen fertiliser. The CAP "Health Check", introduced in 2008, provides a means for promoting measures for combatting climate change. In general, the impacts of such measures are difficult to assess, as a result of the sector's complexity and the many sources of fugitive emissions involved. In the framework of the present report, therefore, relevant projections are confined to a "with-measures" scenario.

Along with key assumptions, precise description of bioenergy policies plays an increasingly important role in such projections. An analysis of production and price projections for world agricultural markets, carried out by the Food and Agricultural Policy Research Institute (FAPRI) of Iowa State University, OECD/FAO and the EU Commission, has found that major uncertainties apply with regard to future production quantitites and prices, as a result of reductions of stocks, linkage between agricultural prices and energy prices and – not least – uncertainties regarding the impacts of state bioenergy policies.[32] At the same time, such factors have impacts

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[31] Osterburg, Bernhard and Dämmgen, Ulrich (2009) Annahmen für die Prognose der Gasemissionen aus der deutschen Landwirtschaft im Jahr 2010, 2015 und 2020. In: Landbauforschung Sonderheft 324A, p. 397-410.

Ledebur O von, Elmahdi K, Wagner S (2007): Market Impact Analysis of Biofuel Policy Implementation. SPECIFIC TARGETED RESEARCH PROJECT n°SSPE-CT-2004-503604 "Impact of Environmental Agreements on the CAP". Document number: MEACAP WP6 D16b.

Osterburg B, Nitsch H, Laggner A, Wagner S (2008): Analysis of policy instruments for greenhouse gas abatement and compliance with the Convention on Biodiversity. SPECIFIC TARGETED RESEARCH PROJECT n°SSPE-CT-2004-503604 "Impact of Environmental Agreements on the CAP". Document number: MEACAP WP6 D16a.

[32] Osterburg & Dämmgen, 2008

on trends for land use and farm-animal populations. Additional relevant effects, on agricultural markets, have already been observed. Explorative analyses carried out in the framework of the EU project MEACAP (cf. Ledebur et al., 2007; Osterburg et al., 2007) point to higher prices and increasing opportunity costs for cropland use – effects leading, in part, to grassland conversion and production intensivication. Still other impacts include increasing competitive pressures in animal husbandry, and substitution of protein-rich feeds for energy-rich feeds, leading to higher nitrogen excretions (cf. Osterburg & Dämmgen, 2008).

4.5.8 Waste management

The waste-management sector is an important source category for both CH_4 and N_2O emissions.

The key regulatory framework for waste management consists of the Technical Instructions on Municipal Waste (TA Siedlungsabfall – TASi) and of provisions of the Act for Promoting Closed Substance Cycle Waste Management and Ensuring Environmentally Compatible Waste Disposal (KrW-/AbfG), the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements and on Biological Waste-Treatment Facilities (AbfAblV), the Ordinance on Installations for Biological Treatment of Waste (30th Ordinance Implementing the Federal Immission Control Act (BimSchV)), the Amendment of the Ordinance on Incineration and Co-incineration of Waste (17th BImSchV) – provisions which, as of June 2005, largely prohibit landfilling of untreated waste (and, thus, landfilling of organic substances responsible for relevant gas formation) and open the way for other types of waste disposal, such as incineration or mechanical-biological waste treatment (BMU 2006c).

All of the aforementioned measures must be included in the "with-measures" scenario.

4.6 *Climate-policy activities of the Länder and of municipalities*

To be effective in a lasting way, climate protection must involve the active participation of all societal stakeholders. Integration of climate-protection activities needs to be intensified at the international and European levels; on the part of the Federal Government, the Länder and the country's municipalities; and on the part of industry and all other relevant groups of society (environmental and consumer organisations, unions, churches, etc.). Nearly all of Germany's Länder now have their own climate protection programmes, and numerous municipalities and towns are working to implement climate-relevant measures.

Munich, capital of Bavaria, is one of Germany's leaders in the area of climate protection by municipalities. As a member of the Climate Alliance of European Cities / Alianza del Clima e.V., it is working, together with over 1,000 other European municipalities, on reducing emissions of carbon dioxide (CO_2), the most important greenhouse gas. Thanks to numerous activities by the city itself, its municipal companies and organisations and its citizens, Munich has been able to achieve a moderate emissions reduction, even as its population and economy have grown. From 2001 to 2006, the per-capita CO_2 emissions of the city's population decreased by 11 percent, to 7.1 tonnes per year. What is more, the Munich City Council is working toward a resolution calling for a 50 % reduction of CO_2 emissions by 2030. With these efforts, the City of Munich is serving as a model for German and European municipalities.

4.6.1 Länder

The climate-protection activities of Germany's Länder include

- implementing federal and EU regulations and support programmes,
- enacting their own projects, efforts and measures
- carrying out their own support programmes and enacting their own relevant legal provisions.

The following Table, which is based on information provided by the Länder themselves, summarises the key focuses of such efforts.

Table 42: Länder

State (Land)	Programmes/concepts	Selected focus areas
Baden-Württemberg	• The "Climate protection 2010 – concept for Baden-Württemberg" (2005) climate-protection concept • The "Climate-protection Plus" programme for municipalities (new edition, 2009) • The "Challenge of Climate Change" collaborative research project (runs until the end of 2009) • "Climate change and consequences for water management" (KLIWA) • Baden-Württemberg Environmental Plan (2007 - 2012) • Energy Concept 2020 • "Regional energy efficiency tables" • Regional energy agencies • The ECOPlus and ECOfit environmental consultation programmes • The "Future of existing buildings" ("Zukunft Altbau") information campaign • Promotion of participation in the "European Energy Award" • "Energy-saving check"	• Promotional and consultation programmes relative to building modernisation, energy concepts, energy efficiency, renewable energies • Expansion of railway transports • Doubling of renewable energies' share of the energy supply, by 2010 (electricity production and primary energy consumption) • Research projects in the area of efficient energy generation and transformation • Projects for reduction of energy consumption by households, trade and industry • Research projects in the area of consequences of climate change and measures for adaptation to climate change • BW Act on heat production from renewable energies • Implementation of measures for adaptation to climate change • Public awareness and education measures

Bavaria	• Climate-protection concept of the Bavarian State Government (2000, 2003) • Global concept for renewable resources in Bavaria (2003) • Bavarian global concept for energy policy (2004) • "Bavaria 2020" climate programme (2007; scheduled to run: 2008-2011; EUR 350 million in additional funding); • Bavarian promotional programme for "Use of geothermal heat" • "BioEnergy for Bavaria" programme	• Energy-oriented modernisation of state buildings • "BioEnergy for Bavaria" programme • Participation in the "Federal/Länder/Municipal investment pact for energy-oriented modernisation of social infrastructure" • Forest-conversion programme • Protective measures for mountain forests • Adaptation of the "2020 Flood Protection Programme" • New orientation for the Schneefernerhaus environmental research station • Research networks in the areas of adaptation (FORKAST), efficiency improvement, new energy technologies (BayFORETA) and power stations (KW 21, with Baden-Württemberg) • Public awareness efforts in the framework of the Bavarian Climate Alliance • Bavarian Climate Council
Berlin	• Climate-protection work programme from 2008	• Enhancement of energy efficiency • Use of renewable energies • Energy-saving
Brandenburg	• Energy Strategy 2020 (2008) • Catalogue of measures for climate protection and for adaptation to the consequences of climate change (2008)	• Increase of renewable energies' share of primary energy consumption to 20 % by 2020 • Reduction of the state's energy-related CO_2 emissions by 2020 • Promotion of energy research • Adaptation to climate change, with a special focus on water bodies and water cycles • Promotion of relevant communication, information provision and co-operation, on the part of networks, working groups, consultation campaigns, etc.
Bremen	• "Climate protection 2010" action programme • "Climate protection and energy programme 2020" (in preparation)	• Expansion of electricity generation from renewable energies, especially from wind • Expansion local and district heating networks fed by combined heat/power generation (CHP) and waste heat • Energy-oriented modernisation of existing residential buildings • Energy saving and enhanced energy efficiency in public buildings • Enhancement of energy efficiency on the part of companies • Reduction of transport-related CO_2 emissions (especially by expanding local public transportation, promoting use of bicycles, promoting car-sharing) • Information provision, consultation and efforts to enhance public awareness
Hamburg	• Hamburg "Climate-protection concept 2007 – 2012"; reduction of CO_2 emissions by 20% with respect to 1990	• Enhancement of efficiency of buildings, via ambitious construction standards and relevant promotion • Promotion of use of renewable energies • Extensive programmes for improving energy efficiency in industry and trade • Infrastructure improvement in the area of "climate-friendly mobility"

Hesse	• "Hesse 2012" climate-protection concept	• CO_2 avoidance in various areas and sectors • Promotion of Hesse's science sector • CO_2 sequestration
Mecklenburg – West Pomerania	• Climate-protection action plan (extension of a climate-protection concept from 1997) • "Energy Land 2020" • MWP concept for bog protection (an update is expected to be published in June 2009) • "Forest share" ("Waldaktie")	• Guideline for promoting climate protection; some EUR 25 million are available for 2007-2013 • Measures to reduce carbon dioxide emissions • Consultation and efforts to raise public awareness • Support of activities for energy saving / enhancing energy efficiency • Completion of a new technology centre at the "Solarzentrum" solar centre • Establishment of a German-Polish centre of excellence for renewable energies • 2007 state atlas of renewable energies • Energy saving and improvement of energy efficiency • Expansion of use of renewable energies and, thus, development of a future-compatible energy mix • Construction and operation of new, efficient fossil-fired power stations, to ensure that energy prices remain affordable and competitive in the long term • Expansion of electricity and gas networks • Further development of decentralised energy supply systems • Energy and CO_2 balance sheet
Lower Saxony	• Government commission on climate protection • Position paper on climate protection • Sustainability alliance • Structures paper for an adaptation strategy	• Co-operation projects with municipalities • Lower Saxony state initiative for fuel cells • Lower Saxony state initiative for energy-saving • Lower Saxony CO_2 balance sheet (covering a two-year report period) • Public awareness and education measures

North Rhine – Westphalia	• "Energy and Climate Protection Strategy 2008"	• Promotion of market introduction of renewable energies (solar, biomass, hydro, geothermal) and of technologies for improvement of energy efficiency (heat/power cogeneration (CHP), pit-gas use, etc.), via various support programmes and campaigns, including
		  • The support programme "Programme for efficient energy use, renewable energies and energy-saving" (www.progres.nrw.de)
		  • Innovation projects via the "Energy.NRW" competition
		  • Electromobility, via the competition "Mobile future – electromobility in North Rhine – Westphalia"
		  • Market introduction
		  • Energy-oriented consultation
		  • "Wood pellets" campaign (information campaign aimed at promoting use of local, renewable energies for heating);(www.aktion-holzpellets.de)
		  • EnergieAgentur.NRW (energy agency);

Rhineland-Palatinate	• Integrated energy and climate-protection concept for	• Building-oriented energy concept • Programmes for promoting energy-efficient new buildings, existing buildings and passive houses

	Rhineland-Palatinate • 7th energy report, of August 2007, for the period 2002-2004 • 8th energy report, for the period 2005-2007 • "Rhineland-Palatinate 2007" climate report • Establishment of an enquete commission, by the Rhineland-Palatinate state parliament, on the topic "climate change". • Modular expansion of use of renewable energies • "CHP initiative for Rhineland-Palatinate"	• Expansion of use of renewable energies in the electricity sector, with special focuses on wind energy (repowering), photovoltaics, hydroelectric power, highly efficient use of bioenergy, expansion of use of geothermal energy • Expansion of renewable energies' share of the heat supply, via expansion of use of CHP and promotion of local and district heating networks • Promotion of energy efficiency in companies, via consultation networks, and promotion of operationally oriented consultations and use of industry benchmarks • Networks / decentralisation – support of smart-grid technologies and promotion of "virtual power stations" • Research and development • Efforts to gain municipalities and municipal associations as strategic partners
Saarland	• Climate-protection concept for 2008-2013 • The "cleverly modernised" ("Clever saniert") future energy programme	• Expansion of use of combined heat & power (CHP) generation • Promotion of non-central biomass-fueled power stations • Climate-protection alliance of companies • "Green house number", for climate-friendly construction and living • Energy-oriented modernisation of state properties • Climate-friendly procurement • Current CO_2 balance sheet • "Zero-emissions municipalities" • Programme for forest expansion • Expansion of use of renewable energies • Climate protection as a focus of education for sustainable development • Promotion of heat pumps, combined heat and power (CHP) units, use of photovoltaic systems at schools and development, pilot and demonstration projects
Saxony	• Climate and energy action plan of the Free State of Saxony (2008) • Strategy for adaptation of Saxony's agriculture to climate change (2009) • Development and testing of an integrated regional programme for adaptation to the consequences of climate change, for the Dresden model region (REGKLAM collaborative research project) (2008-2013)	• 294 measures for assessment of climate trends, for adaptation to climate change, for climate protection and for a sustainable energy sector • Reduction of annual energy-related CO_2 emissions, from the non- emission trading sector, by at least 6.5 million tonnes with respect to the 2006 level, by 2020 • Increasing of renewable energies' share of gross electricity consumption to at least 24%, by 2020 • Assessment of the impacts of climate change on agricultural yields, quality and prices • Development and assessment of adaptation strategies for agriculture and horticulture, grassland management and animal husbandry • Support, from the Free State of Saxony, for relevant implementation
Saxony-Anhalt	• Energy concept for Saxony-Anhalt	• Enhancement of energy efficiency • Expansion of use of renewable energies • Energy-saving

Schleswig-Holstein	• Selected focuses in climate protection, in areas with major potential for reduction of greenhouse-gas emissions http://www.schleswig-holstein.de/UmweltLandwirtschaft/DE/ImmissionKlima/06__Klimaschutz/klimaschutz__node.html • Climate-protection report for 2009 (expected to appear in July 2009)	• Scenarios and integrated concept for climate protection and energy policy, including medium-term objectives • Reduction of greenhouse-gas emissions: Support for the Federal Government's objectives, and achievement of those objectives in the state of Schleswig-Holstein • Renewable energies: Scenario whereby such energies account for 50% of final energy consumption by 2020 • CHP: 25% share by 2020 • Modernisation controlling for state properties • Integration of climate protection in support programmes • Support for cultivation of fast-growing trees • Support for entrepreneurial initiatives for integrated use of renewable resources for substance and energy production ("biorefinery")
Thuringia	• Thuringian climate and adaptation programme (2009) • Thuringian energy and climate strategy 2015 (planned for 2009) • State development programme (updated 2009) • Thuringian bioenergy programme (2006) • Annual energy reports in the framework of annual economic reports • Study of small-scale climate factors, for regionally defined adaptation programmes (planned for 2010)	• Public awareness and education measures: • 3rd and 4th Thuringian Climate Forum (2006/2008), with emphases on water and climate change / consequences of climate change / climate protection / adaptation to the consequences of climate change • "KLIMAbewusst" media campaign, for publicising findings relative to enhancement of energy efficiency in buildings and substitution of fossil fuels with renewable energies • Thuringian "climate-protection weeks" campaign (2009) • Promotion and consultation • Increasing of renewable energies' share of final energy consumption to 22 % by 2015 • Promotion of use of renewable resources • Establishment of a consultation centre, for implementation of the BIOBETH concept for bioenergy-oriented consultation in Thuringia (2007) • Support for the solar energy / photovoltaic systems industry sector

4.6.2 Municipalities

In recent years, municipalities have become a significant factor in efforts toward national climate objectives. Via the National Climate Protection Initiative of 19 June 2008, a promotional instrument, municipalities are being encouraged to define their own contributions to efforts toward the Federal Government's climate protection objectives and to prepare, as a broad group, to implement their own climate-protection measures. As of May 2009, 750 applications for support of municipal climate-protection concepts had been submitted. This support instrument also supports implementation of such concepts. As a result, results of major significance can be expected to emerge from the great relevant potential inherent in municipalities' various tasks and functions.

Municipalities are

- an administrative level for execution of federal and Länder laws,

- authorities that establish norms and standards for local communities,
- entrepreneurs, in cases in which municipal utilities are responsible for local energy services,
- entrepreneurs, in matters involving municipal properties such as administrative buildings, schools, kindergartens, swimming pools, and
- entrepreneurs, in cases involving municipal support programmes for CO_2-emissions reductions, especially programmes for energy-saving and use of renewable energies.

In addition, municipalities have increasingly been functioning as facilitators for other climate-protection stakeholders oriented to common municipal greenhouse-gas reduction objectives and involved in execution of joint measures. As a result of such relationships, for example, the City of Hannover, working via concerted efforts involving 80 partners, will prevent more than 1.8 million tonnes of carbon dioxide emissions by the year 2020.

What is more, municipalities provide suitable environments for execution of pilot and model projects that show other municipalities how efficient climate protection can function. In such contexts as well, the National Climate Protection Initiative plays an outstanding role, by promoting model projects and interacting with the BMU's Environmental Innovation Programme.

More and more municipalities have been participating in competitions related to climate protection. In such competitions, municipalities receive the opportunity to compare themselves with other municipalities, to develop relevant new measures of their own and to review other municipalities' measures for suitability for their own frameworks.

Table 43

Sector	Measures
• Ecologically oriented urban development and regional planning	• Implementation of climate-friendly, energy-efficient development planning, construction planning, and construction-approval processes • Development of less CO_2-intensive spatial structures
• Information provision, consultation and public awareness measures	• Establishment of local and regional energy advising centres • Provision of climate-relevant information, in the framework of environmental consultation
• Energy-saving in consumption sectors	• Improvement of energy efficiency in municipal buildings • Promotion of efficient heat and electricity use in the largest possible number of consumption sectors
• Environmentally compatible energy supply structures	• Expansion of line-based energy networks • Fuel changes • Intensified use of heat/power cogeneration (CHP) / CHP units • Use of renewable and local energy sources
• Environmentally compatible development of the transport sector	• Reductions of automobile transports, via greater reliance on local public transportation • Improvement of the performance of the public transport infrastructure, especially of local public transportation and of other less emissions-intensive modes of transport • Efforts to make goods transports more environmentally compatible
• Municipal waste and wastewater management	• Avoidance of waste; waste separation in collection; waste recycling • Waste treatment • Wastewater treatment, use of gas from wastewater treatment, • Savings in use of process energy

4.7 *Policies and measures pursuant to Article 2 of the Kyoto Protocol*

4.7.1 Activities aimed at promoting decisions by the ICAO and IMO in favour of emissions reduction

The Parties to the Kyoto Protocol have committed themselves to continuing their efforts to limit or reduce emissions from air and sea transports in the framework of the International Civil Aviation Organisation (ICAO) and the International Maritime Organisation (IMO) (to date, quantitative reduction obligations only for Annex 1). To date, neither of the two bodies has approved regulations / procedures for limiting greenhouse-gas emissions.

IMO

The IMO deals with GHG-emissions issues via its Maritime Environmental Protection Committee (MEPC).

The IMO Point of Contact in Germany is the Federal Ministry of Transport, Building and Urban Affairs (BMVBS). Within the IMO framework, Germany is among the countries that are leading efforts in the area of air quality control and GHG reductions. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Environment Agency (UBA) are also represented in the organisation's bodies, in a consultative capacity.

At the last MEPC meeting (No 59, 2009), significant discussions were conducted relative to reduction of greenhouse-gas emissions, and resolutions were adopted:

- A work plan was approved, setting forth the next steps for discussion regarding a market-based instrument for reducing GHG emissions;
- Relevant market-based instruments were discussed, including a German proposal (proposed in co-operation with FRA and NOR) for a global emission trading scheme;
- The technical and specialised discussion regarding the formula for the energy efficiency design index for new ships was completed;
- The technical and specialised discussion regarding an operational indicator (for energy efficiency) and an energy efficiency management plan was completed.

In March 2009, discussion regarding the aforementioned technical measures was continued at an additional meeting of the pertinent sub-committee.

At the first meeting of the MEPC's working group on greenhouse gases, held in June 2008, Germany submitted a paper with a detailed proposal for emissions trading (based on studies commissioned by UBA/BMU).

In addition, at the MEPC's 58th meeting, Germany, in co-operation with France and Norway, submitted a paper that again described the potential for emission trading and that outlined the key elements of a pertinent scheme.

The EU Commission has announced that it will propose relevant measures of its own if the IMO fails, by the end of 2011, to make a concrete proposal for ways of including maritime transports in reduction measures. Currently, the EU is having various

relevant possibilities studied, including emissions-differentiated port fees, emissions standards, levies and emission trading.

The BMU has commissioned a research project aimed at showing how maritime transports could be included within the ETS (in a manner similar to the way in which air transports would be included). In the process, maritime-specific details are being carefully considered.

ICAO

The International Civil Aviation Organisation (ICAO) considers environmental aspects within the framework of its Committee on Aviation Environmental Protection (CAEP), which comprises a range of different working groups. To deal with greenhouse-gas issues, the ICAO has also established a Group on International Aviation and Climate Change (GIACC), alongside the CAEP. That group has been in existence since early 2008. A politically high-ranking group, the GIACC turns to the CAEP for advice on technical matters whenever the GIACC's members deem such reliance to be necessary. The group is working toward the aim of developing a strategy, by mid-2009, for limiting aviation-related CO_2 emissions.

While the ICAO is working on a CO_2-based certification standard, such a standard would not address air-transport growth and would require decades to make an impact, via the composition of aircraft fleets. Along with such technical measures, the CAEP is also considering market-economic instruments. A central focus of such efforts is on linking existing emission trading schemes with mechanisms for offsetting emissions.

Within the ICAO, Germany is a member of both the CAEP and the GIACC. The relevant point of contact is the Federal Ministry of Transport, Building and Urban Affairs (BMVBS).

4.7.2 Information about implementation of policies and measures aimed at preventing adverse effects (including adverse effects of climate change) in developing countries

The following tables list various policies and measures (sorted by sectors), along with their direct and indirect effects on developing countries.

Most of the measures that would be carried out in Germany would not be expected to have direct effects on developing countries. In the case of other measures, the expected effects are largely considered to be positive. Such effects, for example, would include establishment of technical and administrative structures for climate protection.

Almost all of the possible indirect effects are also considered to be positive. Such effects would include beneficial impacts on energy supplies and prices in co-operating countries.

The only possible negative effect would occur via promotion of non-sustainably produced biofuels. Such promotion could leading to destruction of, or adverse shifts

in, resources in developing countries. In future, such effects are to be prevented via implementation of pertinent sustainability ordinances.

Table 44: Cross-cutting measures

Measure	Direct effects	Indirect effects
Emission trading	none	
CDM	positive	
JI	none	
Energy/CO_2 taxes	none	

Table 45: Energy-policy measures

Measure	Direct effects	Indirect effects
Promotion of renewable energies	none	Positive: Potential reduction of dependence on fossil fuels; potential improvement of electricity supplies in rural areas; improvement of air quality
Promotion of biofuels	none	Negative: If biofuel imports lead to destruction of forests and other CO^2 sinks, or if biofuel-biomass cultivation leads to food shortages / food-price increases in developing countries. Positive: Economic development
Promotion of energy efficiency	none	Positive: Can lead to reduced energy costs and improved air quality
Promotion of CHP systems	none	Helps reduce energy costs

Table 46: Agriculture

Measure	Direct effects	Indirect effects
Orienting of subsidies to food security and animal-welfare standards instead of to production quantities	Positive: Enhances competition in agriculture	none
Improved management of animal waste	none	none
Biogas use / anaerobic fermentation	none	Positive: Comparatively cheap energy source.

Table 47: Forestry

Measure	Direct effects	Indirect effects
Reforestation	none	Positiv: Less forest loss
Sustainable forest management	none	none

Table 48: Waste recycling / treatment

Measure	Direct effects	Indirect effects
CH_4 separation from waste and sewage sludge	none	Positive: Cost-effective energy source
Composting	none	none

4.7.2.1 Bioenergy

In 2007, bioenergy met 3.9 % of Germany's total electricity requirements, 6.1 % of its total heat requirements and 7.3 % of its total fuel requirements. It thus met a total of 4.9 % of the country's primary energy requirements.

The Federal Government has committed itself to expanding Germany's use of renewable energies and, thus, to expanding the country's use of bioenergy. For example, biofuels play a role in strategies for reducing greenhouse-gas emissions in the transport sector. As part of that role, biofuels' share of total fuel consumption is to be increased; biofuels are to account for a 15 % share – in terms of energy content – of total fuel consumption by 2020.

In this context, the Federal Government is not losing sight of the fact that the increased biomass production necessary for such growth could have negative ecological, economic and social impacts. This applies especially to increases involving biofuel imports from developing countries. To ensure that biofuels imported from such countries are produced in keeping with the ideal of sustainable development, the Federal Government is working, in the framework of various initiatives, to develop internationally applicable, WTO-conformal sustainability standards and pertinent certification systems. In particular, suitable certification systems are to be developed to ensure that production of biofuels in developing countries does not lead to conflicts with food security needs and individual rights to food.

For this reason, the Federal Government has been working in the following ways, at the international level, to develop relevant sustainability criteria:

- Supporting relevant European activities, such as an approved Directive on the promotion of the use of energy from renewable sources, and an amended Fuel Quality Directive, which applies similar sustainability criteria.
- Actively participating in relevant international fora, such as the "Global Bioenergy Partnership", a G8 initiative. In that forum, the Federal Government is working for the establishment of a globally applicable, WTO-conformal institutional framework with internationally recognised sustainability criteria.
- Working to complement biomass certification with suitable certifications for other areas of biomass use, designed to prevent undesired, indirect land-use changes. The internationally recognised certification of the Forest Stewardship Council (FSC), for sustainable forest management, is one example of such certification.

In its efforts to develop sustainability standards and certification systems, the Federal Government takes account of the various relevant interest groups in developing countries, to ensure that solutions fit with the conditions prevailing in such countries.

The Germany-financed "Bioenergy and Food Security" project of the UN Food and Agriculture Organization (FAO) is oriented to fulfillment of minimum environmental and social standards. The project aim is to develop, in co-operation with political decision-makers of potentially affected countries, criteria for assessing the opportunities and risks inherent in bioenergy and rural development.

Other measures enacted by the Federal Government with the aim of preventing bioenergy use from having negative impacts on developing countries include:

- Advising of partner countries, in the framework of development co-operation, in developing and implementing strategies for sustainable biomass production;
- Support for suitable demonstration projects;
- Support for implementation of standards and certification systems;
- Support for development of large-scale land-use concepts;
- Advising in connection with development and dissemination of decentralised / local energy-supply systems involving bioenergy;
- Advising with regard to the impacts of bioenergy production on food security in developing countries, and support for linkage with national biomass strategies for food security and poverty mitigation;
- Transfer of know-how and technology;
- Training support in the agriculture sector.

4.7.2.2 Climate protection programme for developing countries

This Convention project, carried out by Gesellschaft für technische Zusammenarbeit (GTZ), under commission to the Federal Ministry for Economic Cooperation and Development (BMZ), supports developing countries in fulfilling their obligations under the UN Framework Convention on Climate Change and in making use of the development opportunities arising via such fulfillment.

The climate protection programme supports developing countries in building structures for the Clean Development Mechanism (CDM). In the CDM context, companies from industrialised countries invest in projects, in developing countries, for reducing greenhouse-gas emissions via use of renewable energies, enhancement of energy efficiency or prevention of methane emissions from landfills. For developing countries, the CDM presents opportunities for modernisation of energy supply systems. The climate protection programme supports partner countries in various ways – for example, in preparing national CDM strategies, sector studies and CDM-project planning. In addition, it helps provide the institutional and organisational basis for identifying, preparing and efficiently approving and managing CDM projects. The actual project financing for emissions-reduction certificates comes from the private sector. No funding comes from the development-co-operation sector.

5 Emissions scenarios and projections, and assessment of measures' effects

5.1 On the conclusiveness of forecasts, scenarios and projections

Forecasts and scenarios play an indispensable role in assessment of future possibilities in climate-protection strategy and of the impacts of possible measures. In political discussion, it is often forgotten that there is no certainty about the future, and that scenarios are always "if-then" statements. Every forecast depends closely on the relevant future developments that are chosen for it because they are seen to be likely. The conclusions reached for any scenario thus depend on the relevant underlying chosen premises. This means that at any given time, different, consistent and logical forecasts will always be possible, with each forecast tied to assumptions regarding the further development of the economic, demographic and political framework and, in the present context, to assumptions regarding the interacting factors relative to energy consumption. Goal-oriented forecasts are referred to as "projections". In each case, further study is required to determine the extent to which the results of projections can actually be achieved.

As to methods, emissions projections are based on impacts analyses and on integrated consideration of the combined effects of different measures and policies. The longer the time frames for projections are, the more one must depend on numerical models, which of course provide only a limited view of reality. Because parameters tend to be blurred over time, analyses of the impacts of individual measures tend to be unreliable.

The projections presented in the present paper are based on the study "Policy Scenarios V" ("Politikszenarien V"), which was carried out by a consortium of German research institutes, under commission to the Federal Environment Agency (UBA) and the BMU.[33] The database for this study dates from 2005.

5.2 Forecasting of greenhouse-gas emissions through 2020

5.2.1 Methodological approach and framework data

Under commission to the Federal Environment Agency, the Study "Policy Scenarios V" was carried out by following partners: Öko-Institut e.V. Institute for Applied Ecology; Forschungszentrum Jülich (Jülich Research Centre), Institute for Energy Research – Systems Analysis and Technology Evaluation (IEF-STE); German Institute for Economic Research (DIW Berlin); and the Fraunhofer Institute for Systems and Innovation Research (FhG-ISI). In the study, the involved partners prepared projections for German greenhouse-gas emissions throughout the period 2008 to 2020.

[33] Öko-Institut e.V. Institute for Applied Ecology, Forschungszentrum Jülich, German Institute for Economic Research (DIW), Fraunhofer Institute for System and Innovation Research, Dr. Hans-Joachim Ziesing: Improvement of the methodological basis, and preparation of a greenhouse-gas-emissions scenario, as a basis for the 2009 Projection Report in the framework of EU greenhouse-gas monitoring ("Verbesserung der methodischen Grundlagen und Erstellung eines Treibhausgasemissionsszenarios als Grundlage für den Projektionsbericht 2009 im Rahmen des EU Treibhausgasmonitorings"). UFOPLAN project FKZ 206 42 106.

The projections regarding German greenhouse-gas emissions through 2020 are based on assumptions with regard to

- Population growth
- Economic trends and development of economic structures
- Development of energy prices
- Policies and measures.

With regard to policies and measures, the "with-measures" scenario studied and used by the present report takes account of all measures taken by 2008 and described in Chapter 4.

For the various sectors involved, different methodological approaches and different model instruments were used for analysis and assessment of the various relevant measures, determination of the relevant greenhouse-gas emissions, by source categories, and development of the necessary background information and indicators for the Projection Report. The relevant approaches and instruments permit adequate analysis, for the various relevant areas, on the basis of the available data and information[34].

1. With regard to energy-related greenhouse-gas emissions from combustion processes, the analyses are based on a complex system of different models.
2. The analyses relative to electricity and fuel requirements in the manufacturing sector were carried out with the help of the ISI-Industry model of the Fraunhofer Institute for Systems and Innovation Research (FhG-ISI).
3. For the transport sector, the FhG-ISI's ASTRA model was used.
4. For the buildings sector (both residential and non-residential buildings), the IKARUS space-heating model of the Systems Analysis and Technology Evaluation Programme Group at the Jülich Research Centre's Institute of Energy Research (IEF-STE) was used.
5. Complementary analyses, relative to remaining fuel and electricity requirements in the commerce/trade/services and private households sectors, were carried out with technology-based individual models of the FhG-ISI.
6. Electricity generation from renewable energies was analysed with the Power-ACE model of the FhG-ISI.
7. Electricity generation with fossil fuels (including heat/power cogeneration (CHP)) was analysed with the ELIAS model of the Öko-Institut.
8. Determination of primary energy consumption and determination of energy inputs in other transformation sectors, were carried out with the IKARUS-LP model of the IEF-STE.

A number of iterations were required to model the energy sector:

[34] The present Projection Report defines 10 different sectors in Germany with respect to GHG emissions forecasting. This differentiation, and any maintenance of the relevant territorial principle applied, are of only limited use in assessment of the effects of European emission trading. Germany is currently reviewing the extent to which any modified approach should be used for future reporting.

1. To determine electricity consumption from final consumption and transformation areas, which consumption enters into modelling of the electricity market;
2. To check heat production from CHP systems in the public, industrial and individual-facility sectors against heat requirements in the sectors industry, commerce/trade/services and private households.

Greenhouse-gas emissions from combustion processes were determined with the Öko-Institut's emissions model, which assesses energy-requirements projections for the various final-consumption and transformation sectors, within the system applied for national greenhouse-gas emissions, on the emissions side:

1. With regard to the energy sector's fugitive emissions, the Öko-Institut's emissions model uses source-category-specific modelling based on the relevant quantities for energy demand and provision, as well as on the methods used for the National Greenhouse-Gas Inventory.
2. With regard to emissions from industrial processes, three different approaches have been used:
    - With regard to process-related emissions that relate to the energy sector, emissions have been determined on the basis of pertinent quantities for energy demand and provision, as used in the Öko-Institut's emissions model, and via the methods used for the National Greenhouse-Gas Inventory.
    - With regard to process-related emissions that do not relate to the energy sector, emissions have been determined on the basis of production estimates in the Öko-Institut's emissions model, and via the methods used for the National Greenhouse-Gas Inventory. Separate model-based estimates have been carried out for N_2O emissions from adipic-acid and nitric-acid production.
    - With regard to HFC, PFC and SF_6 emissions, existing projections have been updated and adapted as necessary.
3. .With regard to greenhouse-gas emissions from agriculture, the projections prepared by the Johann Heinrich von Thünen Institute (vTI; Federal Research Institute for Rural Areas, Forestry and Fisheries), for the NIR 2009, have been adopted[35]
4. With regard to greenhouse-gas emissions from the waste-management sector, the Öko-Institut model used in preparation of the National Greenhouse-Gas Inventories has been expanded for the projection.

For analysis of energy-related greenhouse-gas emissions, a component-differentiation procedure was also used. In that procedure, decomposition analysis is used to describe energy productivity, fossil fuels' share of the total primary energy supply and the greenhouse-gas intensity of the fossil fuels used.

With the help of these instruments – and in addition to preparation of the "with-measures" scenario and the relevant background and indicator data – sensitivity

[35] Osterburg and Dämmgen, 2009.

analyses were also carried out for a range of key basic assumptions (population and economic growth, energy prices, etc.).

5.3 Demographic and economic framework data

When the framework data for the calculations on which the present report is based were defined, the economic and financial crisis had not yet begun. In particular, the current economic growth forecasts for the coming years, predicting only slight or even negative growth, were not yet available. Calculations on the basis of different growth rates would yield different results.

The Federal Government currently expects the GDP 2010 to amount to EUR 2,264 billion, in 2005 prices. That figure is nearly 9 % lower than the level assumed in the report. While no official Federal Government projections are yet available for 2015 and 2020, the Federal Government's medium-term projection until 2013 does show that the figures given for 2015 and 2020 must now be considered improbable. If one extrapolates the figure given in the Federal Government's projection for 2010, on an extrapolation basis of 1.9 % growth (= variant with higher growth than the figure used in the Projection Report), one obtains GDP figures of EUR 2,487 billion for 2015 and EUR 2,733 billion for 2020 (both in 2005 prices). These figures are about 8 % and 6.5 %, respectively, lower than the figures in the Projection Report's reference projection. With regard to employment, the difference between the Projection Report's reference projection and the Federal Government's projection for 2010 amounts to about 600,000 persons.

Energy-consumption levels and structures in Germany are determined primarily by trends in population, gross domestic product and energy prices. The trends outlined in the following section are oriented mainly to existing projections. In order to take account of a number of significant uncertainties in the forecasts, the present report considers both a reference development and variants with different framework data.

The strong economic growth that has occurred in recent years, in spite of high energy prices, has awakened hopes that Germany's economic outlook has improved in a lasting way. For that to be the case, the strong growth seen in recent years would have to be due mainly to structural improvements. Only after the current financial crisis has been successfully overcome will it become clear whether that is indeed the case, or whether the growth was really only a temporary phenomenon.

If growth in Germany proves more robust and lasting than has been assumed so far, then energy consumption would tend to increase more strongly than has been expected, thereby increasing the challenges for climate policy. In the reference case, we assume that such a development will indeed occur. As to variants, we also consider an economic trend with weaker growth and one with stronger growth. For demographic trends, the key factors especially include the impacts of migration. Consequently, the present report considers various different possible developments, using current forecasts of the Federal Statistical Office.

5.3.1 Population and households

The assumptions presented in the following section, with regard to the development of demographic framework data, are based on two variants used in the Federal Statistical Office's 11th co-ordinated population forecast (koordinierte Bevölkerungsvorausberechnung) (variant 1 – W1; variant 1 – W2) of 2006, variants

which the Office itself saw as the lower and upper boundaries of the mean population trend. In these variants, a birth rate averaging 1.4 children per woman is assumed. The life expectancy of persons born in 2050 is assumed to be 83.5 years for males and 88 years for females. The two variants differ solely in terms of their migration balance, which for W1 is assumed to be 100,000 persons and for W2 is assumed to be 200,000 persons. The Federal Statistical Office uses variant 1-W1 as the basis for its budgetary forecasts. The assumptions relative to migration in that variant come closest to current actual trends. For the present report's reference case, the demographic development with the larger migration gains (V1 - W2) is assumed. A development scenario with lower migration gains (V1 - W1) is also considered, as an alternative.

Development of the number and average sizes of private households is derived on the basis of these assumptions relative to population growth. Here as well, the Federal Statistical Office's relevant figures are relied on. The Federal Statistical Office's 2007 budgetary forecast is based on demographic development in accordance with variant 1 – W1. Furthermore, the Office distinguishes between a variant in which a trend toward smaller household sizes continues ("trend") and a variant in which household sizes, for various age groups, remain about the same and the average household size decreases only slightly, as a result of the population's ageing ("status quo"). In the reference case, the size structure for private households is assumed to develop in keeping with the Federal Statistical Office's "trend" variant, while the variant case uses the Federal Statistical Office's "status quo" variant.

Table 49 presents the key assumptions made regarding development of the residential population and of households.

While "Policy Scenarios IV" assumed that the population would increase slightly through 2010, and only then would begin decreasing, the present report, in keeping with the Federal Statistical Office's latest figures, assumes that the population decrease has already begun and that it will continue, more or less strongly, until 2020. In that framework, from 2005 to 2020 the population decreases from 82.4 to 81.3 million (reference) or to 80.1 million persons (variant), i.e. decreases by 1.1 or 2.3 million persons.

The key factors determining energy consumption – especially with regard to energy consumption for space heating (i.e. for provision of the energy service "warmed or air-conditioned space") – also include the number and size structure of private households in Germany. As a result of the continuing trend toward one-person and two-person households, in the reference case the number of private households increases throughout the entire projection period. From 2005 to 2020, it increases by a total of 2 million, to 41.2 million. In the variant case, the number of households increases until 2010 and then decreases slightly. In 2020, it amounts to 39.6 million, which is still 0.4 million higher than the corresponding figure for 2005. In the reference case, from 2005 to 2020, the numbers of one-person and two-person households, as percentage shares of the total number of households, increase by 3.1 and 2.4 %, to 40.6 and 36.3 %, respectively. In the variant scenario, they still increase by 1.6 and 2.1 %, to 39.1 and 36.0 %.

Table 49: Residential population and households in Germany – in 1,000s of persons and households

	2000	2005	2010	2015	2020	2010	2015	2020
	1000s of persons or households							
			Reference (V1 - W2, Trend)[3]			Variant (V1 - W1, Status Quo)[3]		
Residential population[1]	82260	82438	82039	81 790	81328	81887	81102	80057
Private households[2]	38124	39178	40108	40629	41185	39691	39635	39580
of which	in %							
1-person households	36,1	37,5	39,4	40,1	40,6	38,8	39,0	39,1
2- person households	33,4	33,9	34,1	35,2	36,3	34,1	35,1	36,0
3- person households	14,7	14,0	13,0	12,3	11,6	13,3	12,9	12,5
4- person households	11,5	10,8	9,9	9,2	8,6	10,1	9,6	9,1
5+- person households	4,4	3,9	3,5	3,2	2,9	3,7	3,5	3,3

[1] End of year.
[2] Average for the year.
[3] Based on the variants used for the 11th co-ordinated population forecast (V1 - W1 a. V1 - W2), and for the current budgetary forecast (Trend a. Status Quo) of the Federal Statistical Office.

Sources: StBA 2006, StBA 2007a, calculations of DIW.

5.3.2 Economic growth and structure

In 2006, the German economy grew at 2.9%, thereby reaching a growth rate not seen previously since the end of the 1990s. That development could indicate that the country's adaptation crisis – due in part to reunification – has now been overcome, thanks to political reforms and corporate restructuring. At the same time, the growth was driven primarily by exports, which showed a real increase of more than 12 % in that year – stimulated by continuing strong economic growth in the U.S., in a number of Asian threshold countries and in eastern Europe. If the strong growth that occurred prior to the economic crisis is to amount to more than a "flash in the pan", relevant reforms (such as further budgetary consolidation, reform of the country's federalist system and improvement of child-care services and of the country's education sector) will have to be continued – after the crisis has been overcome. In the reference case, it is assumed that the real gross domestic product increases by an average of 1.7 % annually, from 2006 to 2020, even as the country's population decreases (and ages). On the other hand, economic growth slows over time, in a trend leading from 1.9 % (2006 to 2010) to 1.7 % (2010 to 2015) and then to 1.6 % (2015 to 2020). To take account of the uncertainties regarding future economic growth, the present report, in addition to considering a reference case, examines a variant with lower economic growth and a variant with higher growth, with both variants diverging equally from the reference case on average. In the variant with lower growth, it is assumed that GDP growth, which increases by an average of 1.5 % annually from 2006 to 2020, weakens after 2010, from 1.4 % (2010 to 2015) to 1.3 % (2015 to 2020). In the variant with stronger growth, the economy remains robust throughout the entire forecast period; growth stays at an average of 1.9 % per year throughout the entire period. The present report uses that variant primarily as a basis for component analysis with aggregated – i.e. sectorally non-differentiated – data.

While the two variants cover a large part of the spectrum of probable developments, both stronger and weaker economic growth are conceivable.

From the development of Germany's GDP for the period 1970 to 2006, one can derive an upper limit, for possible annual real growth for the period until 2020, of 2.2 %. In light of the assumed future population decrease, such a development must be considered highly unlikely, however. And even lower growth than that assumed in the "lower growth" variant is also a possibility for mature industrialised countries – as the economic crisis has shown. At the time the framework data were defined, the more robust economy seen in recent years indicated that such a development would probably not occur in Germany in the foreseeable future, however. For that reason, a variant with such growth is not considered in the present report. This approach also seems justified in that too-low assumptions regarding economic growth could lead to underestimation of future challenges for energy and environmental policy.

Table 50 provides an overview of the assumptions regarding economic growth that are used in the variants.

Table 50: Assumptions regarding economic growth in the reference case and in the variants

	2000	2005	2006	2010	2015	2020	2006/2020	2010/2020
	Billions of EUR							
Reference	2178	2241	2305	2483	2701	2925		
Lower economic growth	2178	2241	2305	2483	2662	2839		
Higher economic growth	2178	2241	2305	2495	2742	3012		
	2006 = 100							
Reference	94,5	97,2	100,0	107,7	117,2	126,9		
Lower economic growth	94,5	97,2	100,0	107,7	115,5	123,2		
Higher economic growth	94,5	97,2	100,0	108,2	118,9	130,7		
	Annual change, in %							
Reference		0,6	2,9	1,9	1,7	1,6	1,7	1,6
Lower economic growth		0,6	2,9	1,9	1,4	1,3	1,5	1,3
Higher economic growth		0,6	2,9	2,0	1,9	1,9	1,9	1,9

Source: Calculations of the DIW

In all cases – i.e. also in the variant with lower growth – it is assumed that productivity grows faster than value creation after 2010. That assumption presupposes higher research expenditures, as well as pronounced efforts to improve the education system and to integrate residents with migration backgrounds. Without marked successes in such areas, the strong growth assumed even for the reference case will hardly be achievable.

With regard to sectoral structural change, no new findings have emerged, with respect to the assumptions made in the study "Policy Scenarios IV" (Öko-Institut e.V. Institute for Applied Ecology, Forschungszentrum Jülich (Jülich Research Centre), DIW Berlin, Fraunhofer Institute for Systems and Innovation Research 2007), that would necessitate any significant changes in those assumptions. For that reason, the assumptions made in "Policy Scenarios IV" regarding the relative growth of relevant sectors have been largely adopted in the present context.

The following tables summarise the key assumptions made regarding economic trends for Germany. Table 51 shows the real (inflation-adjusted) development of value creation, by economic sectors and by total gross domestic product (GDP). As the table shows, from 2006 to 2020, GDP increases by 31 % in the reference case and by about 27 % in the "lower economic growth" variant.

Table 51: Value added, by economic sectors, in billions of EUR (real prices; price basis: 2005)

	2000	2005	2006	2010	2015	2020	2010	2015	2020
	Billions of EUR (real prices; price basis: 2005)								
				Reference			Lower economic growth		
Agriculture and forestry; fisheries	18,1	17,8	17,2	18,4	19,3	20,2	18,4	19,1	19,8
Mining and quarrying	6,5	4,0	3,8	4,0	3,2	2,5	4,0	3,4	2,7
Manufacturing	431,8	455,0	481,5	520,7	563,1	606,4	520,7	555,4	590,0
Energy and water supply	40,1	47,9	48,3	52,6	54,5	56,5	52,6	54,2	55,8
Construction industry	100,8	79,9	84,1	89,2	94,2	99,4	89,2	93,3	97,4
Wholesale and retail trade; repair of m. veh. and pers. /household goods	204,6	209,6	216,5	233,2	241,6	250,2	233,2	240,1	247,0
Hotels and restaurants	33,9	32,8	33,4	35,8	37,8	39,8	35,8	37,4	39,1
Transport and communication	103,7	115,6	121,0	131,4	152,4	174,1	131,4	148,5	165,5
Financial intermediation	116,3	101,3	101,5	107,9	118,6	129,5	107,9	116,6	125,3
R. estate; renting; business activities	447,0	500,1	513,1	556,1	618,1	681,5	556,1	606,7	657,0
Public administration; defence; social security	124,4	121,5	121,4	130,0	132,0	134,0	130,0	131,7	133,3
Education	93,8	91,6	90,0	96,3	99,2	102,2	96,3	98,7	101,1
Health care; veterinary med. and social work	125,7	146,3	148,2	161,0	182,1	203,7	161,0	178,2	195,2
Other community, social and personal services	98,6	96,3	96,8	103,7	116,3	129,1	103,7	114,0	124,1
Gross domestic product	2178,1	2241,0	2305,3	2483,0	2701,4	2924,5	2483,0	2661,8	2839,3
Real figures for 2005 based on real values determined by the Federal Statistical Office with chain indices.									

Sources: StBA 2007b, calculations of the DIW.

The structure of value added (cf. Table 52) changes only slightly through 2020.

The sectors "transport and communication" and "health, veterinary medicine and social services" show markedly increasing shares. From 2005 to 2020, their combined shares increase from nearly 12 % to 13 %. The value-added shares for the sector "real estate, renting, business services" also increase slightly, to a level of 23 % in 2020. In this regard, this sector maintains its slight edge over the manufacturing sector, whose share of total value added remains about the same. The other sectors fall slightly behind in this regard.

Table 52: Structure of real value added, by economic sectors, in %

	2000	2005	2006	2010	2020	2010	2020
	%						
				Reference		Variant with lower economic growth	
Manufacturing	19,8	20,3	20,9	21,0	20,7	21,0	20,8
Wholesale and retail trade; repair of m. veh. and pers. /household goods	9,4	9,4	9,4	9,4	8,6	9,4	8,7
Transport and communication	4,8	5,2	5,3	5,3	6,0	5,3	5,8
R. estate; renting; business activities	20,5	22,3	22,3	22,4	23,3	22,4	23,1
Public administration; defence; social security	5,7	5,4	5,3	5,2	4,6	5,2	4,7
Health care; veterinary med. and social work	5,8	6,5	6,4	6,5	7,0	6,5	6,9
Other	34,0	30,9	30,5	30,2	29,9	30,2	30,0

Sources: StBA 2007b, calculations of the DIW

Table 53 provides an overview of assumptions regarding development of industrial production. As the table shows, value added in industry is expected to increase by about 29 % to 33 % from 2005 to 2020, and particularly high growth rates are expected for the sectors of non-ferrous metals, metal-products production and production of machinery and motor vehicles. About-average growth is expected for basic chemicals, manufacture of rubber and plastic products and other economic sectors. Below-average growth is expected in the areas of food, beverages and tobacco, while negative growth is expected in the areas of pulp and paper, glass and ceramics, non-metallic mineral products and production of basic metals.

Table 53: Gross value added, in industry, in billions of EUR (real prices; price basis: 2005)

	2000	2005	2010	2015	2020	2010	2015	2020
	Billions of EUR (real prices; price basis: 2005)							
			Reference			Lower economic growth		
Quarrying, other mining[1]	2,6	2,2	2,9	3,0	3,0	2,9	2,9	3,0
Food, beverages and tobacco	39,9	37,0	41,4	42,8	44,2	41,4	42,2	43,0
Pulp and paper industry	9,4	10,0	10,0	10,1	10,2	10,0	10,0	9,9
Basic chemicals[2]	19,2	20,1	23,3	24,7	26,2	23,3	24,4	25,4
Other chemical industry[2]	20,3	27,3	27,1	29,5	31,9	27,1	29,1	31,0
Manufacture of rubber and plastic products	19,4	21,8	24,4	26,3	28,2	24,4	25,9	27,4
Glass, ceramics[2]	5,9	5,8	6,2	6,2	6,2	6,2	6,1	6,1
Manufacture of non-metallic mineral products[2]	8,9	7,7	7,3	7,1	6,7	7,3	7,0	6,6
Manufacture of basic metals[2]	8,2	9,9	7,4	7,4	7,2	7,4	7,3	7,0
Non-ferrous metals, foundries[2]	10,5	10,1	13,0	13,6	14,2	13,0	13,5	13,8
Fabricated metal products[2]	45,1	41,5	55,0	60,0	64,8	55,0	59,1	63,1
Machinery and equipment	67,8	69,2	85,9	98,3	110,8	85,9	97,0	107,8
Motor vehicles	59,7	74,3	86,0	93,7	101,4	86,0	92,4	98,7
Other industry sectors	120,9	122,3	132,9	142,7	153,7	132,9	140,8	149,5
Total for industry	437,9	459,0	523,0	565,4	608,7	523,0	557,7	592,3

[1] Including iron-ore mining

[2] Real value added of the relevant overarching industry group, in 2000 and 2005, broken down in keeping with the nominal gross-value-added shares, for the relevant sub-sectors, pursuant to cost-structure statistics of the Federal Statistical Office

Sources: StBA 2007b, StBA 2007c, calculations of DIW.

Development of numbers of gainfully employed persons is an important indicator for development of energy consumption (and of emissions) in industry and, especially, in the commerce/trade/services sector. Table 54 presents numbers of gainfully employed persons, by economic sectors, while Table 55 presents data for the commerce/trade/services sector.

Table 54: Gainfully employed persons, by economic sectors

	2000	2005	2010	2015	2020	2010	2015	2020
	1,000s of persons							
			Reference			Lower economic growth		
Agriculture and forestry; fisheries	936	850	830	780	735	830	782	735
Mining and quarrying	128	89	82	61	43	82	64	48
Manufacturing	8109	7506	7476	7291	7080	7476	7269	7000
Energy and water supply	297	289	287	264	245	287	266	246
Construction	2769	2165	2142	2069	2004	2142	2069	1993
Wholesale and retail trade; repair of m. veh. and pers. /household goods	6078	5899	5924	5587	5265	5924	5607	5276
Hotels and restaurants	1613	1758	1782	1736	1688	1782	1734	1677
Transport and communication	2133	2108	2152	2252	2319	2152	2218	2240
Financial intermediation	1277	1244	1229	1241	1245	1229	1231	1220
R. estate; renting; bus. activities	4525	5158	5500	5616	5689	5500	5562	5557
Public administration; defence; social security	2857	2670	2668	2465	2278	2668	2483	2299
Education	2150	2278	2315	2187	2065	2315	2195	2071
Health care; veterinary med. and social work	3668	4038	4143	4251	4328	4143	4203	4211
Other community, social and personal services	1955	2112	2154	2201	2224	2154	2178	2170
Total	39144	38846	39396	39011	38440	39396	38819	37875

Table 55: Gainfully employed persons and gross value added (real prices; price basis: 2005) in the commerce/trade/services sector, by sectors – reference case

	2000	2005	2010	2015	2020
	1,000s of gainfully employed persons				
Agriculture, horticulture	936	850	830	780	735
Industry SMEs, crafts[1]	649	682	713	1012	1232
Construction	2769	2165	2142	2069	2004
Wholesale and retail trade	6078	5899	5924	5587	5265
Financial intermediation	1277	1244	1229	1241	1245
Transport, communication	2133	2108	2152	2252	2319
Other private services	8093	9028	9435	9552	9601
Health	3668	4038	4143	4251	4328
Education	2150	2278	2315	2187	2065
Public administration, social security	2426	2300	2348	2145	1958
Defence	431	370	320	320	320
Total for commerce/trade/services	30610	30962	31552	31395	31072
	Real gross value added; 2005 = 100				
Agriculture, horticulture	102	100	104	108	113
Industry SMEs, crafts[1]	105	100	110	121	133
Construction	126	100	112	118	124
Wholesale and retail trade	98	100	111	115	119
Financial intermediation	115	100	107	117	128
Transport, communication	90	100	114	132	151
Other private services	92	100	111	123	135
Health	86	100	110	124	139
Education	103	100	105	108	112
Public administration, social security	101	100	109	110	110
Defence	111	100	93	102	112
Total for commerce/trade/services	98	100	110	120	130

[1] Determined as a remainder.

Table 56: Gainfully employed persons and gross value added (real prices; price basis: 2005) in the commerce/trade/services sector, by sectors – variant with lower economic growth

	2000	2005	2010	2015	2020
	1,000s of gainfully employed persons				
Agriculture, horticulture	936	850	830	782	735
Industry SMEs, crafts[1]	649	682	713	958	1131
Construction	2769	2165	2142	2069	1993
Wholesale and retail trade	6078	5899	5924	5607	5276
Financial intermediation	1277	1244	1229	1231	1220
Transport, communication	2133	2108	2152	2218	2240
Other private services	8093	9028	9435	9474	9404
Health	3668	4038	4143	4203	4211
Education	2150	2278	2315	2195	2071
Public administration, social security	2426	2300	2348	2163	1979
Defence	431	370	320	320	320
Total for commerce/trade/services	30610	30962	31552	31220	30581
	Real gross value added; 2005 = 100				
Agriculture, horticulture	100	100	104	107	111
Industry SMEs, crafts[1]	105	100	110	119	129
Construction	126	100	112	117	122
Wholesale and retail trade	98	100	111	115	118
Financial intermediation	115	100	107	115	124
Transport, communication	90	100	114	128	143
Other private services	92	100	111	121	130
Health	86	100	110	122	133
Education	103	100	105	108	110
Public administration, social security	101	100	109	110	110
Defence	111	100	93	101	110
Total for commerce/trade/services	98	100	110	118	126

[1] Determined as a remainder.

Quellen: StBA 2007b, Berechnungen des DIW.

A marked change in employment structures is apparent in both the reference development and the "lower economic growth" variant. As a result of population decreases, and of (assumed) high productivity growth, the number of gainfully employed persons is expected to decrease by a total of 0.4 to 1 million from 2005 to 2020. In the manufacturing sector, the number of gainfully employed persons decreases by about half a million during the same period. In 2020, that sector is expected to account for only 18 % of the total number of gainfully employed persons (the corresponding figure for 2000 is about 21 %). On the other hand, at that time the manufacturing sector will still account for the largest number of gainfully employed persons. In this regard, it will rank ahead of the real estate, renting and business services sector.

Marked employment growth is expected solely in the areas of transport and communication; real estate, renting and business services; and health and social services.

5.4 Development of prices for energy and for emissions allowances

5.4.1 Energy prices and the exchange rate

The expected development of energy prices is a central influencing factor – at least for some consumption sectors and source categories – for development of energy requirements and of greenhouse-gas emissions.

The figures for development of crude-oil prices have been taken from the World Energy Outlook 2007 of the International Energy Agency (IEA 2007) (reference and high prices). As to development of exchange rates, the euro is assumed to be worth US$ 1.40 in 2010 and only US$ 1.30 in in 2020.

Table 57: Import prices for primary fuels (real prices; price basis: 2005), 2005-2020

	Units	2005	2006	2010	2015	2020	2010	2015	2020
				Reference			High prices		
Crude oil	$/Barrel	52,3	60,0	57,4	55,7	58,3	62,6	64,9	70,9
Crude oil	€/t	314,5	348,7	299,4	305,9	337,6	326,7	356,6	410,4
Natural gas	ct/kWh	1,7	2,3	1,8	1,9	2,1	2,0	2,2	2,5
Hard coal for p. stations	€/tSKE	65,0	60,3	77,6	78,9	85,2	83,0	89,0	99,7

Sources: IEA (2007), calculations of DIW Berlin.

Development of import prices for individual fuels depends on the assumptions that are made regarding the development of price relationships between the various fuels – as well as depending on price trends for crude oil and on exchange rates. To determine the price relationships between a) crude oil imports and b) imports of hard coal and natural gas, regressions analyses were carried out for the period 1980 to 2006. In addition, changes in import prices for natural gas were assumed to lag one year behind changes in import prices for crude oil. The regression analyses show a high statistical significance. Pursuant to those analyses, prices for hard-coal imports decrease from a level of 36 % to 38 % of the thermal equivalent price of crude oil in 2010 to a level of about 34 % to 37 % by 2020. For the import price for natural gas, the corresponding relationship is 72 % to 73 % by 2010, after which the natural gas price also decreases slightly in relation to the price of crude oil.

Table 58: Prices for end consumers, by fuels, and including energy taxes (real prices; price basis: 2005)

	Units	2005	2006	2010	2015	2020	2010	2015	2020
				Reference			High prices		
Industry (without VAT)									
Heating oil, EL	€/t	430,0	519,8	461,6	469,7	509,4	495,7	533,2	600,5
Natural gas	ct/kWh	2,2	3,2	2,7	2,8	2,9	2,9	3,0	3,3
Hard coal	€/t	76,5	71,6	89,4	90,8	97,2	95,0	101,1	112,1
Power stations (wio. VAT)									
Natural gas	ct/kWh	2,2	2,7	2,3	2,3	2,5	2,4	2,6	2,9
Hard coal	€/t	76,5	71,6	89,4	90,8	97,2	95,0	101,1	112,1
Braunkohle	€/GJ	1,05	1,05	1,10	1,14	1,18	1,10	1,14	1,18
Households									
Heating oil, EL	ct/l	44,0	58,4	52,6	53,0	57,3	56,6	60,6	68,1
Natural gas	ct/kWh	5,1	6,2	5,8	5,8	5,9	6,0	6,1	6,4
Petrol (€/l)	€/l	1,18	1,34	1,24	1,20	1,19	1,28	1,27	1,29
Diesel (€/l)	€/l	1,02	1,10	1,04	1,01	1,02	1,07	1,07	1,11

Source: Calculations of DIW Berlin.

The end-consumer prices include processing and transport costs, and taxes. Taxes play a significant role especially in prices that private households pay for petrol and diesel fuel. In keeping with decisions currently in force, it is assumed here that the currently applicable energy-tax rates will remain nominally unchanged until 2020 (this does not take account of tax-rate variations, which are considered in modelling of measures). As a result, the real tax burden decreases with the assumed inflation rate. With the assumed development of crude oil prices, that effect contributes to a slight real decrease in fuel prices after 2010 – a decrease that, with high energy prices, continues only until 2015, however. The prices as given for households include value-added tax. It is assumed that the current VAT rate of 19 % will remain in force through 2020.

For purposes of the study, the development of electricity prices is not determined exogenically; it results from the models.

At the request of the party commissioning the report, a variant with even higher energy prices is shown, in addition to the two basic price variants, that is oriented to the high-price scenario of the IEA (IEA 2007). In that variant, crude oil prices increase to US$ 89 per barrel (real; price basis: 2005) by 2020. Because crude oil prices are assumed to retain their price leadership, prices for other fuels increase as well (except for prices for domestically produced lignite). The assumptions for the pertinent relative price development correspond to those in the reference case.

Table 59: Import prices and prices for end consumers (real in each case; price basis: 2005) in the variant "very high energy prices"

	Units	2005	2006	2010	2015	2020
		Import prices				
Crude oil	$/Barrel	52,3	60,0	69,2	79,6	89,1
Crude oil	€/t	314,5	348,7	361,2	437,1	516,0
Natural gas	ct/kWh	1,7	2,3	2,2	2,6	3,0
Hard coal for p. stations	€/tSKE	65,0	60,3	89,9	105,0	120,8
		End-consumer prices				
Industry (wio. VAT)						
Heating oil, EL	€/t	430,0	519,8	539,0	633,9	732,6
Natural gas	ct/kWh	2,2	3,2	3,1	3,5	3,9
Hard coal	€/t	76,5	71,6	102,1	117,5	133,6
Power stations (wio. VAT)						
Natural gas	ct/kWh	2,2	2,7	2,6	3,0	3,5
Hard coal	€/t	76,5	71,6	102,1	117,5	133,6
Lignite	€/GJ	1,05	1,05	1,10	1,14	1,18
Households						
Heating oil, EL	ct/l	44,0	58,4	61,8	72,6	83,9
Natural gas	ct/kWh	5,1	6,2	6,2	6,6	7,1
Petrol (€/l)	€/l	1,18	1,34	1,32	1,37	1,42
Diesel (€/l)	€/l	1,02	1,10	1,12	1,18	1,24

Source: Calculations of DIW Berlin.

5.4.2 Prices for emission allowances within the EU Emission Trading Scheme

In 2007, EU emission allowances were traded at a price near zero on spot markets, while the mean future price for 2010 was about EUR 20 per EUA (European Union Allowance). For purposes of the scenarios, that future price for 2010 is assumed to provide the right scarcity signals, and the spot prices for CO_2-emissions allowances are assumed to increase to EUR 20 per EUA by that time (reference case). The variants considered for that time are prices of EUR 15 (low) and EUR 25 per EUA (high). The spot prices in 2008 also already vary within that range. In the reference case, the price is expected to increase further by 2020, as a result of further-increasing scarcity of emission allowances, to EUR 30 per EUA. In the variants considered, the price in 2020 amounts to EUR 20 (low) or EUR 39 per EUA (high).

Table 60: Assumed development of prices for emission allowances, in 2005 euros, per tonne of CO_2

	2005	2006	2007	2008[a)]	2010	2015	2020
	EUR (2005) per tonne of CO_2						
High	18	17	1	22	25	32	39
Medium	18	17	1	22	20	25	30
Low	18	17	1	22	15	18	20

[a)] January to April 2008 (as of 2008).

Source: DIW

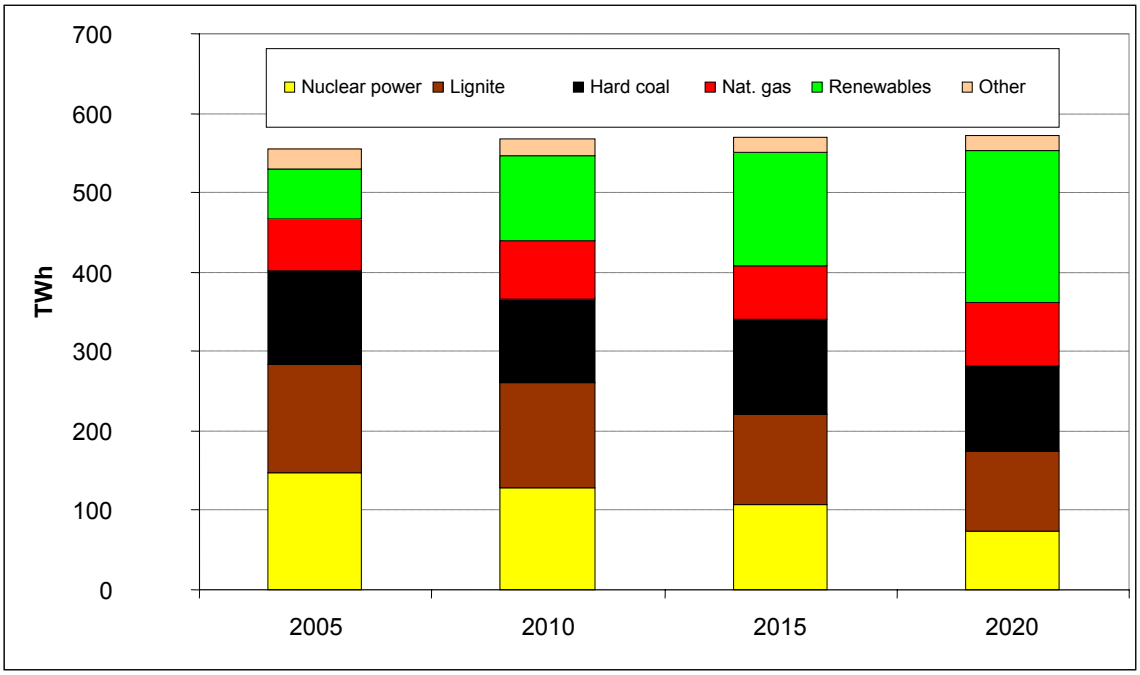
5.4.3 Results of forecasts, by sectors and scenarios

5.4.3.1 Electricity production from fossil fuels

"With additional measures" scenario

In the present section, assessment of the impacts of the measures included in the "with-measures" scenario is oriented solely to *direct* effects, i.e. CO_2 reductions that have a direct effect in the electricity sector. Those effects include CO_2 reductions resulting from changes in power stations overall (efficiency improvements, fuel changes) and effects resulting from decreasing requirements for electricity production from fossil fuels (with such decreases resulting from electricity generation from renewable energies and from reductions in demand). Indirect effects, especially those occurring via supplanting of uncoupled heat production by district heat drawn from CHP systems, or via changes in electricity prices, are considered in the context of final-energy sectors. Figure 15 and Table 61 show the electricity-generation sector's structure under the "with-measures" scenario through 2020.

Figure 15: Development of net electricity generation in the "with-measures" scenario



Source: Calculations of Öko-Institut.

Table 61: Development of electricity generation in the "with-measures" scenario

	2005	2010	2015	2020
			TWh	
Nuclear power	146	128	106	74
Lignite	137	132	115	100
of which, new condensing power stations	0	15	20	20
Hard coal	118	106	119	106
of which, new condensing power stations	0	4	34	34
of which, new CHP	0	0	0	0
Natural gas	65	73	68	82
of which, new condensing power stations	0	16	19	21
of which, new CHP	0	0	0	16
Renewables	63	108	143	190
Other	25	21	20	19
Total	554	568	570	572
Of which, CHP (existing and new, not including renewables CHP)	65	56	47	58

Source: Calculations of Öko-Institut

Electricity generation from renewable energies increases from 63 TWh in 2005 to 190 TWh in 2020. Electricity generation in nuclear power stations decreases, in keeping with the provisions of the Atomic Energy Act (AtG), from 146 TWh to 74 TWh in 2020. Electricity generation from lignite, at a level of 100 TWh in 2020, shows a decrease of 37 TWh from its level in 2005. In light of decommissioning of old lignite-fired power stations, this translates into electricity generation of 20 TWh in new lignite-fired power stations. Electricity generation in hard-coal fired power stations decreases from a level of 118 TWh to 106 TWh; relevant replacement requirements are met solely by new condensing power stations (34 TWh). Electricity generation from natural gas increases from a level of 65 TWh to 82 TWh. Over one-third (16 TWh) of the relevant new natural-gas-fired power stations are built as CHP systems. CHP electricity generation from fossil fuels decreases from a level of 65 TWh (2005) to 58 TWh (2020). CHP electricity generation from renewable energies increases from about 8 TWh (2005) to 20 TWh (2020) (not shown in Table 61).

It needs to be emphasised that any new power generating capacity added in 2010 and 2015 will consist solely either of power stations that are already under construction or of renewable-energy systems. Consequently, policy measures in force until those times will not be able to have any real effect on such capacity.

Modelling points to significant addition of new power stations only as of 2020 (and such new power stations will consist primarily of natural-gas-fired condensing power stations and CHP systems). Since existing CHP systems will be decommissioned as time goes by, for reasons of age, since only condensing power stations will be added during the period until 2015 (in keeping with already specified additions) and since electricity generation from renewable energies will increase only moderately, until 2020 the best that can be hoped for is that CHP electricity generation is stabilised at the 2005 level. The CHP objective will not be achieved.

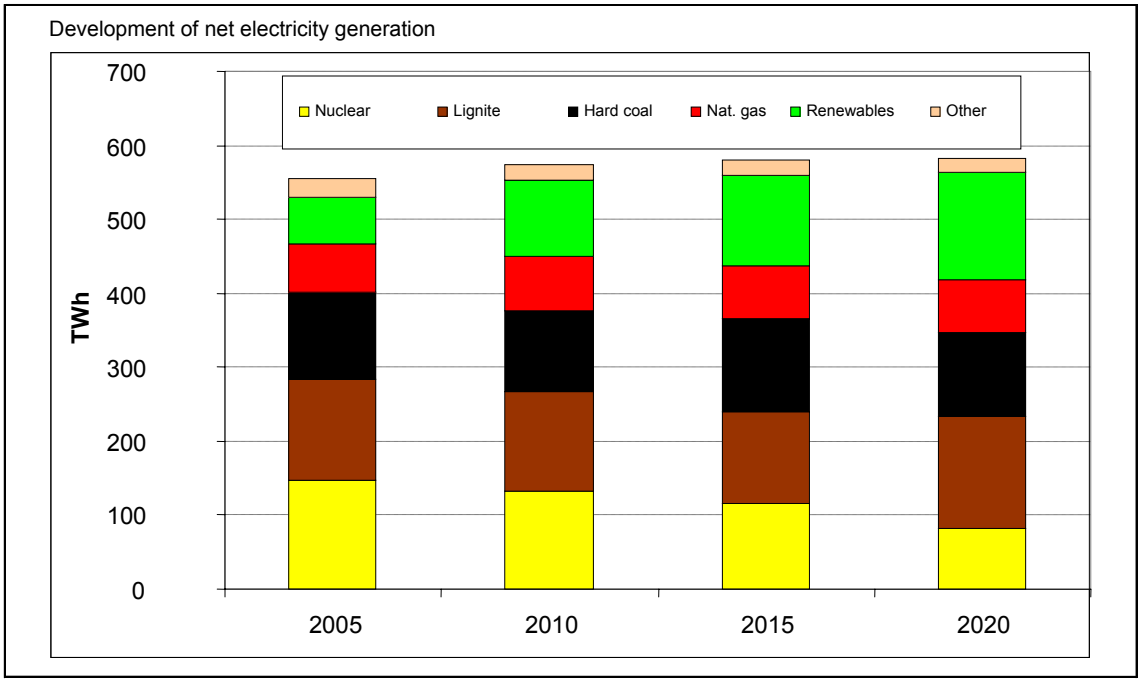
In the "with-measures" scenario, CO_2 emissions from electricity generation decrease from about 363 million t CO_2 (2005) to 287 million t CO_2 in 2020. With regard to emissions avoidance, addition of renewable energies capacities (190 TWh in 2020) thus more than offsets phasing-out of nuclear power (electricity production in 2005: 146 TWh). Via measures under the "with-measures" scenario, savings of about 21% over 2005 levels, and of about 35% over 1990 levels, can be achieved with respect to CO_2 emissions from all power stations through 2020.

Figure 16 and Table 62 show the results of the "without-measures" scenario. The effects correspond to a situation in which the measures termed "overly quantifying" in Section 5.4.1.1 are not applied, and in which, in comparison to the "with-measures" scenario, lower electricity feed-in from renewable energies, and higher electricity consumption, are expected.

Table 63 shows the differences in electricity generation, and in CO_2 emissions[36], between the "without-measures" scenario and the "with-measures" scenario.

As the overview of the applicable differences shows, in the "with-measures" scenario, as compared to the "without-measures" scenario, renewable energies have a considerably higher share of electricity generation, and electricity demand is lower. As an overall result, a smaller share of required new construction has to be met with fossil-fuel power stations. What is more, in the "with-measures" scenario, electricity generation in existing power stations decreases, because hours of usage of such power stations decrease. Consequently, CO_2 emissions in 2020 are 51 million t CO_2 higher in the "without-measures" scenario than they are in the "with-measures" scenario. While in the "with-measures" scenario emissions decrease by 21 % between 2005 and 2020, in the "without-measures" scenario they are only slightly lower in 2020 than they were in 2005. In the "without-measures" scenario, fossil-based CHP electricity generation amounts to 48 TWh in 2020, or 10 TWh lower than in the "with-measures" scenario (58 TWh). In addition, in 2020 CHP electricity generation from renewable energies is slightly lower in the "without-measures" scenario, at about 17 TWh, than it is in the "with-measures" scenario (20 TWh).

Figure 16: Development of electricity generation in the "without-measures" scenario



Source: Calculations of Öko-Institut.

[36] In the present project, a consistent fuel/emissions framework was prepared only for the "with-measures" scenario; no such framework was prepared for the "without-measures" scenario. Consequently, the applicable differences with regard to CO_2 emissions are taken directly from the ELIAS results.

Table 62: Development of electricity generation and of CO_2 emissions in the "without-measures" scenario

	2005	2010	2015	2020
			TWh	
Nuclear power	146	132	116	83
Lignite	137	135	124	150
of which, new condensing power stations	0	15	20	60
Hard coal	118	108	126	114
of which, new condensing power stations	0	4	34	34
of which, new CHP	0	0	0	0
Natural gas	65	75	72	73
of which, new condensing power stations	0	16	19	21
of which, new CHP	0	0	0	2
Renewables	63	102	122	143
Other	25	21	20	20
Total	554	573	580	582
Of which, CHP (existing and new, not including renewables CHP)	65	58	51	48

Source: Calculations of Öko-Institut

Table 63: Effects of existing measures on electricity generation with power stations (difference between "with-measures" scenario and "without-measures" scenario)

	2010	2015	2020
		TWh	
Nuclear power	-4	-10	-8
Lignite	-3	-9	-49
of which, new condensing power stations	0	0	-40
Hard coal	-3	-8	-8
of which, new condensing power stations	0	0	0
of which, new CHP	0	0	0
Natural gas	-2	-4	9
of which, new condensing power stations	0	0	0
of which, new CHP	0	0	14
Total renewables	6	21	47
Other	0	0	0
Total	-5	-9	-10
Of which, CHP (existing and new, not including renewables CHP)	-2	-4	9

Source: Calculations of Öko-Institut.

Table 64 lists the relevant individual measures taken to date and summarises their effects. The figures refer solely to direct CO_2 effects, i.e. to measures' direct effects within the power-station sector. Indirect effects resulting from use of district heating, instead of uncoupled heat, are taken into account in the context of sectors for use of CHP heat.

Table 64: Summary of the effects of measures taken to date (2000 – 2006)

Measure/ implementation/ institution	Type	Description/objectives (impacts)	Implementation status (entry into force)	Direct emissions-reduction effects		
				2010	2015	2020
				Millions of. t CO_2 eq.		
Elimination of the natural gas tax	F	Improvement of the attractiveness of electricity generation with natural gas	2006	0	0	0
Charge for avoided network utilisation	O	Economic improvement of decentralised feed-in (especially of CHP power)	2001	0	0	3
Emission trading	E	Cost-effective CO_2-emissions reduction	2005	0	0	15
CHP Act	E	Compensation for CHP power generation	2002, 2007 amend.	0	0	0
Renewable Energies Act (EEG)	R,E	Minimum compensation for feed-in of power from renewable energies	In force since April 2000, amendments 2004/2008	4	13	36
Electricity saving	O	Reduction of electricity consumption with regard to the "without measures" scenario	2005	3	6	7
Total effects of individual measures				7	19	61
Total effects of individual measures (not including overlapping effects				7	19	51

Source: Calculations of Öko-Institut.

5.4.3.2 Electricity generation from renewable energies

Developments in the "with-measures" scenario

Table 65 shows the effects of measures in the "with-measures" scenario. The central measure in the area of electricity generation from renewable energies is the Renewable Energy Sources Act (EEG). Table 66 provides a detailed overview of development of electricity generation from renewable energies in the "with-measures" scenario.

Table 65: Overview of measures in the "with-measures" scenario

Measure/implementation/ institution	Type	Description/objectives (impacts)	Implementation status (entry into force)	Effect for power supply		
				2010	2015	2020
				TWh		
Renewable Energies Act (EEG) / Federal Government	R, E	Minimum compensation for feed-in of power from renewable energies (aim: share of at least 30% by 2020)	In force since April 2000, amendment 2004, amend. 2008	106	142	189
Research and development/ Federal Government	D	Promotion of R&D, including demonstration, energy-research programme	June 2005	not quantifiable		
Unweighted sum of effects of individual measures				106	142	189
Weighted sum of effects of individual measures (not including overlapping effects)				106	142	189

Electricity generation from renewable energies reaches a level of about 189 TWh in 2020, or about 33 % of gross electricity consumption. Electricity generation from wind energy, both on land and offshore, plays an especially important role in such growth. In 2020, wind energy accounts for a total of 53 % of electricity generation from renewable energies.

Table 66: Electricity generation from renewable energies, in the "with-measures" scenario

	2005	2010	2015	2020
	TWh			
Hydroelectric power	21,5	22,5	23,9	24,3
Wind energy, onshore	27,2	46,8	56,2	67,4
Wind energy, offshore	0,0	0,4	9,8	33,8
Photovoltaic	1,3	5,9	11,2	16,8
Geothermal	0,0	0,0	0,6	0,9
Biomass (gas & liquid))	5,9	15,7	21,9	25,6
Biomass (solid)	5,4	10,3	13,7	16,3
Waste, biogenic	2,1	4,25	4,25	4,25
Import of power from renewables	0	0	0	0
Total generation	63	106	142	189
For information purposes:				
Gross electricity consumption (GEC) (lead study)	612	614	589	571
	%			
Share of GEC, high-price %	10,4	17,2	24	33,2

Sources: Calculations of Fraunhofer ISI, Nitsch, 2008

In the following section, the effects of the 2009 amendment of the Renewable Energy Sources Act (EEG) are analysed via comparison of a) a scenario based on support terms under the EEG 2004 and b) the "with-measures" scenario.

The amendment of the EEG has central impacts in the area of wind energy. Increases in the compensation rates for electricity generated from onshore wind energy systems lead to continuing growth in electricity generation. In the "with-measures" scenario, electricity generation increases by 9 TWh in comparison to the scenario based on the 2004 amendment of the EEG. The effects in the area of offshore wind energy are even more pronounced. Adaptation of pertinent compensation rates can be expected to cause development of offshore wind energy to also commence in Germany. In comparison to the scenario based on the 2004 EEG amendment, in which offshore wind energy does not develop, electricity generation increases by 33.8 TWh. Additional increases occur in the area of biomass, and especially in the area of electricity generation from biogas. In the area of biogas, an increase of the bonus for electricity generated with renewable resources (NAWARO), and the introduction of a "liquid-manure" bonus, boost expansion. As a result of the considerably intensified degression in compensation rates for electricity generation from photovoltaic systems, electricity generation increases somewhat less markedly in that area.

Table 67: Effects of the 2009 amendment of the Renewable Energy Sources Act (EEG) (differences between the "with-measures" scenario and the scenario for the EEG 2004)

	2005	2010	2015	2020
	TWh			
Hydroelectric power	0,0	0,0	0,0	0,0
Wind energy, onshore	0,0	2,5	5,6	9,2
Wind energy, offshore	0,0	0,4	9,8	33,8
Photovoltaic	0,0	-0,8	-1,6	-4,2
Geothermal	0,0	0,0	0,0	0,0
Biomass (gas & liquid)	0,0	4,0	5,8	6,4
Biomass (solid)	0,0	0,5	1,3	1,5
Waste, biogenic	0,0	0,0	0,0	0,0
Import of power from renewables	0,0	0,0	0,0	0,0
Total production	0,0	10,8	27,0	54,6

Source: Calculations of Fraunhofer ISI

5.4.3.3 Other transformation sectors

Results of the projections

Table 68 provides an overview of the development of CO_2, CH_4 and N_2O emissions of heat producers in the other transformation sectors. As the overview shows, in this sector, CO_2 emissions are clearly the predominant emissions among all greenhouse-gas emissions. As was the case for the development from 1990 to 2005, greenhouse-gas emissions in the other transformation sectors are tied both to energy demand levels and to the energy-supply structure. Decreasing reliance on coal and coal products continues through 2020. In the perspective until 2020, petroleum products also contribute less and less to the energy supply. Their contributions are replaced partly via energy-saving, partly via natural gas and partly via renewable energies. While provision of natural gas in the transformation sector does not lead to additional energy consumption – and, thus, to additional emissions [37] – increasing production of biofuels boosts energy requirements for biorefineries. Because biomass is used to meet such transformation installations' own requirements, no additional CO_2 emissions occur, however. Additional CH_4 and N_2O emissions from such transformation installations remain at low levels.

[37] Pursuant to the conventions for greenhouse-gas emissions inventories, energy consumption and emissions of natural gas compressor stations are allocated to the transport sector and included in that sector's results.

Table 68: CO_2, CH_4 and N_2O emissions of other transformation sectors, in the "with-measures" scenario

	1990	2000	2005	2010	2015	2020
	kt CO_2-eq.					
CO_2 emissions						
Development, 1990 - 2005	30.821	21.268	21.099			
"With-measures" scenario				17.055	16.499	15.498
CH_4 emissions						
Development, 1990 - 2005	40	10	11			
"With-measures" scenario				9	9	9
N_2O emissions						
Development, 1990 - 2005	321	99	113			
"With-measures" scenario				92	90	89
Total, CO_2+CH_4+N_2O						
Development, 1990 - 2005	31.182	21.376	21.223			
"With-measures" scenario				17.157	16.598	15.596
Total, CO_2+CH_4+N_2O				Change since 1990, in %		
"With-measures" scenario				-45,0	-46,8	-50,0
Total, CO_2+CH_4+N_2O				Change since 2005, in %		
"With-measures" scenario				-19,2	-21,8	-26,5
Remarks: only energy-related emissions as defined for purposes of the NIR; not including power stations of refineries and of the other transformation sector						

Sources: IKARUS model calculations of IEF-STE and emissions calculations of the Öko-Institut

As a result of changes in the fuel mix, in the "with-measures" scenario greenhouse-gas emissions in other transformation sectors decrease by nearly 6 million t CO_2 equivalents.

5.4.3.4 Transport

Developments in the "with-measures" scenario

Table 69 and Table 70 show the reductions resulting from individual measures in the "with-measures" scenario, while Table 71 shows total energy demand for the transport sector in the "with-measures" scenario. The individual reductions achieved, under the assumptions made, show that the Biofuel Quota Act and the CO_2 strategy for automobiles are the most important measures. In particular, spreading of truck road tolls provides relatively little reduction, because truck engines have reached an advanced level of development; because no new drive technologies, such as electrical or hydrogen-power engines, are planned for that sector (in contrast to what is planned for the automobile sector); and because such spreading provides no incentives for avoiding goods transports and shifting such transports to other modes of transportation. If energy demand for goods transports is to be substantially reduced, significant quantities of such transports must be shifted to railways and to inland waterways.

In the "with-measures" scenario, petrol and diesel fuel remain the main fuels for domestic transports in 2020. In the scenario, kerosene demand grows sharply, in keeping with the assumed growth in demand for air transport.

Table 69: Energy saving via the "with-measures" scenario

Measures	2010	2015	2020
	PJ		
Ecological tax reform 1999 to 2003	-35,1	-35,4	-34,7
Greater spreading of truck road-use tolls	-2,7	-2,7	-4,0
Biofuel Quota Act	-3,4	-7,7	-140,7
CO_2 strategy for automobiles: as of 2012 130 g CO_2/km instead of 140 g CO_2/km	-34,4	-69,3	-83,4
Motor-vehicle taxes determined on the basis of emissions of pollutants and of CO_2	-23,6	-45,9	-43,1
Labelling of new automobiles to show fuel consumption and CO_2 emissions			

Source: Federal Environment Agency, calculations of Fraunhofer ISI

Table 70: Reduction of greenhouse-gas emissions via measures in the "with-measures" scenario

Measure/implementation/ institution	Type	Description/objectives (impacts)	Implementation status (commencement of effects)	Direct emissions-reduction effects		
				2010	2015	2020
				Millions of t CO_2 eq.		
Ecological tax, 99-03	F	Ecological reform of automobile tax, for the period 1999 to 2003, with an increase of 3.07 ct per litre and year (for a total of 15.34 ct/l as of 2003)	1999	-2	-2	-2
Spreading of truck road-use tolls	V	Greater spreading of truck road-use tolls on federal autobahns, for trucks with over 12 t (for three-axle vehicles: 0.106-0.127-0.159-0.207 €/km, depending on emissions class)	Affects new vehicles as of 2008	0	0	0
Biofuel Quota Act (net GHG reduction of 50%)	R	Implementation of the Biofuel Quota Act of December 2006, which mandates mixing of biofuels with petrol (ethanol) and diesel fuel (RME, BTL). The mandated percentage levels for biofuels are 6.75% for 2010, 8% for 2015 and 17% for 2020, measured by volume, and 14% for 2020, measured by energy content.	Affects fuel prices as of 2006; effects increase until 2020 and then remain constant.	-0,2	-0,6	-10
CO_2 strategy for automobiles; i.e. CO_2-emissions target	E	Implementation of the CO_2 strategy for automobiles via introduction of CO_2 emissions standards, leading to average CO_2 emissions, for the German new-automobile fleet in 2012, of 130 g CO_2/km. This reduction is to be achieved via engine- /drive- oriented measures.	Effects as of 2008	-2,5	-5,0	-6
CO_2-based motor-vehicle tax	F	Basing of motor-vehicle taxes on pollution and CO_2 emissions, as of 1 January 2009.	Effects as of 2009	-2	-3	-3
CO_2-oriented labelling of automobiles	E	Introduction of non-ambiguous labelling, to show fuel consumption and CO_2 emissions, for new automobiles as of 1 August 2008. Efficiency class "A" comprises automobiles with less than 1,000 kg empty weight that emit less than 111.5 g CO_2/km, automobiles with less than 1,500 kg empty weight that emit less than 143.5 g CO_2/km and automobiles with less than 2,000 kg empty weight that emit less than 175.5 g CO_2/km.	Effects as of 2008			
Unweighted sum of effects of individual measures				-6,7	-10,5	-21,1

Source: Federal Environment Agency, calculations of Fraunhofer ISI

Table 71: Transport-related energy demand in the "with-measures" scenario (not including construction-sector transports and pipeline transports)

	2000	2005	2010	2015	2020
	PJ				
Petrol	1.237	1.008	855	787	714
Diesel fuel	1.145	1.106	1.182	1.183	1.112
LPG	0	0	0	0	0
CNG	0	0	0	0	0
(Bio-) ethanol	0	0	34	39	71
Biodiesel/FAME	9	71	116	140	242
Vegetable oil	0	0	0	0	0
Hydrogen	0	0	0	0	0
Electricity	57	58	60	62	63
Kerosene	60	69	82	98	115
Total (national)	2.508	2.312	2.329	2.308	2.317
Internat. air transport	239	277	330	390	459
Maritime shipping	91	111	111	111	111

Source: Calculations of Fraunhofer ISI

5.4.3.5 Private Households – space heating and water heating

Developments in the "with-measures" scenario

In the "with-measures" scenario, current practice is assumed to use some 32 % of the available potential for modernisation. Via instruments enacted by 2020, that figure would increase to 37 %. From 2006 to 2020, measures analysed in connection with the "with-measures" scenario reduce emissions by 14.0 million t CO_2, to 102 million t. That corresponds to a 22 % reduction of total emissions with regard to the corresponding levels in 1990.Table 72 shows estimates of the CO_2 reductions that the various measures would achieve. Among monetary support measures, KfW's support programmes for energy-efficient construction and modernisation, which provide reductions totalling 7.1 million t, and the Market Incentive Programme for renewable energies, which provides reductions totalling about 4.8 million t CO_2, deliver the largest contributions.

Two key regulatory measures, amendment of the Energy Saving Ordinance (EnEV) as of mid-2009 and introduction of the Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG), lead to total emissions reductions of 5.2 million t CO_2. Because these instruments are overarching measures, their calculated effects entail some double-counting. As a result, their reductions cannot simply be added to those achieved via monetary support measures.

Table 72: Emissions savings via instruments in the "with-measures" scenario

Measure/implementation/ institution	Type	Description/objectives (impacts)	Implementation status (start of effects)	Direct emissions-reduction effects		
				2010	2015	2020
				Millions of t of CO_2 eq.		
KfW CO_2-oriented building -modernisation programme	F	monetary support	as of 2006	2,8	5,1	7,1
ÖKO PLUS	F	monetary support	as of 2006	0,2	0,4	0,6
Ecological construction ("Ökologisch Bauen")	F	monetary support	as of 2006	0,4	0,7	1,1
"City conversion East" ("Stadtumbau Ost")	F	monetary support	as of 2006	0,0	0,1	0,1
Support for social housing	F	monetary support	as of 2006	0,0	0,1	0,1
On-site energy consultations	F	monetary support	as of 2006	0,2	0,3	0,5
Market Incentive P. for renewables, solar	F	monetary support	as of 2006	0,6	1,1	1,7
Market Incentive P. for renewables, biomass	F	monetary support	as of 2006	0,8	1,7	2,7
Market Incentive P. for renewables, heat pumps	F	monetary support	as of 2008	0,2	0,3	0,4
KfW Home Ownership Programme	F	monetary support	as of 2006	-0,3	-0,4	-0,5
Amendment of the Energy Saving Ordinance	R	regulatory measure	as of 10/2009	0,5	2,1	3,7
Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG)	R	regulatory measure	as of 2009	0,3	0,9	1,5
Amendment of the Ordinance on Heating Costs	R		as of 2009	0,0	0,1	0,2
Dena	I/O/ET		as of 2006			
Information and motivation	I/O		as of 2006			
Campaigns for further training and for quality	D		as of 2006			
R&D in the buildings and heating sectors	ET		as of 2006			
Deductions to take account of overlapping				0,8	3,0	5,1
Unweighted sum of effects of individual measures				5,7	12,6	19,2
Weighted sum of effects of individual measures (not including overlapping effects)				4,9	9,6	14,0

Source: Calculations of the Jülich Research Centre, IEF-STE

5.4.3.6 Electricity consumption of private households

Results of the projections

Table 73 provides an overview of development of electricity consumption by private households, in the scenarios for which the present report has carried out calculations. Only the "with-measures" scenario was considered in detail. The "without-measures" scenario includes only the relevant development without the effects of the measures assessed for the "with-measures" scenario.

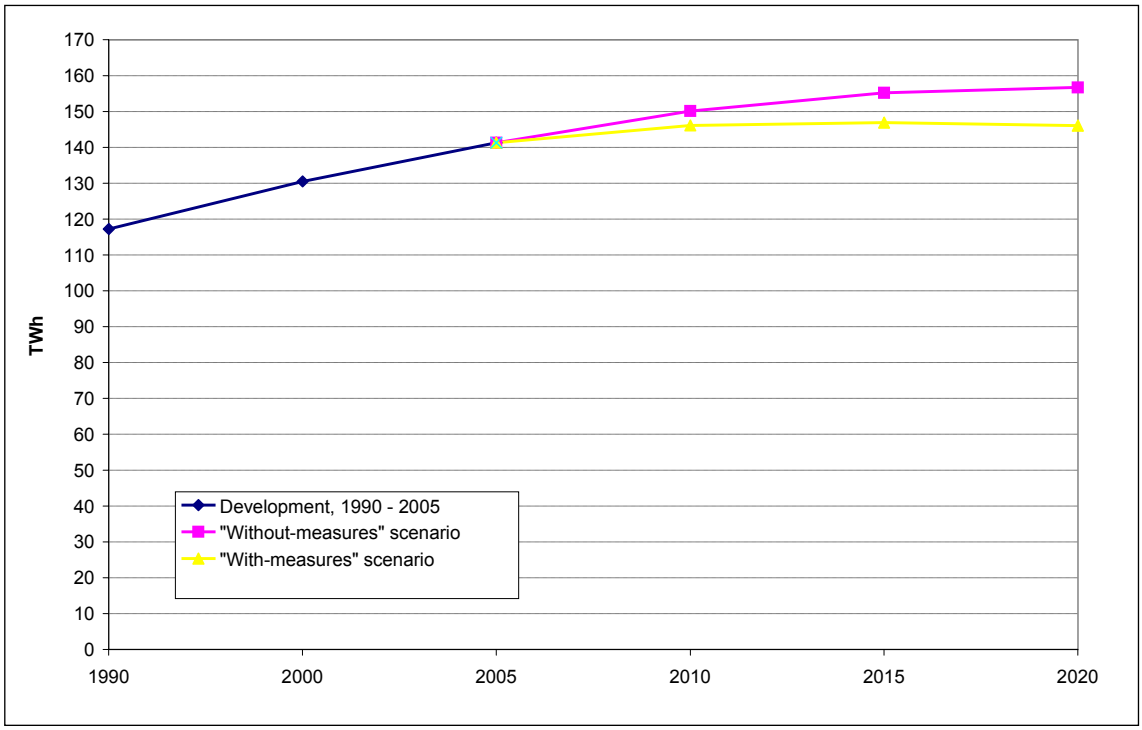
Table 73: Development of electricity consumption by private households, 1990 – 2020, in accordance with various scenarios

	1990	2000	2005	2010	2015	2020
	TWh					
Development 1990 - 2005	117	131	141			
Without measures-scenario				150	155	157
With-measures-scenario				146	147	146
With-measures-scenario				24,7	25,3	24,6
With – measures -scenario				3,4	4,0	3,4

Sources:AGEB (2008), calculations of Jülich Research Centre, IEF-STE

According to calculations for the "with-measures" scenario, use of fossil fuels decreases by a total of 245 PJ by 2020. Decreases in use of heating oil account for over 60 % of the final-energy savings in the area of fossil fuels.

Figure 17: Development of electricity consumption by private households, 1990 – 2020, in accordance with various scenarios



Sources: AGEB 2008, calculations of Fraunhofer ISI and IEF-STE

Table 74 shows the various usage areas' contributions to this development. The largest consumption decreases are expected in the areas of lighting, space heating / water heating and standby consumption of ICT equipment, while electricity consumption by ICT equipment is expected to continue increasing overall at least until 2015.

Table 74: Development of electricity consumption by private households, 1990 – 2020, in accordance with various scenarios and usage areas

	2005	2010	2015	2020
	Electricity consumption in TWh			
Without -measures-scenario	**141,3**	**150,1**	**155,2**	**156,7**
With-measures-scenario	**141,3**	**146,1**	**146,9**	**146,1**
Large electrical appliances	45,8	46,1	45,7	45,6
ICT-devices	28,7	34,9	38,3	40,0
Including standbyy	*8,7*	*9,0*	*7,4*	*6,2*
Lighting	11,8	11,6	11,2	10,9
Space heating/hot water	46,0	44,3	42,2	39,8
Other applications	9,0	9,3	9,6	9,8

Sources: AGEB 2008, calculations of Fraunhofer ISI and IEF-STE

With regard to development of electricity consumption in the "with-measures" scenario, only the impacts of the Energy Consumption Labelling Ordinance (Energieverbrauchskennzeichnungsverordnung – EnVKV), the key relevant measure, were considered. With regard to refrigerators, the impacts of the Ordinance on Maximum Energy Consumption (Energieverbrauchshöchstwerteverordnung – EnVHV) were also estimated. Here, as in the "Policy Scenarios IV" (Öko-Institut et al. 2007), it was assumed that continuation of the EnVKV and the EnVHV in their current forms would lead, via further increases in the relative numbers of "A" devices (and, increasingly, of "A+" and "A++" devices), to reductions of an order similar to that achieved in the period 2000-2004. The savings assumed for that period amounted to about 2.2 TWh.

Table 75: Effects of electricity-oriented measures in the private households sector – "with-measures" scenario

Measure/implementation /institution	Type	Description/objectives (impacts)	Implementation status (start of impacts)	Effect on electricity supply		
				2010	2015	2020
				TWh		
Energy Consumption Labelling Ordinance (Energieverbrauchs-kennzeichnungsverordnung – EnVKV) / Ordinance on Maximum Energy Consumption (Energie-verbrauchshöchstwerteverordnung – EnVHV)/ in force / Federal Government	R	Mandatory labelling of house-hold electrical appliances, to show consumption of energy and other resources (since 1 January 1998: refrigerators / freezers, washing machines, dryers; since 1 March 1999: dishwashers; since 1 July 1999: household lamps; since 1 January 2003: room air conditioners, electric ovens). At present, mandatory maximum permissible energy-consumption levels, pursuant to EnVHV, only for refrigerators and freezers and for some household lamps.	ongoing, since 1 January 1998	2,8	5,6	6,2
Unweighted sum of effects of individual measures				2,8	5,6	6,2
Weighted sum of effects of individual measures (not including overlapping effects)				2,8	5,6	6,2

Source: Estimates of Fraunhofer ISI, on the basis of "Policy Scenarios IV" (Öko-Institut et al. 2007)

5.4.3.7 Commerce-trade-services and industry; electricity and process heat / steam

Results of the projections

The following two tables show the development of greenhouse-gas emissions in the industry and commerce-trade-services sectors. In both sectors, CO_2 is far and away the most important greenhouse gas. Already by 2005, the greenhouse gases nitrous oxide (laughing gas) and methane accounted for less than 1 % of total greenhouse-gas emissions in the areas of industry and commerce-trade-services.

Table 76: Development of greenhouse-gas emissions in industry

	1990	2000	2005	2010	2015	2020
	kt CO_2 eq.					
CO_2 emissions						
Development, 1990 - 2005	99 079	78 824	81 303			
"With-measures" scenario				78 623	85 414	86 874
CH_4 emissions						
Development, 1990 - 2005	192	97	92			
"With-measures" scenario				89	92	92
N_2O emissions						
Development, 1990 - 2005	935	508	510			
"With-measures" scenario				507	536	538
Total, CO_2+CH_4+N_2O						
Development, 1990 - 2005	100 206	79 430	81 905			
"With-measures" scenario				79 219	86 042	87 504
Total, CO_2+CH_4+N_2O				Change as of 1990, in %		
"With-measures" scenario				-20,9	-14,1	-12,7
Total, CO_2+CH_4+N_2O				Change as of 2005, in %		
"With-measures" scenario				-3,3	5,1	6,8
Remarks: only energy-related emissions as defined for purposes of the NIR; not including fuel inputs in industrial power stations of the manufacturing sector						

Sources: Federal Environment Agency (ZSE, NIR), model calculations of Fraunhofer ISI and Öko-Institut

Table 77: Development of greenhouse-gas emissions in commerce-trade-services

	1990	2000	2005	2010	2015	2020
	kt CO_2 eq.					
CO_2 emissions						
Development, 1990 - 2005	86 665	54 333	54 014			
"With-measures" scenario				50 716	46 946	42 572
CH_4 emissions						
Development, 1990 - 2005	1 630	118	74			
"With-measures" scenario				73	76	80
N_2O emissions						
Development, 1990 - 2005	249	161	157			
"With-measures" scenario				142	133	122
Total, CO_2+CH_4+N_2O						
Development, 1990 - 2005	88 543	54 612	54 245			
"With-measures" scenario				50 931	47 155	42 774
Total, CO_2+CH_4+N_2O				Change as of 1990, in %		
"With-measures" scenario				-42,5	-46,7	-51,7
Total, CO_2+CH_4+N_2O				Change as of 2005, in %		
"With-measures" scenario "				-6,1	-13,1	-21,1
Remark: Not including construction-sector transports						

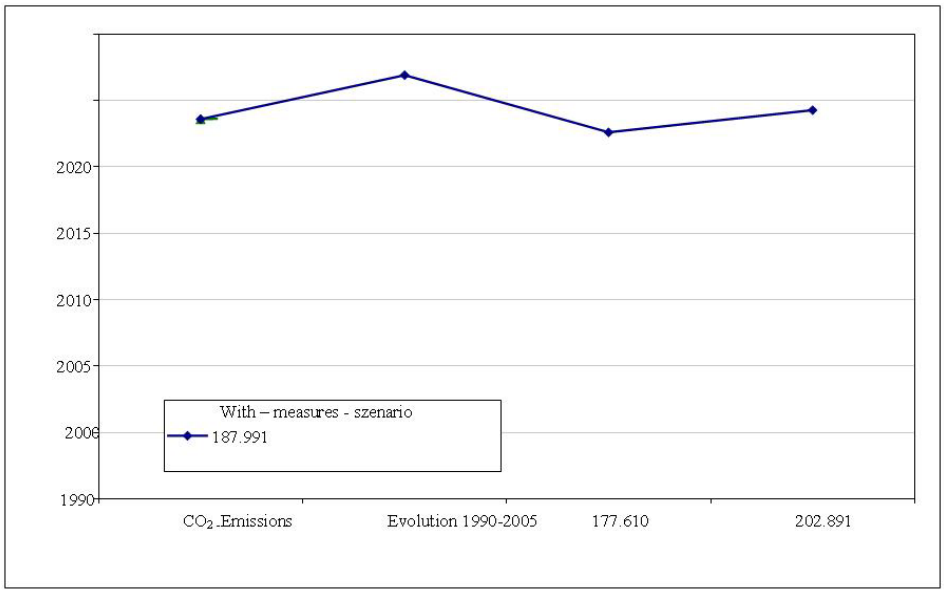
Sources: Federal Environment Agency (ZSE, NIR), model calculations of Fraunhofer ISI und Öko-Institut

In the "with-measures" scenario, political measures have very little impact on development of CO_2 emissions in both the industry and commerce-trade-services sectors. Only emission trading has a marked impact. Other measures in the "with-measures" scenario are oriented primarily to electricity consumption, but their impacts are also not very large. All in all, CO_2 emissions are forecast to increase until 2020 even in the "with-measures" scenario. That development is primarily the result of the following two factors: development of value added, and development of production quantities, the two factors that influence emissions the most. In the period covered by the forecast, both factors increase more strongly than energy efficiency does.

Summing of CO_2 emissions from industrial power stations, especially installations with combined heat/power generation (CHP), is important primarily from a methodological perspective. In the present study, industrial power stations are included in accounting for the transformation sector. Where such power stations are CHP installations, they also have impacts on CO_2 emissions in industry, in that added CHP installations replace installations that produce heat and power separately, which installations are summed with the industry sector. Addition of CHP installations thus increases emissions in the transformation sector and reduces emissions in industry. Overall, however, it leads to lower emissions than those of scenarios with separate generation of electricity and heat.

Development of heat production from industrial CHP installations is shown in Figure 18. In the "with-measures" scenario, that development is relatively constant until 2020.

Figure 18 Development of heat production from industrial CHP installations [PJ]



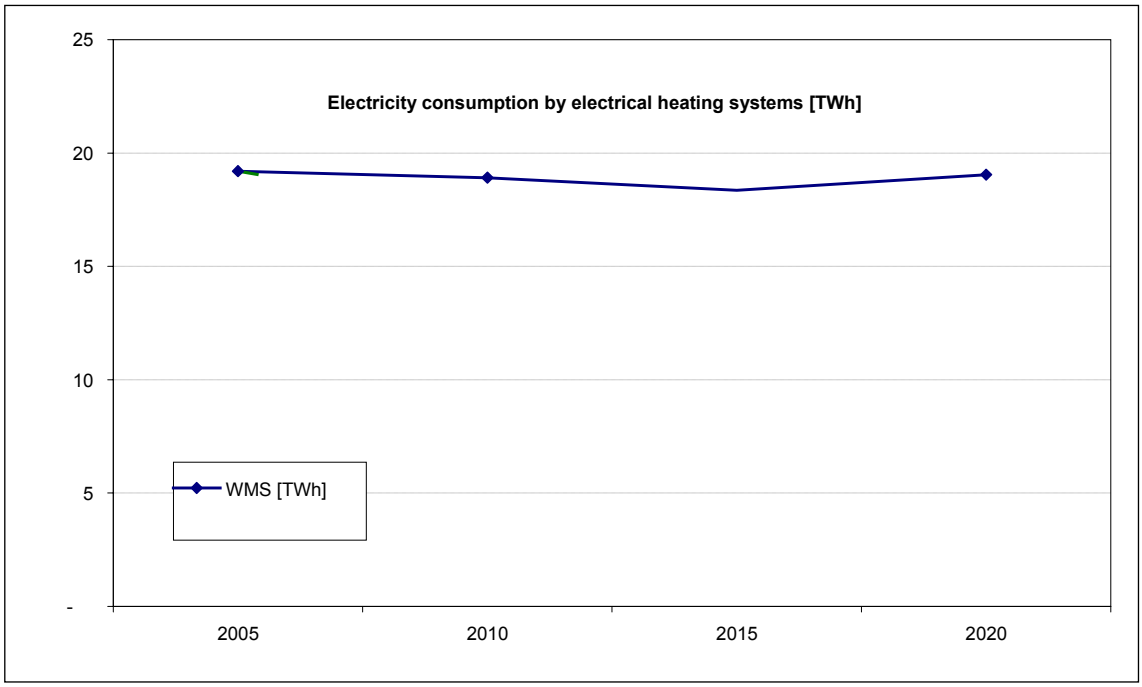
["With-measures" scenario; Emissions; Development, 1990-2005]

Source: Model calculations of Fraunhofer-ISI.

In the commerce-trade-services sector, the most important factors affecting energy consumption (and, thus, CO_2 emissions) are employment growth and improvements in energy efficiency. Initially, rather constant development of employment levels

through 2020 results in relatively constant energy consumption. In the "with-measures" scenario, with additional efficiency improvements, such constant development leads to slight reductions in energy consumption and in CO_2 emissions. Adoption of electrical heating systems also has marked impacts on electricity consumption (Figure 19). In the "with-measures" scenario, electricity consumption by electrical heating systems, in the commerce-trade-services sector, remains about constant. The resulting energy consumption, by industry and commerce-trade-services, and broken down by scenarios, is shown in Table 78. It should be noted that these figures do not include fuel requirements for industrial power stations and for space heating.

Figure 19: Development of electricity consumption of electrical heating systems, in the commerce-trade-services sector



Source: Model calculations of Fraunhofer-ISI.

Table 78: Development of fuel and electricity consumption in the industry and commerce-trade-services sectors

	1990	1995	2000	2005	2010	2015	2020
	Energy consumption, PJ / TWh						
Industry - WMS							
Fuels [PJ]	1 730	1 607	1 567	1 504	1 516	1 641	1 665
Electricity [TWh]	208	190	208	234	240	245	249
Industry - WAMS							
Fuels [PJ]	1 730	1 607	1 567	1 504	1 540	1 726	1 843
Electricity [TWh]	208	190	208	234	228	221	213
CTS - WMS							
Fuels [PJ]	466	220	142	173	176	173	170
Electricity [TWh]	116	124	140	131	132	127	123
CTS - WAMS							
Fuels [PJ]	466	220	142	173	174	168	160
Electricity [TWh]	116	124	140	131	130	117	106
Remarks: Not including fuel inputs in industrial power stations of the manufacturing sector; not including fuel inputs for space heating							

[WMW = "With-measures" scenario; WAMS = "With-addl.-meas." scen.; CTS = commerce/trade/services]

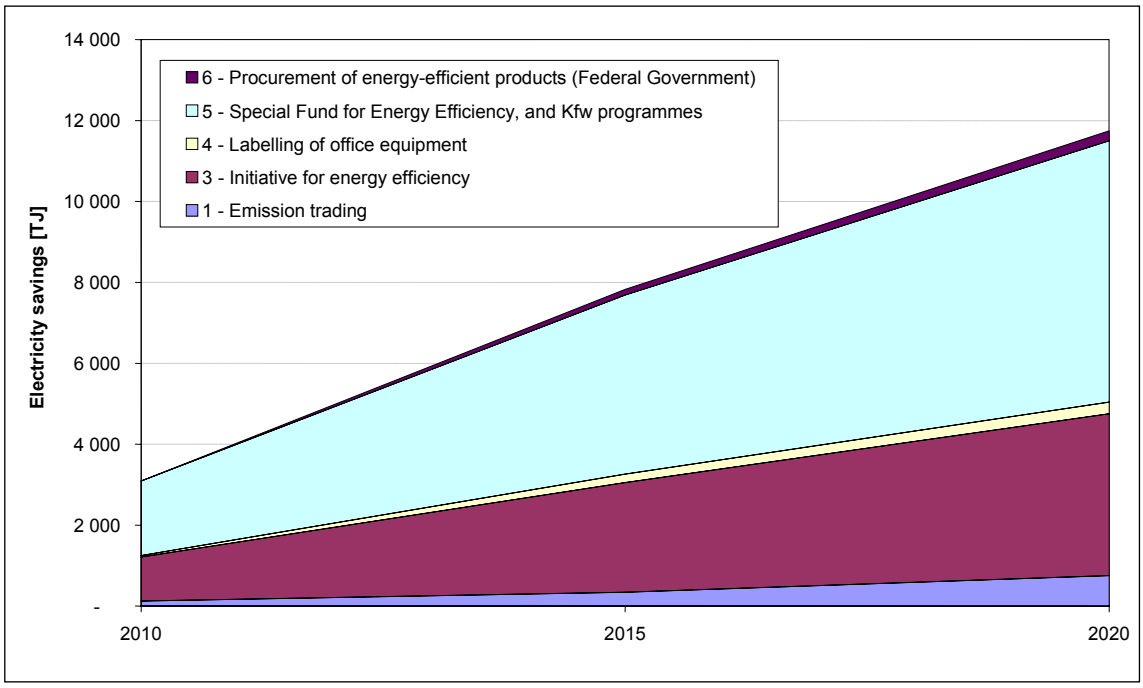
Source: Model calculations of Fraunhofer-ISI.

The following diagrams provide an overview of the quantitative impacts of the various industry measures (the impacts in industry and commerce-trade-services have been combined for each measure). Any overlapping of measures has been taken into account in the modelling, and any such overlapping has been deducted from the measures' effects as shown.

In the "with-measures" scenario, the largest electricity savings are produced by the "Special Fund for Energy Efficiency in SME" and the "Energy Efficiency Initiative" of the German Energy Agency (Deutsche Energieagentur). Federal-sector procurement of energy-efficient products, and labelling of office equipment, have relatively small effects. Federal-sector procurement of energy-efficient products has relatively small effects because federal buildings account for a small share of the entire tertiary sector's electricity consumption. Labelling of office equipment has relatively small effects because IT equipment already has relatively low electricity consumption, and – especially – because "Energy Star" labelling leads to relatively small changes in consumer behaviour. Initially, the electricity savings are triggered by emission trading seem surprising, since emission trading only provides incentives to reduce direct CO_2 emissions. In the present context, electricity savings are the result of measures that reduce both direct CO_2 emissions and electricity consumption.

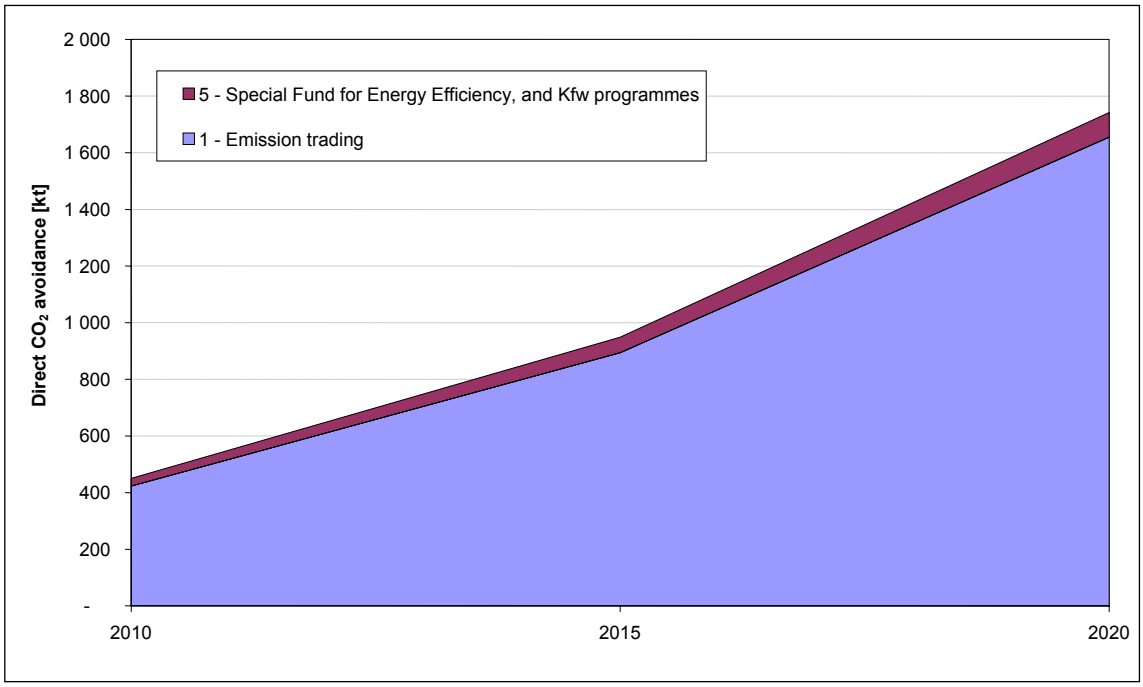
In the "with-measures" scenario, emission trading is the most important measure with regard to direct CO_2 emissions (Figure 20). Otherwise, the "Special Fund for Energy Efficiency in SME" also reduces CO_2 emissions – at a lower level, however. It must be remembered that the Special Fund's impacts in 2008 consisted primarily of improvements in buildings' energy efficiency. Such impacts have also been assumed for the future. As a result, the electricity-consumption and emissions reductions calculated here correspond to only about 20 % of the measures implemented within the Special Fund.

Figure 20 Impacts of measures in industry and commerce-trade-services: reductions of electricity consumption



Source: Model calculations of Fraunhofer-ISI.

Figure 21: Effects of measures in industry and commerce/trade/services, "with-measures" scenario: CO_2 avoidance



Source: Model calculations of Fraunhofer-ISI.

The measures' effects, in terms of avoided electricity consumption and avoided CO_2 emissions, are shown in the following tables, broken down by industry and commerce/trade/services.

Table 79: Overview of measures and their effects in the commerce/trade/services sector, "with-measures" scenario

Measure/ implementation/ institution	Type	Description/objectives (impacts)	Implementation status (start of impacts)	2010	2015	2020
				Direct em.-reduction effects		
				Million t CO_2 eq.		
Special Fund for Energy efficiency in SME, and KfW programmes	F	Linking of subsidised energy consultations with low-interest investment loans for implementation of measures. Aimed at SMEs.	In force since 2008	0,01	0,02	0,03
Unweighted sum of effects of individual measures				0,01	0,02	0,03
Weighted sum of effects of individual measures (not including overlapping effects)				0,01	0,02	0,03
				Effect on electricity supply		
				TWh		
Initiative for energy efficiency	I	Information programmes and campaigns aimed at lowering transaction costs, primarily in the area of cross-cutting technologies	already implemented	0,01	0,20	0,36
Labelling of office equipment	R	Labelling of office equipment (computers, printers, etc.) that conforms to defined minimum standards (Energy Star)	already implemented	0,01	0,06	0,08
Special Fund for Energy Efficiency, and KfW pro-grammes	F	Linking of subsidised energy consultations with low-interest investment loans for implementation of measures. Aimed at SMEs.	In force since 2008	0,06	0,38	0,64
Federal-sector procurement of en.-efficient products	V	Federal-sector procurement of energy-efficient products and services	In force since 2008	0,00	0,04	0,07
Unweighted sum of effects of individual measures				0,08	0,67	1,15
Weighted sum of effects of individual measures (not including overlapping effects)				0,08	0,67	1,15

Table 80: Overview of measures and their effects in the industry sector, "with-measures" scenario

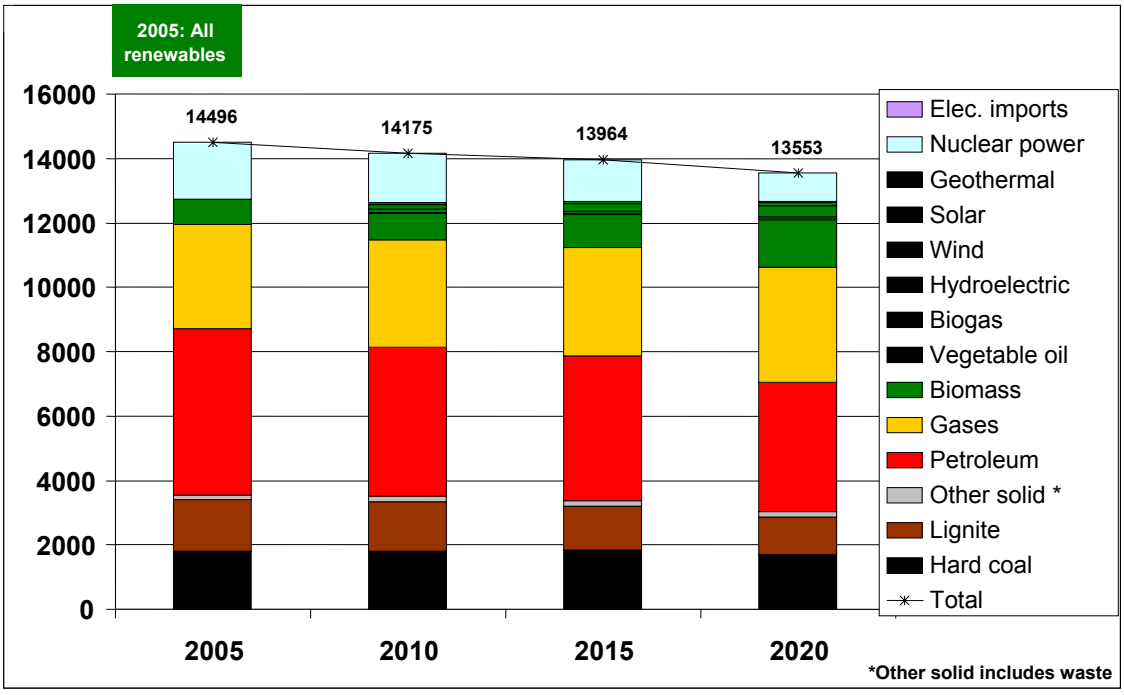
Measure/ implementation/ institution	Type	Description/objectives (impacts)	Implementation status (start of impacts)	2010	2015	2020
				Direct em.-reduction effects		
				Million t CO_2 eq.		
Emission trading	E	Trading with emissions certificates (cap and trade). Primarily affects energy-intensive industry.	In force since 2007	0,42	0,89	1,66
Special Fund for Energy efficiency in SME, and KfW programmes	F	Linking of subsidised energy consultations with low-interest investment loans for implementation of measures. Aimed at SMEs.	In force since 2008	0,02	0,04	0,06
Unweighted sum of effects of individual measures				0,44	0,93	1,72
Weighted sum of effects of individual measures (not including overlapping effects)				0,44	0,93	1,72
				Effect on electricity supply		
				TWh		
Emission trading	E	Trading with emissions certificates (cap and trade). Primarily affects energy-intensive industry.	In force since 2007	0,0	0,1	0,2
Initiative for energy efficiency	I	Information programmes and campaigns aimed at lowering transaction costs, primarily in the area of cross-cutting technologies	Already implemented	0,3	0,6	0,7
Special Fund for Energy efficiency in SME, and KfW programmes	F	Linking of subsidised energy consultations with low-interest investment loans for implementation of measures. Aimed at SMEs.	In force since 2008	0,5	0,9	1,2
Unweighted sum of effects of individual measures				0,78	1,50	2,11
Weighted sum of effects of individual measures (not including overlapping effects)				0,78	1,50	2,11

5.4.3.8 Primary and final energy consumption

Primary energy consumption

In the "with-measures" scenario, primary energy consumption decreases from about 14,500 PJ in 2005 to about 13,500 PJ in 2020 (-6.9 %). This reduction is accompanied by a shift in the structure of primary energy consumption, as Figure 22 shows. From 2005 to 2020, consumption of nuclear power, petroleum and coal decreases markedly. For example, primary energy consumption of petroleum products decreases by nearly 1,150 PJ during the period under consideration, while coal consumption decreases by about 540 PJ. Use of nuclear power also decreases until 2020, as a result of the phase-out agreement between the Federal Government and the operators of nuclear power stations. By contrast, natural gas consumption increases throughout the entire period, from 3,240 PJ in 2005 to about 3,560 PJ in 2020, thereby increasing its relative share of primary energy consumption. Strong growth occurs especially in the area of renewable energies, consumption of which increases about 2.6-fold between the base year 2005 and 2020, the end of the analysis period. Wind energy and biomass play especially prominent roles in this development. In 2020, biomass accounts for over 70 %, or about 1,470 PJ, of total consumption of renewable energies, amounting to about 2000 PJ. Wind energy, accounting for 350 PJ, is the second most important renewable energy source. The remaining 180 PJ consist primarily of contributions from hydroelectric power, solar energy and ambient heat. Still-smaller contributions come from use of liquid and gaseous bioenergies.

Figure 22 Primary energy consumption, by energy sources, in the "with-measures" scenario (WMS)



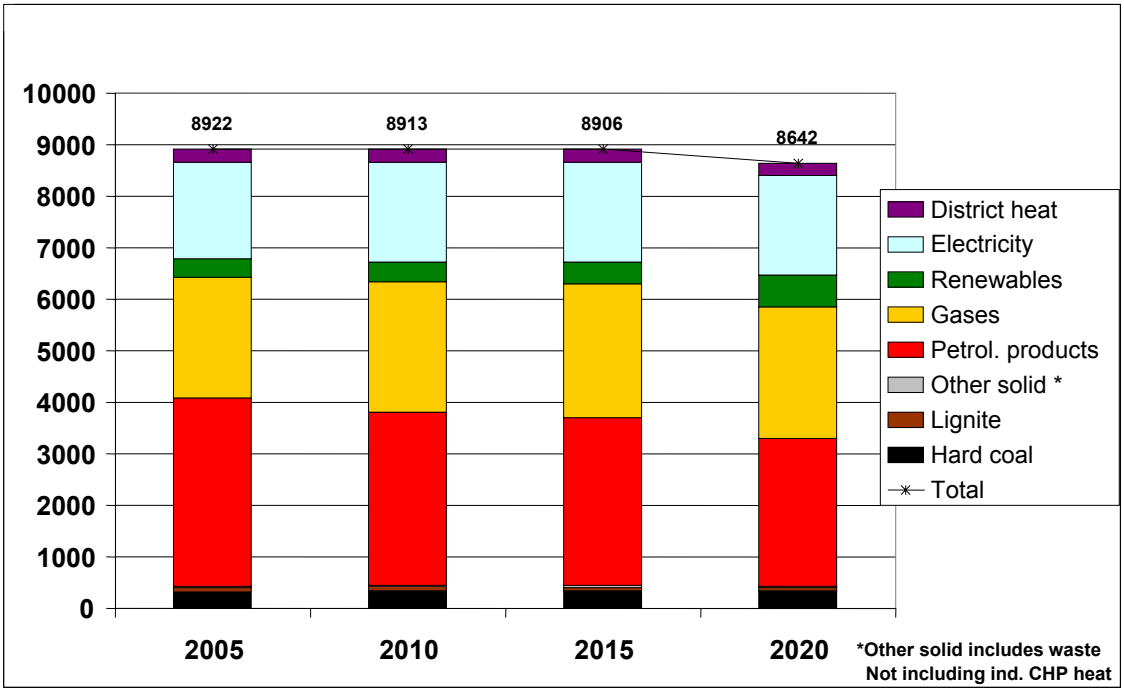
Sources: Calculations of Jülich Research Centre (Forschungszentrum Jülich).

Final energy requirements

Final energy consumption overall is obtained by summing the final energy consumption figures produced by relevant sectoral analyses carried out outside of the model.

The pertinent development in the "with-measures" scenario (WMS), broken down by energy sources, is shown in Figure 23 .

Figure 23 Development of total final energy consumption in the "with-measures" scenario

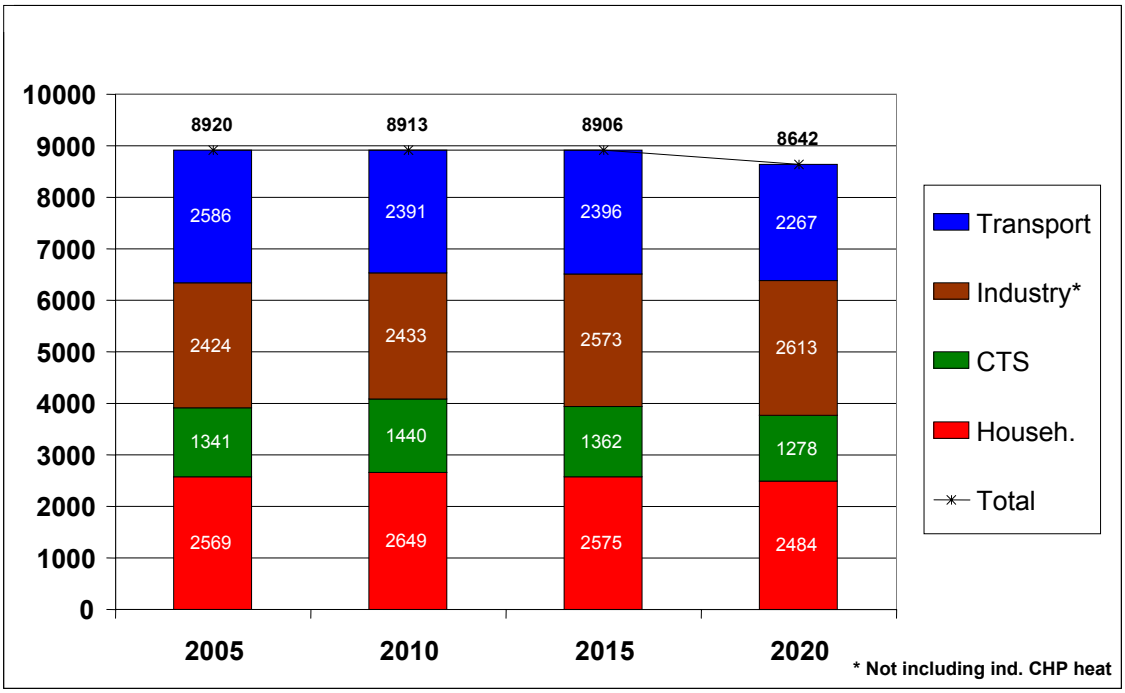


Sources: Fraunhofer ISI, Jülich Research Centre, Öko-Institut.

Total final energy consumption shows a slightly decreasing trend. It decreases from 8,920 PJ in 2005 to about 8,640 PJ in 2020, or about by 3 %. As was the case for development of primary energy consumption, development of final energy consumption differs widely from fuel group to fuel group. Consumption of coal, which mainly occurs in the industry sector – commerce/trade/services and households participate in it only to a small extent – remains about the same throughout the period under consideration. On the other hand, consumption of petroleum products decreases markedly – by nearly 22 % – in the period under consideration. End-user consumption of gases increases, by some 210 PJ, between 2005 and 2020. Different sectors' contributions to this increase differ, however. While consumption in industry increases by about 150 PJ, and consumption by the commerce/trade/services sector grows by 30 PJ, consumption in the households sector decreases slightly (-40 PJ). At the same time, the transport sector's consumption increases by 70 PJ, via marked growth of use of compressed natural gas (CNG). As a result of insulation measures in buildings (an area that includes both the households and commerce/trade/services sectors), demand for district heat decreases by about 11 % over the period under

consideration. Electricity consumption overall increases slightly (+22 TWh in 2020 with respect to 2005), although most of that growth takes place by 2010. In contrast to trends for fossil fuels, end-user consumption of renewable energies increases sharply. From 2005 to 2020, that consumption increases by nearly 70%, from about 370 PJ to 620 PJ. Use of biofuels in the transport sector accounts for the majority of that growth, with biofuels consumption increasing by about 220 PJ (biodiesel and bioethanol). Renewables growth in the households and commerce/trade/services sectors is moderate by comparison. It consists largely of increased use of biomass for heating and increased reliance on solar energy and ambient heat. Figure 24 shows how the sectoral breakdown of final energy consumption develops through 2020. Note: the model results as of 2010 do not include industrial CHP heat production.

Figure 24 Sectoral breakdown of total final energy consumption in the "with-measures" scenario



Sources: Fraunhofer ISI, Jülich Research Centre, Öko-Institut.

5.4.3.9 Total energy-related greenhouse-gas emissions

Emissions from combustion processes

The summed development of CO_2, CH_4 and N_2O emissions from combustion processes, in the "with-measures" scenario (WMS) is shown – along with the emissions allocated to international bunkering – in Table 81. In the WMS, emissions reductions of 17.4 % are achieved from 2005 to 2020. Combustion-related CO_2 emissions play the predominant role among such emissions; CH_4 and N_2O emissions from combustion processes are of subordinate importance. In the WMS, CO_2-emissions reductions of about 57 million t CO_2 are expected in from 2005 to 2010. Also in that scenario, CO_2-emissions reductions of about 144 million t CO_2 (WMS) are expected by 2020, with regard to the 2005 level. As the comparison with the outset values from 1990 shows, such reduction contributions are needed, if the discussed emissions targets for the year 2020 (30 % or 40 % below the 1990 level) are to be met. In the WMS, combustion-related greenhouse-gas emissions (a key source for Germany) are reduced by about 29.5 % from 1990 to 2020.

Table 81: Development of CO_2, CH_4 and N_2O emissions from combustion processes, in the "with-measures" scenario, 1990-2020

	1990	2000	2005	2010	2015	2020
	kt CO_2 eq.					
CO_2 emissions						
Development, 1990 - 2005	177.610	202.891	188.536			
"With-measures" scenario				187.991	188.666	184.431
CH_4 emissions						
Development, 1990 - 2005	1.294	350	199			
"With-measures" scenario				184	176	172
N_2O emissions						
Development, 1990 - 2005	785	1.883	1.623			
"With-measures" scenario				1.674	1.726	1.807
Total, CO_2+CH_4+N_2O						
Development, 1990 - 2005	179.689	205.125	190.358			
"With-measures" scenario				189.849	190.568	186.409
Total, CO_2+CH_4+N_2O				Change as of 1990, in %		
"With-measures" scenario				5,7	6,1	3,7
Total, CO_2+CH_4+N_2O				Change as of 2005, in %		
"With-measures" scenario				-0,3	0,1	-2,1
Remark: Not including construction-sector transports						

Sources: Federal Environment Agency (ZSE, NIR), model calculations of Fraunhofer ISI und Öko-Institut

Sources: Federal Environment Agency (2008 a+b), calculations of Fraunhofer ISI, IEF-STE and Öko-Institut.

Results of the projections

Table 82 shows the development of fugitive CH_4 emissions from the energy sectors for the "with-measures" scenario (WMS). The total relevant emissions reduction, about 6 million t CO_2 eq. from 2005 to 2020, is primarily the result of reductions of German hard-coal mining; the net effect in that sector (a combination of decreasing emissions in active mines and constant emissions from decommissioned mines) amounts to a reduction of about 5 million t CO_2 eq.. Slight changes in CH_4 emissions result from a reduction of CH_4 emissions from natural gas distribution; reduced natural gas use in private households and in the commerce/trade/services sector, from 2005 to 2020, leads to an emissions reduction of about 0.3 million t CO_2 eq..

All in all, the energy sector's fugitive CH_4 emissions decrease by about 48 % from 2005 to 2020.

Table 82: Development of the energy sector's fugitive CH_4 emissions in the "with-measures" scenario, 2000-2020

	2000	2005	2010	2015	2020
	kt				
Active coal mining					
Hard-coal deep mining	*439,8*	*254,5*	*183,9*	*102,2*	*0,0*
Hard-coal processing	*19,3*	*14,3*	*10,4*	*5,8*	*0,0*
Open-pit lignite mining	*1,8*	*2,0*	*1,9*	*1,6*	*1,4*
Coal transformation	0,4	0,4	0,4	0,4	0,4
Decommissioned mine pits	129,1	2,9	2,9	2,9	2,9
Oil production and provision					
Transport	*3,4*	*3,9*	*3,2*	*2,6*	*1,9*
Storage	*2,7*	*2,3*	*2,0*	*1,9*	*1,7*
Natural gas					
Production	*56,8*	*53,1*	*55,9*	*55,0*	*50,6*
Transport	*37,8*	*40,1*	*41,8*	*41,8*	*43,2*
Distribution	*191,3*	*165,9*	*170,9*	*161,6*	*151,1*
Other leakages	*58,5*	*67,0*	*69,0*	*65,3*	*61,0*
Total	941,0	606,3	542,2	441,0	314,2
Total (kt CO_2 eq.)	19.761	12.732	11.386	9.261	6.598
compared to 2005	*55,2%*	*-*	*-10,6%*	*-27,3%*	*-48,2%*

Sources: Federal Environment Agency (2008 a+b), calculations of the Öko-Institut.

5.4.3.10 HFC, PFC and SF6 emissions (industrial processes and product use)

Results of the projection

Use of the above-described methodological approach, in connection with the "with-measures" scenario (WMS), yields the emissions development shown in Table 83. As the table shows, HFC emissions will continue to be the largest emissions contribution; sharply increasing HFC emissions from refrigerators and air conditioning systems are only partly offset by (absolute) emissions reductions in other areas (foam production). All in all, in the WMS, emissions of HFC, PFC and SF_6 are returned to the 2005 levels by 2020.

Table 83: Development of HFC, PFC and SF_6 emissions from industrial processes and product use, in the "with-measures" scenario, 2000-2020

	2000	2005	2010	2015	2020
	kt CO_2 eq.				
HFC emissions					
Production of halocarbons and SF_6 (2E)	1.207	516	C,IE	C,IE	C,IE
Refrigeration and air conditioning systems (2F)	3.553	7.491	10.847	9.623	8.399
Foam blowing[b] (2F)	1.206	1.250	381	426	471
Fire extinguishers (2F)	2	7	8	11	14
Aerosols and metered dose inhalers (2F)	483	613	564	620	685
Semiconductor production (2F)	17	16	10	10	10
Not specified /confidential[a] (2F)	1	3	510	506	502
Subtotal, HFC	6.469	9.896	12.319	11.195	10.080
PFC emissions					
Aluminium prodution (2C)	356	338	167	167	167
Refrigeration and air conditioning systems	84	132	141	109	78
Production of halocarbons and SF_6 (2E)	NO	NO	NO	NO	NO
Semiconductor production (2F)	346	249	125	125	125
Not specified /confidential[a] (2F)	0	0	13	13	13
Subtotal, PFC	786	718	446	415	383
SF_6 emissions					
Magnesium foundries[b] (2C)	650	668	301	412	524
Production of halocarbons and SF_6 (2E)	C,IE	C,IE	C,IE	C,IE	C,IE
Semiconductor production (2F)	56	75	11	11	11
Electrical equipment (2F)	1.158	762	592	594	595
Automobile tyres (2F)	1.195	65	0	0	0
Trace gases (2F)	12	12	18	18	18
Soundproof windows (2F)	1.234	1.348	1.076	1.490	1.904
Not specified /confidential[a] (2F)	772	450	412	412	413
Subtotal, SF_6	5.078	3.380	2.409	2.937	3.464
Total	12.333	13.994	15.174	14.546	13.927
with regard to 2005	*-11,9%*	*-*	*8,4%*	*3,9%*	*-0,5%*
with regard to 1995	*-20,1%*	*-9,4%*	*-1,7%*	*-5,8%*	*-9,8%*

Remarks: [a]Values that, in the inventories, are marked as confidential, that are not broken down further, or that cannot be consistently allocated. [b]Divergences from inventory values for 2005 on the basis of new findings of UBA

Sources: Federal Environment Agency (2008 a+b), Öko-Recherche 2005, calculations of the Öko-Institut.

5.4.3.11 Results of projections for process-related greenhouse-gas emissions (including product use)

Table 84 provides an overview of emissions of CO_2, CH_4, N_2O, HFC, PFC and SF_6 from industrial processes, for the "with-measures" scenario (WMS). In the "with-measures" scenario, total emissions decrease by nearly 18 % from 2005 to 2020. The largest contribution to this development is made via measures in the area of N_2O emissions (i.e. especially inclusion of N_2O emissions from adipic-acid and nitric-acid production within the EU emission trading scheme).

Table 84: Development of total greenhouse-gas emissions from industrial processes and product use, in the "with-measures" scenario, 1990-2020

	1990	2000	2005	2010	2015	2020
	kt CO_2 eq.					
CO_2 emissions						
Development, 1990 - 2005	84.157	82.983	77.917			
"With-measures" scenario				73.640	73.023	71.717
C_4 emissions						
Development, 1990 - 2005	4	2	2			
"With-measures" scenario				2	2	2
N_2O emissions						
Development, 1990 - 2005	25.865	6.868	15.579			
"With-measures" scenario				11.154	2.878	2.925
HFC emissions						
Development, 1990 - 2005	4.369	6.469	9.896			
"With-measures" scenario				12.319	11.195	10.080
PFC emissions						
Development, 1990 - 2005	2.708	786	718			
"With-measures" scenario				446	415	383
S_6 emissions						
Development, 1990 - 2005	4.785	5.078	3.380			
"With-measures" scenario				2.409	2.937	3.464
Total greenhouse-gas emissions						
Development, 1990 - 2005	121.888	102.187	107.493			
"With-measures" scenario				99.970	90.449	88.571
Total greenhouse-gas emissions				Change as of 1990, in %		
"With-measures" scenario				-18,0	-25,8	-27,3
Total greenhouse-gas emissions				Change as of 2005, in %		
"With-measures" scenario				-7,0	-15,9	-17,6

Sources: Federal Environment Agency (2008 a+b), Öko-Recherche 2005, calculations of the Öko-Institut.

5.4.3.12 Agriculture

Results of the projections

The projections for the years 2010, 2015 and 2020 have been derived on the basis of the assumptions made in the framework data.

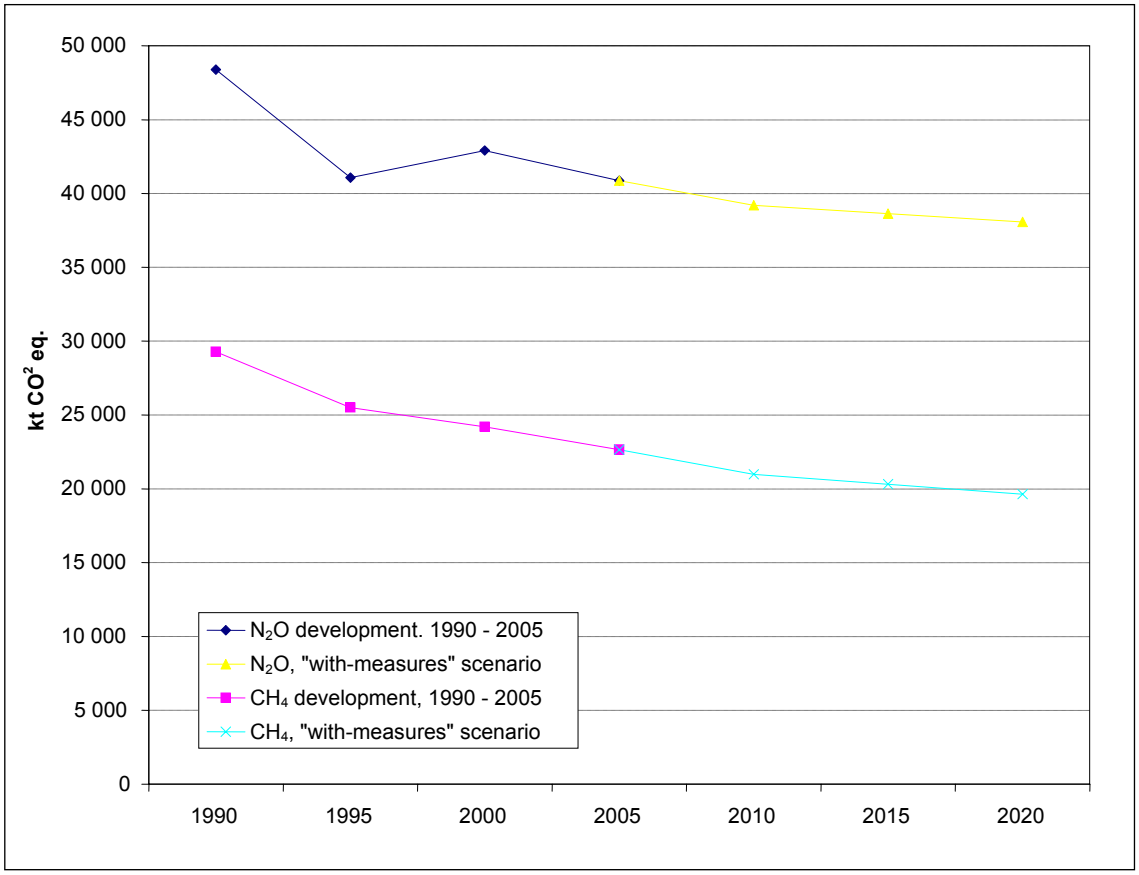
Table 85: Development of CH_4 emissions in agriculture, 1990-2020

Year	1990	1995	2000	2005	2010	2015	2020
Reference	Greenhouse-gas inventory, 2008				Projection (WMS)		
	[kt CH_4]						
Agriculture (CRF 4)	1.394,9	1.214,8	1.152,8	1.079,2	999,8	967,6	935,5
A. Fermentation	1.146,8	987,8	929,2	873,4	800,4	774,4	748,3
B. Fertiliser use	280,0	257,9	253,9	235,9	227,4	221,3	215,1
D. Agricultural soils	-32,0	-31,0	-30,3	-30,2	-28,1	-28,0	-28,0
C., E., F., G.	NO	NO	NO	NO	NO	NO	NO
	[kt CO_2 eq.]						
CH_4 emissions, in CO_2 eq.	29.292	25.510	24.209	22.662	20.995	20.320	19.645
	[%]						
Change with respect to 1990		-12,9	-17,4	-22,6	-28,3	-30,6	-32,9
Change with respect to 2005					-7,4	-10,3	-13,3

Sources: Federal Environment Agency (2008a), Federal Environment Agency (2008b), calculations of Öko-Institut

Table 85 shows the impacts of changes in relevant land use on development of CH_4 and N_2O emissions. From 2005 to 2020 (from 1990 to 2020), total CH_4 emissions in the relevant areas, fermentation, fertiliser use and agricultural soils, decrease by 13.3 % (32.9 %). Total N_2O emissions in the relevant areas, fertiliser use and agricultural soils, decrease by 6.9 % from 2005 to 2020 and by 21.3 % from 1990 to 2020. Figure 25 combines these changes in emissions of the two gases. Ultimately, total agricultural emissions decrease by 9.2 % from 2005 to 2020, and by 25.7 % from 1990 to 2020, to 57,723 kt CO_2 eq. in 2020.

Figure 25 Development of CH_4 and N_2O emissions in agriculture, 1990-2020



Sources: Federal Environment Agency (2008a), Federal Environment Agency (2008b), calculations of Öko-Institut

5.4.3.13 Waste management

Results of the projections

The results of the model calculations for the "with-measures" scenario show that a significant reduction of CH_4 emissions from landfills is the predominant factor in the sector's overall emissions development. From 2005 to 2020, the global warming potential of CH_4 and N_2O emissions from the waste-management sector decreases by nearly 7 million t CO_2 eq.. At the same time, emissions from considerably expanded, and heavily used, installations for composting and for biological and mechanical waste treatment increase only minimally.

Table 86: Development of CH_4 and N_2O emissions from waste management, 2000-2020

	2000	2005	2010	2015	2020
	kt				
Waste input					
Landfills	10.935	8.578	735	735	735
Composting installations	10.284	12.391	12.500	12.500	12.500
Mechanical-biological waste treatment	1.246	1.542	7.122	7.122	7.122
CH_4 emissions					
Landfills	892	464	302	207	149
Municipal wastewater treatment	8	6	6	6	6
Composting	26	26	28	28	28
Mechanical-biological waste treatment	0,2	0,2	1,1	1,1	1,1
Subtotal, CH_4	926	496	337	242	184
N_2O emissions					
Municipal wastewater treatment	7,47	7,57	7,57	7,57	7,57
Composting	0,66	0,68	0,71	0,71	0,71
Mechanical-biological waste treatment	0,29	0,43	0,71	0,71	0,71
Subtotal, N_2O	8,42	8,67	8,99	8,99	8,99
Total (kt CO_2 eq.	22.060	13.110	9.858	7.864	6.640
with respect to 2005	*68,3%*	*-*	*-24,8%*	*-40,0%*	*-49,4%*

Quellen: UBA (2008 a+b), Öko-Institut/ifeu (2005), Berechnungen des Öko-Instituts.

5.4.3.14 Development of emissions, by greenhouse gases

"With-measures" scenario

Table 87 shows the development of emissions of CO_2, CH_4, N_2O, HFC, PFC and SF_6, for the "with-measures" scenario (WMS). In that compilation, greenhouse-gas emissions from international fuel bunkering (maritime shipping and international air transports) are listed separately, and not included in the relevant sum totals.

From 2005 to 2020, greenhouse-gas emissions decrease by about 18.7 %. With respect to the base year of the Kyoto Protocol, that decrease amounts to an emissions reduction of 33.5 %. The largest reduction contribution is made in the area of CO_2 emissions; that area accounts for over 80 % of the total emissions reduction. The contributions from reduction of CH_4 and N_2O emissions are about the same. At the same time, as the overview highlights, emissions from international (air) transport continue to show an increasing trend even in the WMS. In the WMS, only emissions of the synthetic gases HFC, PFC and SF_6 increase (and the increases begin from low basic levels).

Table 87: Development of total greenhouse-gas emissions, in the "with-measures" scenario, by gases, 2000-2020

	2000	2005	2010	2015	2020
	Millions of t of CO_2 eq.				
Carbon dioxide	883,4	876,9	814,6	783,8	721,4
Methane	64,7	47,7	40,6	35,8	31,2
Nitrous oxide	59,1	65,5	59,4	50,5	49,6
HFC	6,5	9,9	12,3	11,2	10,1
PFC	0,8	0,7	0,4	0,4	0,4
SF_6	5,1	3,4	2,4	2,9	3,5
Total	1.019,5	1.004,0	929,8	884,7	816,1
with respect to 2005	*1,5%*	*-*	*-7,4%*	*-11,9%*	*-18,7%*
with respect to base year[a]	*-17,0%*	*-18,2%*	*-24,3%*	*-27,9%*	*-33,5%*
For information purposes:					
International air transport and maritime bunkering	*24,8*	*29,3*	*30,5*	*32,2*	*34,1*

Remark: [a]The base year is 1990 for carbon dioxide, methane and nitrous oxide, and 1995 for HFC, PFC and sulphur hexafluoride

Sources:Federal Environment Agency (2008 a+b), calculations of Fraunhofer ISI, IEF-STE and Öko-Institut.

In light of the relatively long lead times of the measures required for the emissions reductions, the pace of emissions reductions increases over time. The large reduction contribution seen between 2005 and 2010 is due primarily to a number of special effects (electricity exports, development of energy prices, etc.).

5.4.3.15 Development of greenhouse-gas emissions by source categories

"With-measures" scenario

Table 88 presents an overview, structured by source categories, of emissions development in the "with-measures" scenario (WMS), for the period 2000 to 2020. Nearly half of the emissions reductions achieved in this period are achieved by the energy sectors, especially the electricity-generation sector. In the WMS, the transport sector provides the second-largest contribution, while the third-largest (by quantity) group of emissions reductions is achieved in the area of process-related greenhouse-gas emissions.

Table 88: Development of total greenhouse-gas emissions, in the "with-measures" scenario, by source categories, 2000-2020

	2000	2005	2010	2015	2020
	Million CO_2 eq.				
Energy sectors	351,3	366,1	335,1	314,4	285,6
Industy	99,2	104,6	100,2	105,4	108,0
CTS	54,6	54,2	50,9	47,2	42,8
Households	118,9	116,2	114,5	108,6	102,1
Transport	184,3	165,5	147,7	142,5	118,2
Fugitive emissions from energy sectors	19,8	12,7	11,4	9,3	6,6
Industrial processes	101	106	99	89	87
Product use	1	1	1	1	1
Agriculture	67	64	60	59	58
Waste management	22	14	10	8	7
Total	1.019,5	1.004,0	929,8	884,7	816,1
with respect to 2005	*1,5%*	*-*	*-7,4%*	*-11,9%*	*-18,7%*
with respect to base year	*-17,0%*	*-18,2%*	*-24,3%*	*-27,9%*	*-33,5%*
For information purposes:					
International air transport and maritime bunkering	*24,8*	*29,3*	*30,5*	*32,2*	*34,1*

Remark: [a]The base year is 1990 for carbon dioxide, methane and nitrous oxide, and 1995 for HFC, PFC and sulphur hexafluoride

Sources: Federal Environment Agency (2008 a+b), calculations of Fraunhofer ISI, IEF-STE and Öko-Institut.

With regard to the pace of emissions reductions, process-related emissions and the waste-management sector need to be highlighted. From 2005 to 2020, the waste management sector's total greenhouse-gas emissions decrease by over 50 %, while greenhouse-gas emissions from industrial processes are reduced by nearly 50 %. Emissions reductions of about 20 % are achieved in final consumption sectors – with the exception of industry – and in the area of energy transformation.

5.4.3.16 Analysis of components of energy-related greenhouse-gas emissions

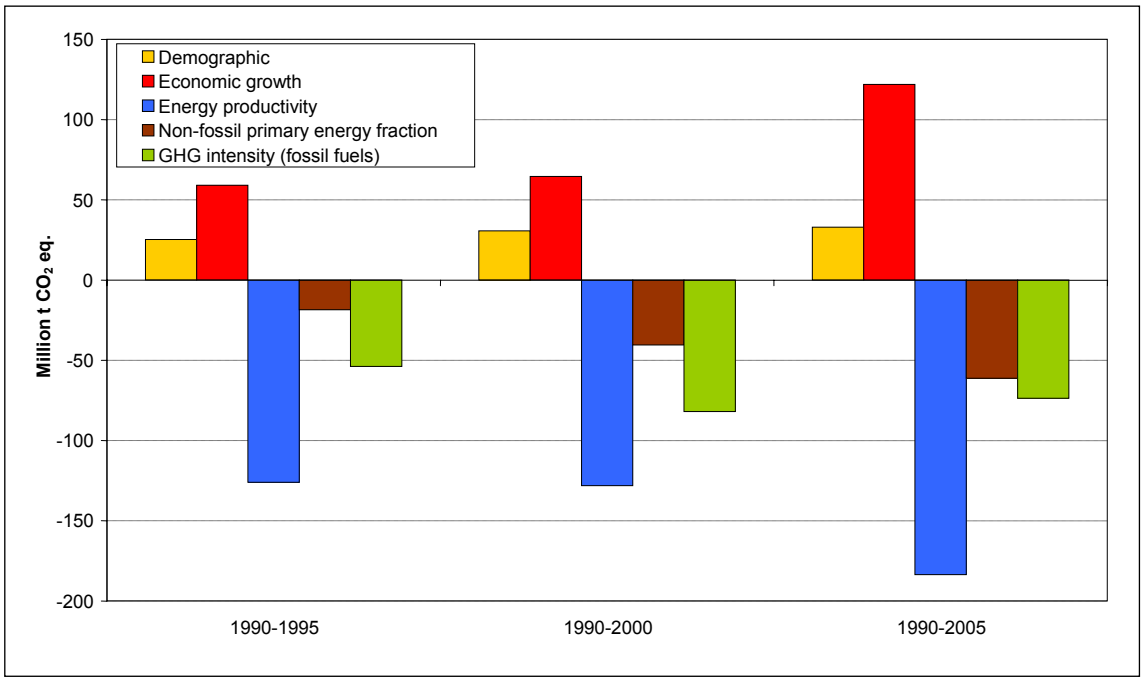
In the area of energy-related greenhouse-gas emissions, component analysis has been used to highlight the contributions of various relevant basic developments. In the process, the following components are differentiated:

- the influence of demographic trends,
- the contribution of economic growth,
- the effect of changed energy productivity[38],
- the contribution of changes in shares for non-fossil energy sources,

[38] A non-negligible contribution to energy-productivity increases for the economy as a whole results from the statistical conventions for primary-energy-side assessment of renewable energies, and of nuclear energy. The component analysis was not adjusted to take account of such statistical artifacts.

- the impacts of changes in the fossil-fuel mix.

Figure 26 Components of the development of energy-related greenhouse-gas emissions in Germany, 1990-2005



Sources: Federal Environment Agency, Working Group on Energy Balances (AG Energiebilanzen), Federal Statistical Office, DIW Berlin, calculations of the Öko-Institut.

Figure 26 shows the results of component analysis for the periods 1990 to 1995, 1990 to 2000 and 1990 to 2005.[39]

As the overview shows, the largest emissions-reduction contributions since 1990 have resulted from improved energy productivity (relationship between gross domestic product and primary energy consumption), although the largest such effect took place in the first half of the 1990s – i.e. had to do primarily with economic restructuring in the new German Länder. Only after 2000, following a phase of stagnation at the end of the 1990s, were significant emissions reductions again achieved.

A comparably constant effect is seen in the growing share of non-fossil energy sources, i.e. in growth of renewable energies and, in the 1990s, of electricity production from nuclear power stations. On the other hand, the contribution from changes in energy sources, toward less carbon-intensive fossil fuels, increased considerably until 2000. Thereafter, it decreased again considerably – most likely as a result of energy-price trends. Germany's economic development is the key driving factor offsetting emissions reductions. For the period 1990 to 2005, that factor must be assigned an emissions-increasing contribution of about 122 Mt CO_2 eq..

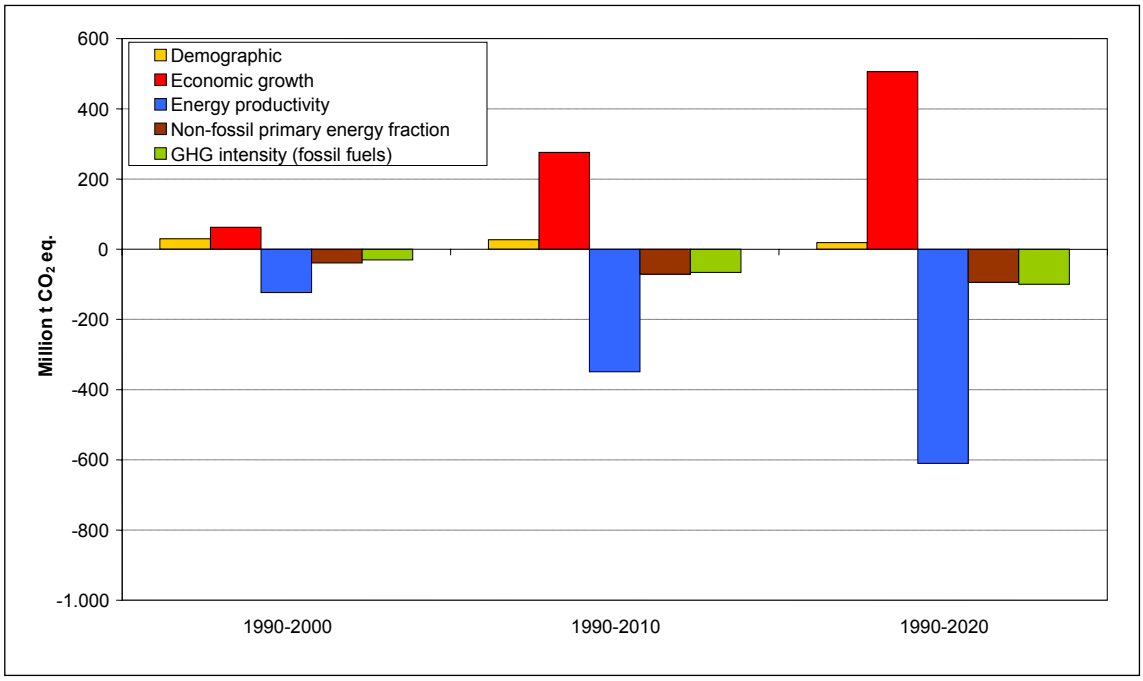
[39] The component-analysis procedure used here has been developed from an approach described by Diekmann et al. (1999). In a departure from that approach, the analysis shown here takes account of energy-related CH_4 and N_2O emissions, as well as energy-related CO_2 emissions. The 1990 GDP figure for Germany on which the calculation is based was estimated by DIW Berlin; official statistics do not include pertinent data.

Population growth in the period 1990 to 2005 accounts for an emissions-increasing contribution of about 33 Mt CO_2 eq.. For the period 1990 to 2005, therefore, the emissions-increasing contributions from economic and population growth, about 155 Mt CO_2 eq., must be balanced against reduction contributions from increased energy productivity (nearly 184 million t CO_2 eq.), a growing contribution from non-fossil energy sources (61 million t CO_2 eq.) and changes in the mix of fossil fuels (nearly 74 million t CO_2 eq.), amounting to a total of nearly 319 Mt CO_2 eq., yielding a net reduction of energy-related greenhouse-gas emissions of nearly 164 Mt CO_2 eq..

Figure 27 shows the result of component analysis for the development of energy-related greenhouse-gas emissions in the WMS. The various relevant components show different development patterns.

- Demographic trends show marked changes over time. While population growth provides a marked emissions-increasing contribution from 1990 to 2005, as of 2005 that trend reverses. In comparison to the situation in 1990, population growth provides a slightly emissions-increasing contribution for the emissions development until 2020 (nearly 19 million t CO_2 eq.), while in comparison to the situation in 2005, population decreases until 2020 tend to reduce emissions (by about -13 million t CO_2 eq.).
- Economic growth clearly functions as an emissions-increasing component. Its contribution amounts to about 506 million t CO_2 eq. for the period 1990 to 2020 and about 388 million t CO_2 eq. for the period 2005 to 2020.
- Development of the economy's overall energy productivity runs counter to such trends. For the period 1990 to 2020, that development represents a reduction contribution of 610 million t CO_2 eq., while for the period from 2005 to 2020 it represents a reduction contribution of nearly 433 million t CO_2 eq..
- The emissions-reduction contribution from the increased contribution (overall) from non-fossil energy sources (as a net effect combining lower nuclear-power use and increasing use of renewable energies) amounts to nearly 95 million t CO_2 eq. for the period 1990 to 2020 and -35 million t CO_2 eq. for the period 2005 to 2020.
- As to the emissions intensity of fossil fuels, that factor provides a reduction contribution of nearly 100 million t CO_2 eq. for the period 1990 bis 2020, and a contribution of about 56 million t CO_2 eq. for the period 2005 to 2020.

Figure 27: Components of the development of energy-related greenhouse-gas emissions, for the "with-measures" scenario in Germany, 1990-2020



Sources: Federal Environment Agency, Working Group on Energy Balances (AG Energiebilanzen), Federal Statistical Office, DIW Berlin, calculations of the Öko-Institut.

5.4.3.17 Results of the sensitivity analysis

A number of sensitivity analyses were carried out for the "with-measures" scenario. Some of these sensitivity analyses were carried out for individual sectors, while others were carried out at aggregated levels.

The Annex includes a list of the sensitivity analyses carried out for the individual relevant sectors. In those analyses, the following influencing parameters were studied sector-specifically

- higher energy prices for the sectors industry, transport and electricity generation from fossil fuels;
- lower population growth, and lower growth of residential space in the building sector;
- changed assumptions with regard to modernisation rates, use of available potential and use of renewable energies, in the building sector;

The following sensitivity analyses (for energy-related greenhouse-gas emissions) were carried out at high levels of aggregation:

- higher economic growth;
- lower economic growth;

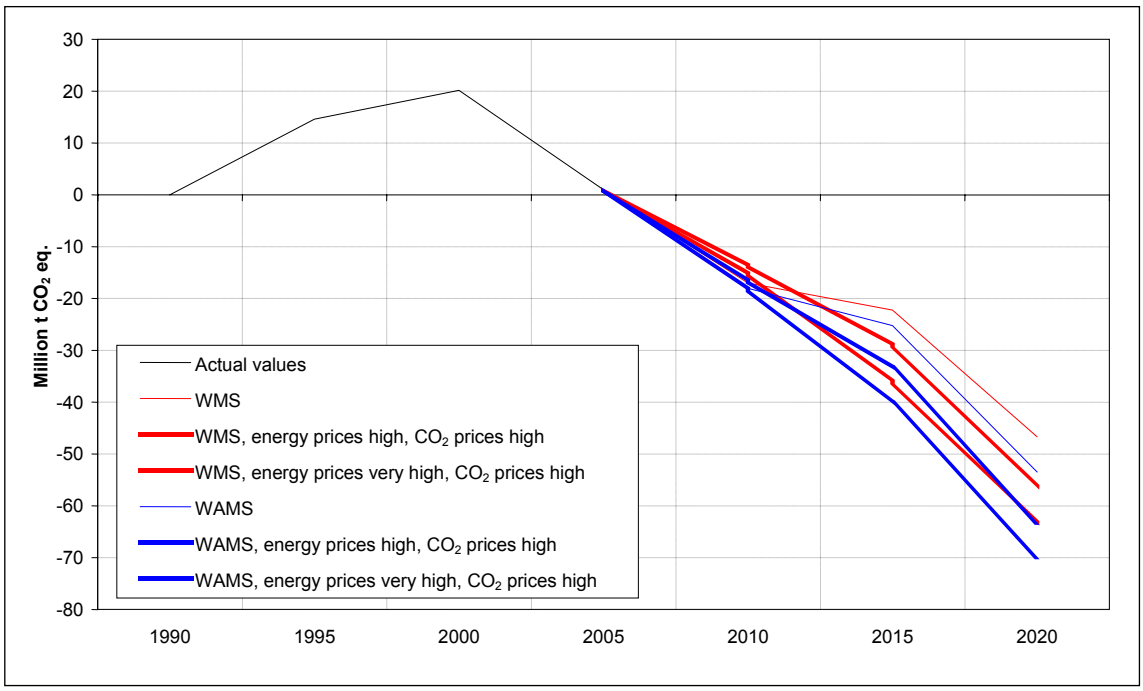
The following central results emerged from the sector-specific sensitivity analyses for the two relevant final-consumption areas:

- In the industry sector, higher fuel and certificate prices create (either directly, or indirectly, via the electricity market) additional incentives for emissions reduction. The changes in the variants "high prices" and "very high prices"

produce only very small changes in results, i.e. changes of about 1% in electricity consumption and of about 0.5% in fuel consumption. Those changes correspond to an additional emissions-reduction volume of about 0.5 to 1 million t CO_2 eq..

- Additional effects occur in the transport sector; these are summarised in Figure 28. In the "high prices" variant, additional emissions reductions of about 10 million t CO_2 eq. occur in 2020. In the "very high energy prices" sensitivity variant, transport-sector emissions decrease by an additional some 7 million t CO_2 eq..

Figure 28: Results of sensitivity analyses for the development of energy prices and for the transport sector, 1990-2020



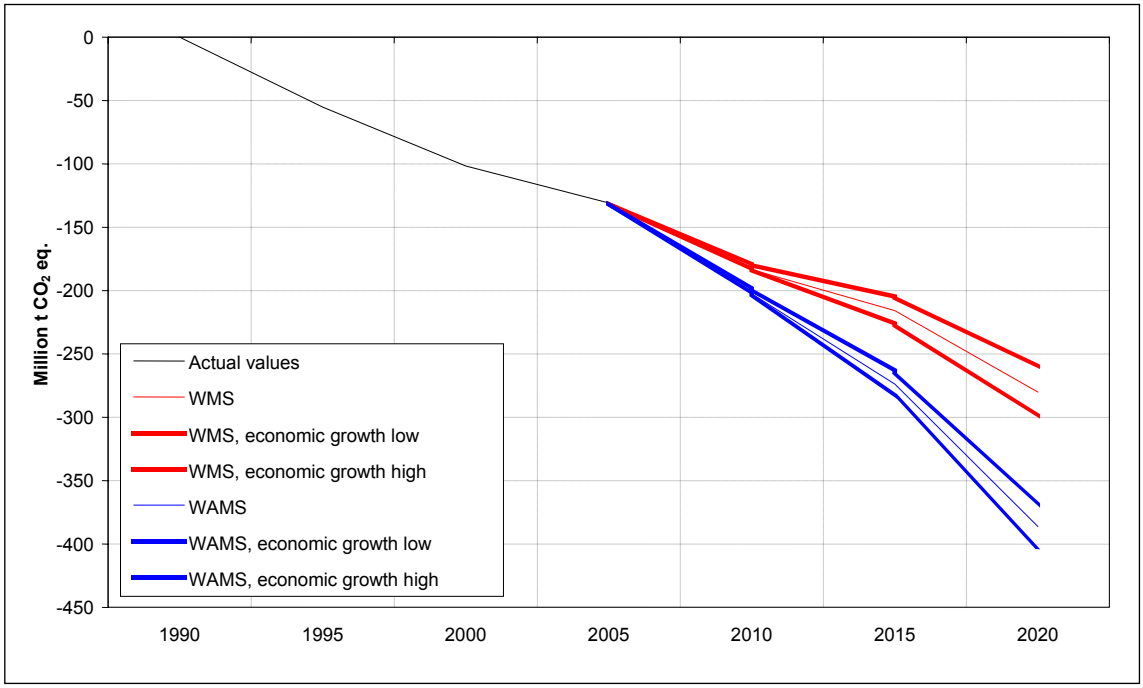
Sources: Federal Environment Agency, Working Group on Energy Balances (AG Energiebilanzen), Federal Statistical Office, DIW Berlin, calculations of the Öko-Institut.

The following central results emerge with regard to the building sector:

- The variant with lower population growth, and thus lower residential space requirements, leads to additional emissions reductions of about 0.5 million t CO_2 eq. for the year 2020, in the "with-measures" scenario.
- Active residential-space management, which also leads to lower residential-space requirements, reduces emissions emissions by about 0.7 million t CO_2 eq. in 2020, in the "with-measures" scenario.
- An increase in the rate of modernisation oriented to energy efficiency yields an emissions reduction of about 2.6 million t CO_2 eq. in 2020.
- A variation in the degree of use the potential for building modernisation, amounting to ±10%, corresponds to emissions changes of ±2,4 million t CO_2 eq. in 2020 (on the basis of the "with-measures" scenario).

- An increase in usage of renewable energies in the building sector, amounting to 10%, yields an emissions reduction of about 1.3 million t CO_2 eq. in the "with-measures" scenario. In the electricity-generation sector, the various energy-price variants show only slight effects on investment behaviour and on management of existing installations:
  - As a result of massive expansion of use of renewable energies, and of increasing electricity-saving, only small additional fossil-fired generating capacities are added.
  - Changes in energy prices do not by themselves lead to significant changes in additional-capacity requirements.
  - The retroactive effects of installation-operation changes, on electricity prices, do not trigger any significant changes in electricity demand.

Figure 29: Results of sensitivity analyses with regard to economic growth, and total energy-related greenhouse-gas emissions, 1990-2020



Sources: Federal Environment Agency, Working Group on Energy Balances (AG Energiebilanzen), Federal Statistical Office, DIW Berlin, calculations of the Öko-Institut.

A final group of sensitivity analyses was carried out for various variants of economic growth. These sensitivity analyses are based on component analysis for development of energy-related greenhouse-gas emissions (cf. Chapter 6.4.3.16), analysis for which only the parameters for economic growth were changed.

These analyses, the results of which are presented in Figure 29, reveal that a variation in value added, amounting to about 3% in 2020 (cf. Section 6.3), leads to emissions differences amounting to about 19 to 20 million t CO_2 eq. for the "with-measures" scenario.

The sensitivity of the emissions development, with regard to the underlying economic trends, is thus considerable.

In summary, it is clear that development of energy prices (especially with regard to the transport sector) and overall economic growth (with regard to total energy-related emissions) are especially significant with regard to the sensitivity of emissions development. The analyses carried out in these respects show that the aforementioned changes in basic assumptions regarding emissions levels can lead to differences amounting to some ±27 million t CO_2 eq.. In comparison to the base-year emissions level, that corresponds to a range of about 2.2 percentage points.

6 Vulnerability, impacts of climate changes and impacts of adaptation measures[40]

On 17 December 2008, the Federal Cabinet approved the "German Strategy for Adaptation to Climate Change". That strategy provides a framework for adaptation to the impacts of climate change in Germany. In the main, it outlines the Federal Government's contribution to such adaptation, thereby providing orientation for other stakeholders. The strategy is based on the precautionary principle. It lays the foundation for a medium-term co-operative process in which the Federal Government, the Länder and other relevant societal groups gradually assess the risks inherent in climate change, identify the possible relevant requirements for action, define relevant objectives and develop and implement adaptation measures. The present Chapter is based on the German Adaptation Strategy.

6.1 *General impacts of climate change; relevant tendencies and time horizons*

Increasingly, climate changes have been occurring that have impacts on nature and the environment. The indications of such impacts include melting glaciers and the earlier arrival of spring.

Temperature and rainfall projections for the future indicate that additional impacts can be expected. The greater the global climate changes actually are, the greater such impacts will be. Climate-change impacts can be grouped as follows:

- Impacts resulting from continual changes (such as seasonally shifted vegetation periods, earlier commencement of breeding for bird species within a given region, long-term changes in new groundwater formation and lower winter heating requirements). For most areas of action in question, such impacts will tend to be felt in the medium term.
- Impacts involving more frequent and / or more intensive occurrence of extreme weather events, such as torrential rains, storms and storm tides, heat waves and long droughts. Such impacts include forest fires, floods and low water, and heat stress.
- Impacts of increasing climate variability. Climate fluctuations could have near-term impacts – for example, droughts could occur at short intervals, thereby overwhelming the ability of the agriculture and forestry sectors to respond and adapt. Such variability could complicate the task of adaptation.

[40] German Strategy for Adaptation To Climate Change (Deutsche Anpassungsstrategie an den Klimawandel), Cabinet resolution of 17 December 2008; cf. Bundestags-Drs. (Bundestag printed document) 16/11595 of 19 December 2008.

In addition to affecting natural systems, climate change also affects economies and societies. Regional differences in the availability and use of natural resources – such as differences in water availability – along with environmental impacts, such as habitat loss or fragmentation, as well as (on the other hand) land renaturation, can have regional and local impacts on adaptation capability and, thus, can influence the severity of impacts of climate change.

Regional differences can also arise with regard to positive or negative impacts. For example, persistent droughts could threaten harvests in agriculture and forestry, while new basic climatic conditions could make it possible to plant new crop varieties. Certain areas, such as tourism, expect higher average temperatures to benefit German coastal regions.

Many of the slow relevant changes cannot be attributed simply to the sole factor of climate change; they are also influenced by factors such as population growth; changes in urban and surburban development; ways of using the natural environment; and general economic and societal change.

Any strategy for adaptation to climate change must thus take account of any applicable close relationships to other developments, and of any possible interrelationships; it must be closely linked with political initiatives for shaping such change processes; and it must be oriented to the aims of sustainability.

6.2 Impacts on nature and society – derivation of options for action

The following sub-chapters describe – primarily in qualitative terms – the possible impacts of climate change on representative sectors and areas and outline relevant options in varying levels of detail. For some areas, the possible impacts of climate change, and the relevant possible adaptation options, need to be studied in greater depth.

For all relevant areas, information and data are required that provide a basis for recognising critical changes and for taking decisions regarding future actions. Along with findings of climate research and of climate (impacts) modelling, therefore, monitoring systems and knowledge networks provide a key basis for all relevant areas. Long-term climate-impacts monitoring, ideally taking common account of all relevant environmental media, provides concrete data that play a valuable role in documenting and substantiating the impacts of climate change. What is more, such monitoring can also show the extent to which measures for adaptation to climate change are successful

6.2.1 Human health

Climate change can have many impacts on human health. As a result of weather and climate changes, infectious diseases and non-transmittable diseases (such as cardiovascular diseases and allergy disorders) can increase. Extreme weather events can increase injury rates.

6.2.1.1 Transmittable diseases

A milder climate can favour the spread of pathogens that are already endemic to Germany (such as hantaviruses, and such as Borrelia bacteria and TBE viruses, which are borne by ticks). In addition, such climate changes can enable pathogens that were previously non-endemic in Germany, and that are introduced to the country

by chance, by either people or animals, to gain a foothold and spread in Germany. Such pathogens can spread when infected people or animals come into contact with potent vectors (such as certain mosquitoes or ticks). And additional such vectors could become established in Germany, such as the Asian tiger mosquito (*Aedes (Stegomyia) albopictus*), which can transmit dengue and Chikungunya (CHIKV) viruses. Such viral infections entail intensive acute febrile phases. In recent years, pathogens, vectors (sand flies) and autochthonic cases of Leishmaniasis, an infectious disease previously non-endemic in Germany, have been documented in Germany.

Increasing temperatures can also affect the safety and shelf life of food. Infections caused by salmonellae, campylobacter and other pathogens in spoiled food are already among the most common infectious diseases. As warming continues, increasing rates of such gastrointestinal diseases must be expected.

Pursuant to the Protection Against Infection Act (IfSG), monitoring of infectious diseases must also include monitoring of a number of pathogens whose prevalence can be influenced by climate changes. The Act's list in this regard is not exhaustive, however. And certain pathogens and infectious diseases that do not fall under reporting obligations, pursuant to the IfSG, and yet are climate-sensitive could play increasingly important roles in future.

Such challenges call for interdisciplinary efforts involving all relevant departments, specialised authorities and research institutions. In addition, the Federal Government and the Länder need to be obtaining and analysing additional data with the aims of promptly detecting any relevant disease-related developments in Germany, of understanding their causes and contexts, of better assessing the relevant risks and of developing suitable prevention and intervention strategies. Such efforts should especially entail the following:

- ➔ Epidemiological studies on vector migration and transmission, on introduction of tropical diseases and on relevant potential effects on endemic pathogens.
- ➔ Basic research on biological strategies for combatting vectors.
- ➔ Basic research for characterising possible changes in the pathogenicity and life cycles of pathogens, and of their vectors and reservoirs, and basic research on relevant treatment strategies and vaccine development.
- ➔ Review of existing monitoring systems with regard to their effectiveness in detecting and following climate-sensitive endemic or imported pathogens and their animal vectors and reservoirs.
- ➔ Development of suitable strategies for early detection of suspected and confirmed cases of disease caused by pathogens appearing in Germany for the first time.
- ➔ Systematic study and modelling of populations (humans, animals, vectors) with regard to numbers of new cases, and total cases, of certain climate-sensitive infections.
- ➔ Promotion of prevention of infections caused by climate-sensitive pathogens.
- ➔ Via international collaborative efforts, world-wide identification and characterisation of pathogens for risky infections.

- ➔ Development and improvement of laboratory procedures for detecting climate-sensitive pathogens, with the aim of enhancing diagnosis with regard to infected persons, contaminated blood products and infected organs.
- ➔ Experimental study of the risks of transmission, establishment and spread of risky pathogens in Germany.
- ➔ Development of new therapies, vaccines and vaccination procedures.
- ➔ Analysis of changes and trends in food-borne infections.

6.2.1.2 Non-transmittable diseases and related health consequences

The health consequences of extreme weather/environmental events, such as torrential rainfall, floods, storms, avalanches and mudslides, primarily include injuries and death. The especially hot summer of 2003 was an example of such an extreme event. As a result of the heat wave, some 7,000 people in Germany died of heart attacks, cardiovascular diseases, kidney failure, respiratory problems or metabolic disorders. Such extreme events can affect the somatic and psychosomatic health of large numbers of people in affected areas.

Along the Baltic Sea coast, and in lakes, nutrient inputs, in combination with mild temperatures, can lead to blue-green algal blooms (blooms of cyanobacteria). Since certain types of cyanobacteria produce numerous toxins, such blooms can considerably impair water quality in affected bodies of water, especially with regard to their use for swimming. Contact with polluted water can trigger skin and gastrointestinal irritations and can even cause liver damage and other serious types of health disorders.

Prolonged or seasonally shifted appearances of airborne allergens have been tied to increases in rates of allergic reactions.

In view of the increasing prevalence of allergic disorders, in 2007 the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) enacted an action plan aimed at easing everyday life for allergy sufferers. That plan includes the "Ambrosia" action programme[41], which is being co-ordinated by the Julius Kühn Institute (JKI). As part of that effort, an information sheet on contamination of feeds with seeds of Ambrosia artemisiifolia L. has been prepared and published (and is available online) under commission to the BMELV. That move is being supported by the DWD (German weather service), via provision of pollen-count forecasts for Ambrosia in co-operation with the German Pollen Information Service (Deutscher Polleninformationsdienst). A number of German Länder have also been taking measures to combat Ambrosia. At the same time, in light of the great distances that such pollen can cover, and of the wide range of Ambrosia in Europe, such efforts must also be co-ordinated at the EU level. The BMELV has initiated such co-ordination in the EU Commission framework.

Other types of climate-related health impacts are also possible:

- ➔ Summer high-pressure systems can promote formation of ground-level ozone, which can lead to respiratory difficulties, and climate change can increase the frequency of such systems;

[41] www.jki.bund.de/ambrosia

- ➔ More intensive solar radiation can increase skin-cancer risks; and
- ➔ Impairments of ecosystems (such as forests) that humans depend on for recreation, or for their beneficial effects on local municipal climates, can also have negative impacts on health.

Measures aimed at preventing and guarding against climate-change impacts in the area of non-transmittable diseases, and especially with regard to vulnerable segments of the population (such as children, elderly people and people with multiple diseases/disorders), must take account of numerous additional influencing factors, such as changes in living, housing and environmental conditions, changes in health habits and changes in health care. A reliable relevant database needs to be created, with the aim of deriving a health-policy-transfer concept for provision (inter alia) of evidence-based recommendations relative to required adaptation strategies. Relevant information provision and public-awareness efforts should be aimed at medical specialists, at the general public and at especially vulnerable groups.

6.2.1.3 Public awareness and health care

Even though Germany has a well-developed health-care system, the challenges of adapting to climate-related health problems have not yet been clearly grasped in Germany. As a result of still-inadequate understanding and information about the ways in which climate change can directly and indirectly affect health, too little is being done in the way of relevant public awareness and precaution. To address this problem, the Federal Government and the Länder should conduct targeted, factually oriented efforts to educate the general public, individual risk groups and key "multipliers", such as medical and disaster-response personnel. Such education is an important basis for adaptation measures. In addition, these key stakeholders should jointly develop a pertinent health-policy concept that includes, inter alia, recommendations for ways of preventing heat-related disorders, and other health risks associated with climate change, and that proposes ways of managing health aspects of extreme weather events and natural disasters.

The Federal Government has been responding to such new challenges via efforts such as defining new priorities within the task areas of the Robert Koch Institute (RKI 2010). In addition, the Environment and Health Action Programme (Aktionsprogramm Umwelt und Gesundheit; APUG), an initiative sponsored by three German ministries (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Federal Ministry of Health (BMG), and the BMELV), is helping to inform and educate the public and to promote co-operation between all responsible agencies and administrative levels.

Functioning early-warning systems – for example, systems that warn of heat risks or of geological risks such as mudslides – help reduce health risks. Deutscher Wetterdienst (DWD; German health service) operates a heat-wave warning system that provides early forecasts to the Länder (and to individual districts, as necessary) regarding heat waves. The Federal Government and the Länder should strive to enhance networking between the DWD, informed agencies at the Länder and district levels, relevant institutions in the areas of health care and disaster protection and schools and kindergartens, to ensure that preventive and acute measures can be taken as necessary at relevant sites.

6.2.1.4 Linking of health care with other relevant areas

In this context, health care and structural planning are closely linked. Suitable forms of architecture, and of city and landscape planning, for example, can help prevent climate-related overheating of cities – and, thus, can help ease and prevent heat shock and stresses in people. Population centres should have fresh-air corridors that provide ventilation (and they can achieve that aim by setting aside special fresh-air pathways and linking them with extensive green areas that function as "cooling islands "). City planners and municipal authorities should work to prevent sealing of open areas for purposes of settlement development and transport infrastructure.

In addition, public and private builders and building owners should ensure that collective and communal facilities (such as hospitals, nursing homes and housing for senior citizens) are adequately insulated (with thermal insulation) and are properly cooled, especially via use of passive measures and solar cooling systems.

Health risks from other types of extreme events (such as storms or floods) can be reduced especially via suitable public behaviour; precautionary measures in the construction sector and in municipal infrastructure; risk and crisis management by infrastructure operators; emergency response plans; and properly adapted flood and coastal protection.

6.2.2 Water cycles, water-resources management, coastal and sea protection

The impacts of climate change on water cycles manifest themselves via long-term trends (for example, in groundwater levels, in changes in Alpine run-off regimes linked to the Rhine and Danube rivers, in changes in water quality) and in more-frequent occurrence of extreme events (such as floods, storm surges and droughts). What is more, climate changes can exacerbate existing regional imbalances in water availability. Climate change can intensify the challenges relative to complex interactions between different uses of water bodies, creating wide ranges of different adaptation requirements for such areas as water-resources management, flood protection and coastal protection. The executive and enforcement competencies for all these areas lie with the Länder.

Studies have shown that climate change is likely to have the following types of impacts on water-resources management:

- The probability of floods resulting from more-frequent and more-intensive strong rainfall in summer will increase. The frequency, duration and height of storm surges could increase.
- Because winters will be warmer, snow will account for a smaller share of total precipitation. As a result, snowpacks will diminish and more precipitation will run off immediately. Winter flood risks will also increase.
- More-frequent low-water periods during summer dry periods will affect cooling-water availability and ecological health.
- Extreme wind and precipitation events could increase, thereby increasing erosion risks and the possibility that pollutant concentrations, waste fertilisers and waste pesticides, from various areas, can find their way into ground and surface waters.

- Increasing water and bottom temperatures of aquatic systems in summer will, among other effects, reduce lower oxygen concentrations in water bodies. This will cause additional stress for aquatic flora and fauna already suffering under overly high water temperatures and too-small water volumes. During low-water periods, lower oxygen concentrations and higher water temperatures tend to dissolve substances bound in sediments and thus can lead to substance discharges into water bodies. In addition, as dilution ratios worsen, and in the absence of technical countermeasures (which are available), discharges – for example, from wastewater-treatment plants – and diffuse inputs create even greater stresses for water bodies.
- Since Germany's drinking-water supplies are obtained largely from locally available groundwater resources, and only partly via bank filtration or from surface waters (for example, reservoirs), no fundamental problems in drinking-water supplies are expected even under changed climatic conditions. On the other hand, regional scarcities might occur in areas that suffer extensive periods of drought.
- At the same time, low summer water levels in surface waters tend to increase water concentrations of undesirable substances. Such substances burden ecosystems and, where drinking water supplies are obtained via bank filtration, can increase overhead and expense in drinking-water purification.
- Increasingly frequent dry periods during summer months would tend to intensify drying of wetlands and bogs. Such trends would impair the ability of intact wetlands and bogs to buffer strong-rainfall events.
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The additional requirements for action and options with respect to the impacts of climate change include:

6.2.2.1 Consideration of the impacts of climate change in integrated river-basin management

The Water Framework Directive (WFD – Directive 2000/60/EC) and the EC Flood Risk Management Directive (Directive 2007/60/EC) provide for integrated management of river basins. Such management involves co-ordinated management of the protection and use of all water bodies in a river basin – across national and Länder boundaries. Such management is aimed at the concrete goal of ensuring that water bodies remain in a healthly state. In future, the impacts of climate change will play a more and more significant role with regard to water bodies and their management. The monitoring programmes under the WFD need to be reviewed for their adequacy in reliably detecting and assessing such impacts.

Therefore, in establishment of measures programmes and management plans with regard to the Water Framework Directive (initially, by the end of 2009; then, in a six-year cycle), priority should be given to measures options that are considered to be robust and efficient in managing relevant challenges even under a broad spectrum of climate impacts. This applies especially to investment measures that will have long-term effects. In the WFD framework, measures should be preferred that maintain or reinforce water bodies' natural ability to adapt, as well as their habitat diversity (for example, renaturation of water bodies and riparian meadows; enhancement of water

retention via setting-aside of retention areas; and properly adapted agricultural management). A provision in the Act for reorganisation of water law (Gesetz zur Neuregelung des Wasserrechts), providing for minimum water levels, especially in watercourses, represents an important step toward such adaptation.

The Flood Risk Management Directive explicitly relates the impacts of climate change to management of floods from surface waters and along coastlines. Bases for action and planning, such as six-year risk analyses, danger/risk maps and flood-risk management plans, are regularly adapted in light of the latest findings with regard to the impacts of climate change.

The Federal Government supports implementation of the Water Framework Directive and the Flood Risk Management Directive via research into relevant methodological aspects. Both directives have been legally transposed, on a nation-wide basis, in the Federal Water Resources Act (Wasserhaushaltsgesetz). Furthermore, working in the framework of the Joint Task "Improvement of Agricultural Structure and of Coastal Protection" ("Verbesserung der Agrarstruktur und des Küstenschutzes"; GAK), the Federal Government has long supported the Länder in implementing flood-protection measures in inland and coastal areas, and it plans to continue providing such support within the framework of available budget resources. In addition, via a special framework plan under the GAK, additional coastal protection measures, required as a result of climate change, are being supported throughout the period 2009 to 2025 with federal funding totalling EUR 380 million.

6.2.2.2 Adaptation of infrastructure

In the area of inspection and any necessary adaptation of the existing water-supply and wastewater-management infrastructure, the impacts of climate change must be viewed in close relationship to the impacts of other change processes, such as demographic change, economic change and land-use changes. This need applies, for example, to adaptation of water and sewage lines, water reservoirs and systems for chemical purification of drinking water, aimed at preventing such effects as flooding of combined sewage systems during strong rainfall, water shortages during dry periods and bacterial contamination as a result of inadequate water-line throughput or excessively high water-line temperatures.

In future, channelling of rainwater will have to be reviewed, and designed, in keeping with aspects such as land consumption, demographic change and reduction of pollutant loads. The (failed) draft version of an environmental code (Umweltgesetzbuch) thus included provisions for rainwater treatment. Such provisions called for rainwater to be allowed to seep away locally, to be used in sprinkler irrigation or to be discharged into water bodies, via a separate sewage network and with no mixing with polluted or contaminated water.

Reservoirs, storage units and retention basins are important components of the water-resources-management infrastructure. Such retention systems are integrated, multifunctionally, within the overall water-resources management system, and within catchment areas for the drinking-water supply, hydroelectric systems and runoff management (water injection during low-water periods; flood protection). For water resources to be used multifunctionally in the framework of adaptation to climate change, however, adaptive reservoir-management methods must be applied. Such methods involve chronologically and spatially differentiated management of retention facilities, taking account of the natural-area and water-resources requirements of downstream users.

6.2.2.3 Efficient water use

All in all, Germany's water supply seems assured for the future. At the same time, regional usage conflicts could ensue in future, especially in connection with prolonged and increasingly frequent regional dry phases and low-water periods, and with regard to surface waters and – especially – near-surface removal of groundwater (for example, for irrigation purposes). In the area of demand management, methods and techniques for enhancing water-use efficiency are available. Use of such methods and techniques should be considered, in keeping with the principle of proportionality:

- "Greywater", roof-runoff water and process water should be used for technical and industrial purposes that do not require water of drinking-water quality,
- Water-saving methods should be refined, especially in the context of commercial/industrial production processes,
- Precautions should be taken to prevent water losses in the distribution network,
- More efficient methods should be used in cooling of power stations and in irrigation of agricultural land, and
- Treated, microbiologically pure wastewater should be used for irrigating agricultural land.

At the same time, it must be remembered that more-intensive water cycles always entail "more-intensive substance cycles". In short, concentrations of impurities can increase if filtration and purification equipment is not improved (or if its used is not intensified) to a comparable degree.

6.2.2.4 Support for local flood-protection measures

Again and again, it has been seen that public-sector precautionary flood-protection measures cannot stop the impacts of suddenly appearing and often highly damaging strong-rainfall events. This is all the more significant in that, in all likelihood, it will long remain impossible to define likely risk zones for strong-rainfall events. For precautionary reasons, therefore, local statutes should require such measures as reviewing of the possibility of installing non-return valves in all building connections to the public sewage network. Where necessary, sewage networks should be modified to prevent risks of network-based flooding.

Since short-notice warnings in risk areas are of little use, relevant public agencies must carry out public awareness and information measures aimed encouraging citizens to behave in suitable ways and to take their own precautionary measures (to protect their property). Such public awareness and information measures can be carried out by a range of different stakeholders, and the Federal Government can support such measures. Ideally, however, municipal authorities themselves should provide information regarding relevant local circumstances and specific adaptation options.

6.2.2.5 Climate change in marine-conservation policy: precautions and impacts management

For years, Germany has been working, in the framework of regional co-operation for protection of the North Atlantic (OSPAR) and the Baltic Sea (HELCOM), to have

climate change taken account of also in marine-conservation policy (cf. the OSPAR Quality Status Report 2000 and the 2007 HELCOM report "Climate Change in the Baltic Sea Area"). In addition, the German Advisory Council on Global Change (WBGU), in a special report entitled "The future of the oceans – too warm, too high, too acidic" ("Die Zukunft der Meere – zu warm, zu hoch, zu sauer") has addressed key aspects in this connection.

To protect the oceans, it is necessary to limit all factors that contribute to warming and to acidification. Marine-conservation policy has few task areas of its own in this regard. It profits from all measures that help to prevent, or at least slow, the increase of greenhouse-gas concentrations in the atmosphere. Protective measures such as the establishment of well-managed and adequately large protected areas play an important role in protecting species – especially species that are sensitive to climate-related stresses – at least from certain anthropogenic stress factors and enhancing their survival chances. In the framework of HELCOM and OSPAR, the Federal Government and the Länder have already named a number of protected areas for incorporation in a network of well-managed marine-conservation areas that has been jointly approved by the two protection efforts and that is to be established by 2010.

International co-operation plays an important role in marine conservation, since marine ecosystems are not affected only by the actions of parties bordering directly on marine water bodies.

Marine conservation must be based on a holistic ecosystemic approach. Such an approach calls for integration of all policy areas that can affect the quality of the marine environment, especially its biological diversity.

The European marine conservation strategy, including the Marine Strategy Framework Directive, which entered into force in July 2008, is a significant example of such integration. That effort is being complemented, and specially outlined for Germany, by a National Marine Strategy that was adoped by the Federal Government in October 2008.

The European marine-conservation policy is linked with the objective of establishing a global network of marine conservation areas by 2010, a goal adopted at the World Summit on Sustainable Development (WSSSD) held in Johannesburg in 2002. The relevant resolution was upheld by the global community, in the framework of the "Programme of Work on Protected Areas" under the UN Convention on Biological Diversity, at the 7th CoP for that Convention.

6.2.3 Soil

Soil ecosystems have special significance in the context of possible impacts of climate change and of relevant adaptation measures. Soils are a plant-growth resource that is subject to the direct influence of climate and uses, and they provide habitat for microorganisms and animals. The pedosphere – like the atmosphere – is a central interface to human habitats.

Proper soil conservation includes use of locally adapted plants and of suitable soil cover. Climate influences many soil processes. It thus affects the development of soils, soil characteristics and soil functions. Climate and usage changes affect nutrient and water cycles and soil-formation processes (humus formation / carbon binding, groundwater formation, soil degration via erosion, nutrient cycles / growth conditions). Consequently, such changes can affect key natural soil functions and, in some cases, can impair them.

To prevent, or mitigate, any negative impacts of farming, locally adapted land-use strategies must be applied. Agricultural procedures in keeping with good practice principles pursuant to the Federal Soil Protection Act , and to relevant EU cross-compliance, already take account of indirectly significant protection and buffer functions.

Climate-related changes in soil systems have direct impacts on natural production systems, on water cycles (both qualitatively and quantitatively) and on biological diversity. At the same time, proper precautionary measures help reduce and prevent soil erosion, and adverse soil compression, and they help protect organic substances in the soil, thereby protecting the soil's ecological vitality. Such measures are thus suitable measures for adaptation to climate change.

In many cases, the soil's proper function is protected directly via measures in other sectors, including agriculture and forestry, water-resources management, nature conservation and regional planning, or such protection is provided via close, integrated co-operation with such sectors. Collection (measurement) and provision of reliable data on the impacts of climate change plays a decisive role in derivation of suitable adaptation measures. In the case of soil, detailed research on key control factors' impacts on soil functions (functions such as C and N cycles, soil biology) is required. Precise spatial and chronological assessment of trends with regard to such factors as carbon storage, or release of N_2O, is possible only on the basis of time series of soil measurements taken in dense arrays of measuring sites. At present, measurement data that would permit quantitative assessment of climate and usage effects on soil functions are available for only a few isolated sites. Discussion is thus underway regarding ways of optimising, and possibly expanding, existing monitoring programmes.

Discussion regarding sustainability of the agricultural sector in Europe, and of the EU soil conservation strategy, and findings from research in support of greenhouse-gas reporting, have shown that soil conservation needs to be further optimised with regard to risks of erosion and humus depletion, especially in hydromorphic soils. In the interest of preventing conflicts of aims, the Federal Government and the Länder are discussing, and co-ordinating, relevant soil protection aims and mitigation strategies in an interdepartmental approach involving all relevant stakeholders (agriculture, forestry, water-resources management, nature conservation, atmospheric and climate research).

6.2.4 Biological diversity

A great many indications of climate-change impacts on biological diversity in Germany have been recorded. Such indications are found in areas such as species' annual rhythms; species' ranges and breeding success; habitat composition and structure; and diversity changes within species. Since different species react to climate changes in different ways, new compositions of species can be expected to form. This will involve changes in relationships between species that share habitats or that are interdependent. In addition, synchronisation of developmental phases could break down (for example, in the synchronisation whereby certain fish species spawn at times at which the food supply for their young is plentiful). What is more, food networks and competition situations will change.

According to estimates, in the coming decades climate change could cause up to 30 % of Germany's flora and fauna species to become extinct within Germany, as a result of their limited adaptability. At the same time, more and more human-

introduced species will become established in the wild. Such species that are already established will expand their ranges, and new species will migrate into the country. Model calculations indicate that species that are now rare and endangered (especially Red List species) will account for a disproportionately large share of the species suffering such decline.

Adverse impacts are expected especially on mountain and coastal species, as well as on species specifically adapted to water bodies, wetlands or small, special habitats. The reason for this is that many such habitats offer no alternative refuge in the presence of climate changes. And climate change could cause such habitats to undergo profound changes, via mechanisms such as increasingly severe dryness, disproportionately strong warming or sea-level rise. The Wadden Sea (Wattenmeer), an especially sensitive ecosystem, could be especially at risk if it loses habitats to permanent flooding and to erosion. Species with little ability to extend their ranges will also face increasing risks.

For species and their habitats, the impacts of land-use changes can be as profound as direct impacts of climate change. Climate change can be expected to increase land requirements for various measures. While additional land is likely to be required for achievement of nature conservation objectives (for example, for biotope networks and alternate habitats), needs such as expanded cultivation of renewable resources, additional dike construction and protection of transport routes will compete for scarce land resources. In the fact of such challenges, the Federal Government and the Länder will need to take suitable measures to ensure achievement of the quantitatively and qualitatively defined objectives, for protected areas and conservation networks, set forth in the National Biological Diversity Strategy and in the Federal Nature Conservation Act.

Many planned measures for protection of biological diversity (such as biotope networks and renaturation projects) will help to safeguard or even restore natural systems' ability to adapt. In addition, the many efforts underway to reduce pollutant and nutrient discharges into ecosystems, via national and international environmental laws, are helping to protect habitats and biological diversity. Implementation of such measures, which are set forth, inter alia, in the National Biological Diversity Strategy, is thus also an important element of the German Strategy for Adaptation to Climate Change. Implementation of some such measures has already begun.

In the interest of an integrated approach, the Federal Government and the Länder should consider, and undertake, integrated measures, i.e. measures that make use of synergies between nature conservation, climate protection and adaptation to the impacts of climate change, and that protect biological diversity. Such synergies are possible, for example, when measures make use of wetlands' abilities to store carbon and to buffer the impacts of extreme events on water cycles. Important steps for development of such measures have already been initiated via the National Biological Diversity Strategy, the EU Commission's communication "Halting Biodiversity Loss by 2010 – and Beyond" (which is supported by the EU Council and the EU Parliament) and the National Sustainability Strategy. With its sector strategy on "Agrobiodiversity", and as a contribution to efforts to adapt to climate change, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) has proposed concrete measures for protecting and sustainably using agrobiodiversity. The Länder "Climate Biomonitoring" ("Klima-Biomonitoring") concept outlines the creation of a separate methods set and database that would address topics such as necessary specific actions and measures options that move beyond the

aforementioned requirements in addressing the need to adapt to climate change. Such topics are described in the following section.

6.2.4.1 Establishment of effective biotope-network systems

Working closely with stakeholders on all relevant levels, from the local to the European, the German Länder need to establish and develop effective biotope-network systems that can enable species and populations to adapt when their climatically suited habitats shift. Wherever possible, development of such biotope networks should be taken into account in refinement of agricultural-sector environmental measures, and other relevant measures, in the context of the second pillar of the EU's Common Agricultural Policy and in the framework of a national programme for riparian meadows (Nationales Auenprogramm). Fragmentation of natural systems and land consumption need to be reduced. To that end, settlement, infrastructure and transport planning need to be judiciously designed, and suitable measures need to be taken along existing transport pathways and watercourses. In 2009, an ongoing research project will provide methods for defining priorities for networking habitat corridors in the supra-regional road network. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) have established a joint working group that is charged with developing ways of implementing the planned network concept nation-wide. Since landscapes do not end at national boundaries, the Federal Government and the Länder are working to co-ordinate relevant measures with neighbouring European countries.

6.2.4.2 Further development of the network of protected areas

The Federal Government and the Länder should analyse options for ways of adapting the existing system of protected areas to future requirements arising through climate change. The Natura 2000 network already offers suitable refuges and adaptation areas, both on land and in the sea, as well as areas that remain free of uses. It thus is contributing to efforts to mitigate the negative impacts of climate change. The Länder should take requirements arising via climate change into account in preparation and revision of care, development and management plans for protected areas, as well as for any buffer zones that need to be established.

6.2.4.3 Support for species and biotopes that are likely to be particularly affected

In co-operation with research institutions and relevant associations, the Federal Government and the Länder should establish monitoring and research programmes that document the impacts of climate change, and of measures for climate protection and adaptation; that usefully describe such impacts via indicators; that yield reliable forecasts regarding expected developments; and that validate such forecasts via cross-checking against monitoring results. At the same time, efforts to that end should build on existing monitoring and research programmes wherever possible.

Furthermore, for precautionary reasons, the Federal Government and the Länder should take greater account of findings of climate (impacts) research, including the relevant uncertainties, in programmes and instruments of nature conservation (including species conservation, biotope conservation, area conservation and contractual nature conservation programmes). In the process, attention should also be given to expected climate-related changes in species' endangerment situations and to the feasibility of pertinent objectives. The significance of such results and

analyses includes their importance for assessment of interventions and design of compensation measures. Efforts in this regard need to be intensified in connection with introduction of marine-species conservation programmes.

For biotopes of species that face high risks from climate change (see above), other endangerment factors and adverse forms of use should be reduced. Adequately large populations, with adequate genetic diversity, are a key basis for adaptation processes.

- The example of wetlands: the impacts of regionally increasing summer dry periods and of rising temperatures need to be mitigated. This can be achieved via preparation and implementation of concepts and programmes that regenerate wetlands, stabilise hydrological conditions in bogs and reduce grassland drainage. Furthermore, interconnections and structural diversity in water bodies should be enhanced, and riparian meadows should be restored and revitalised. Relevant measures are already being supported via state funding programmes. Such measures should be intensified, and implemented via co-operation between a) the competent authorities for nature conservation, agriculture and water-resources management, and b) land users.

Furthermore, integrated strategies for development of coastal ecosystems, including estuaries, are needed. Where necessary, such strategies should provide for establishment of refuge habitats for communities affected by sea-level rise, and they should make use of synergies between nature conservation and coastal protection.

6.2.4.4 Addressing the problem of invasive species

The Federal Government and the Länder should strive to find a common approach, within the framework provided by the Basic Law, for addressing the problem of invasive species (including marine invasive species). In the interest of facilitating measures for preventing problems arising via migration of such species into Germany, states sharing common borders should establish suitable early-warning systems, with respect to species groups that have not yet received sufficient attention in this regard. Wherever possible, biotope networks should be designed in ways that do not encourage the spread of invasive species.

6.2.4.5 Taking account of nature conservation aspects in promotion and use of renewable energies

Efforts to expand use of renewable energies, in the interest of limiting the extent of climate change, must proceed in accordance with sustainability criteria, especially with a view to preventing adverse impacts on nature and landscapes. The attractiveness of agricultural environmental programmes, and of contractual nature conservation programmes, with respect to other usage options must be maintained.

In site selection for expansion of energy-plant cultivation, it is especially important to take account of the needs of sensitive biotopes and of priority areas for nature conservation.

6.2.4.6 Landscape planning as a management approach

In future, landscape planning should increasingly take account of expected climate-change pressures on nature and landscapes. The aim in this regard must be to support adaptation options and flexibility in development of nature and landscapes. Where regional landscape planning provides specifications relative to preventing

adverse impacts from interventions in ecosystems, the ecological and spatial impacts of climate change – including future impacts – should be taken into account in assessment of the possible consequences of interventions. With the help of municipal landscape planning and provisions for managing interventions, greater account should be taken of climate-relevant functions of nature and of open areas within settlements. This need also applies in connection with final compaction around structures and with development of areas within settlements. Via research projects, the Federal Government and the Länder should develop ways of achieving the aforementioned objectives.

6.2.4.7 Agrobiodiversity

In development of agricultural systems and methods adapted to climate change, the Federal Government and the Länder should ensure that agrobiodiversity is protected even under different framework conditions. Efforts should be made, via use and improvement of suitable management systems, to enhance synergies between agricultural production, nature conservation, soil conservation, protection of water bodies and climate protection.

6.2.5 Agriculture

Agriculture depends directly on weather and climate. Different production areas react differently to climate changes. Regional differences in the severity of climate change have already become apparent, and such differences could intensify the impacts of climate change. Regions that today are too cold or too wet for agricultural purposes could profit from gradual warming and longer growing periods by becoming able to cultivate crops with warmth requirements that were previously out of reach. On the other hand, climate change could have adverse effects in regions that are already warm and dry today.

Although higher atmospheric CO_2 concentrations can boost plant growth, both qualitatively and quantitatively, such CO_2 fertilisation effects should not be overemphasised, since available water supplies will be the factor on which yields primarily depend.

Furthermore, increasingly frequent weather extremes could present risks for agricultural production. As stresses from heat, cold, drought, wetness, heavy rainfall, wind and storms increase, significant harvest failures will have to be expected. Crops are especially susceptible to damage when such stresses occur during sensitive growth phases, such as leaf formation, flowering or fruit development and ripening. The consequences of spring droughts can thus be more serious than those of summer droughts.

In addition, damage from more-frequent heavy rainfall and hailstorms could increase. In fruit cultivation especially, earlier flowering could increase frost risks. What is more, weather extremes can reduce plants' winter hardiness, i.e. their ability to withstand prolonged winter frosts. Introduced plant pests, including warmth-loving pests, are still other potential sources of damage, although the relevant specific risks are difficult to forecast.

In animal husbandry, higher summer temperatures could reduce feeding and productivity, thereby considerably diminishing production yields. For example, dairy cows tend to reduce their milk outputs as soon as temperatures climb higher than 20 to 25° C. Climate change could also be a significant factor with regard to the introduction and spread of new, vector-transmitted diseases, by offering vectors more

favourable conditions for spreading and survival. The outbreaks of Bluetongue Disease that have occurred since mid-August 2006, causing major economic losses, may be a result of climate change. The virus responsible for the disease formerly occurred in South Africa. It has been able to spread in Europe because it is also transmitted by endemic biting midges, as new research has found. Although it is still unclear how the virus was introduced, the unusual climatic conditions of the last two years are considered to be a factor in both the initial spread of the virus (by making it easier for the Bluetongue Disease virus to multiply in midges) and in the disease's "overwintering" (by not providing a vector-free period during the winter).

As the above-outlined consequences for the agricultural sector suggest, efforts must be intensified to enable the domestic agricultural sector to adapt as necessary to expected climate changes. Such adaptation could be supported via measures in agricultural operations, in animal and crop breeding, in agricultural advising and in the policy sector. Additional research and development is required in a number of areas. Adaptation to more-frequent weather extremes presents a thornier challenge. For the agricultural sector, one answer could involve multi-risk insurance policies.

In a resolution of September 2008, a conference of German ministers of agriculture called attention to ongoing measures in the extensive programmes of the Federal Government and the Länder and expressed support for further development of such measures. The focuses of such efforts include:

- ➔ Via effective plant variety protection laws, plant breeders need to remain able to develop adapted plant varieties, and to modify other crops as necessary or include them in breeding programmes.
- ➔ Promotion of water retention in drought-endangered agrarian and forest landscapes, via the Joint Task "Improvement of Agricultural Structure and of Coastal Protection" ("Verbesserung der Agrarstruktur und des Küstenschutzes"; GAK).
- ➔ Promotion of irrigation infrastructures via the GAK.
- ➔ Promotion of procedures for improving soil fertility, soil structure and natural control mechanisms, in the framework of environmental measures for the agricultural sector.
- ➔ Know-how transfer, especially with regard to adapted methods of cultivation, animal husbandry, animal nutrition and animal health.
- ➔ Promotion of measures relevant to breeding and management methods in animal husbandry.
- ➔ Dialogue and knowledge exchanges with Länder experts.
- ➔ Monitoring of climate changes, to promote understanding of the need for adaptation measures.
- ➔ Promotion of innovation in plant breeding, within the context of an innovation programme.

Innovation should be promoted in the area of plant breeding, with regard to adaptation to climate change, nutrient balance in crops, resistance properties and quality characteristics. At the same time, attention should be given to increasing natural yield capabilities, and to enhancing genetic diversity of crops with a view to expanding crop rotation.

Via cultivation of renewable resources, opportunities should be used to expand the spectrum of usable plant species and, via widening of crop-rotation plans, to achieve positive impacts on agrobiodiversity.

The Federal Government and the Länder should undertake measures for protection and sustainable use of a broad basis of genetic resources. In the process, priority should be given to in-situ measures, although consideration should also be given to ex-situ measures. With regard to the possible impacts of climate change, and to protection of adaptability, contributions (including characteristics and ecological interrelationships) of agrobiodiversity should be analysed and assessed – with the aim of protecting and reinforcing such contributions.

At the end of November 2008, EU agriculture ministers reached a political agreement on the Common Agricultural Policy, in the framework of the "Health Check". The agreement calls for, inter alia, an increase of modulation. This involves reductions of direct payments to farmers, along with payment of the then-available funds into the European Agricultural Fund for Rural Development (EAFRD). That fund is available for (inter alia) financing of measures that assist the EU agriculture sector in responding more effectively to new challenges and opportunities in the areas of climate change, water-resources management, protection of biological diversity and production of bioenergy.

6.2.6 Agriculture and forestry

Natural occurrence of tree species is influenced by a complex of factors, especially factors involving climate, soil and water. Over time, humans have influenced forests and changed their structures. Nonetheless, human-influenced forest ecosystems have always continually adapted themselves to environmental conditions. The extent, trends and speed of current climate change now threaten to overwhelm forests' ability to adapt, however. As summer temperatures increase, and dry periods become more prolonged, forests become subject to heat and drought stress. Such risks are especially great for dry and relatively warm regions in eastern and south-western Germany, as well as for sites with a generally poor water supply or with stands that, for various reasons, are poorly adapted as it is. What is more, such warmer and drier conditions can increase the risk of forest fires.

And heightened stress exacerbates the risk of losses via pests, such as bark beetles. Large swarms of certain pests, such as the nun moth or the cockchafer (May bug), can occur more frequently, and previously insignificant or ignored pests can multiply.

Alpine mountain forests could be especially affected by climate change. In mountainous regions, climate change could be more severe than in lowland areas. At the same time, risks of natural hazards (heavy precipitation, mudslides, floods, falling rocks) could increase in such areas. Forests' importance in protecting settlements and infrastructure could thus increase as a result.

Forests need to adapt promptly to climate change, if future risks of increasingly frequent calamities – and related disruptions of the wood market and of forest functions – are to be mitigated. Forest owners should move to convert forests from single-species stands into locally adapted mixed stands that face smaller risks. Properly adapted game populations are a key basis for such conversion.

At the same time, climate change is only one of a number of stress factors for forests. Many forests are in poor health as a result of air pollution – now, especially, in the form of large depositions of atmospheric nitrogen. Since the 1970s, that phenomenon

has been referred to as "new types of forest damage". The impacts on soils and vegetation will persist for long periods of time.

Longer growing seasons, resulting from higher temperatures and CO_2-fertilisation effects (i.e. more vigourous plant growth as a result of higher atmospheric CO_2 concentrations), could increase wood production, as long as adequate supplies of water and nutrients are available. Such positive effects are likely to be negligible in comparison to the adverse effects of climate-related stress factors, however.

To date, discussions regarding individual tree species have produced no consensus on relevant recommendations. For this reason, the Federal Government and the Länder should reassess cultivation recommendations, for all tree species, in an approach that differentiates by locations and that takes account of aspects of climate change, the long production periods involved and the related uncertainties and risks. All of this represents a major challenge for researchers and practitioners alike.

Furthermore, the Federal Government and the Länder should work to provide necessary information, with the aim of convincing Germany's more than 1.3 million forest owners of the need for adaptation measures. From a perspective of forest management, efforts should be aimed at maximally stable, mixed stands that are better able to withstand widespread calamities, such as those caused by storms and bark beetles, and that are better able to adapt to climate changes. In selection of tree species and varieties, preference should be given to trees adapted to local conditions and their expected development. Along with native tree species, Douglas fir and other non-native tree species provide useful options. At the same time, relevant aspects of nature conservation need to be taken into account.

In keeping with the uncertainties inherent in scenarios for climate changes and their impacts on long-term forest production, forest owners should diversify their risks widely and strive to maintain a broad range of options.

In the medium term, the Länder should strive to expand the scientific basis for decisions relative to climate-adapted forest conversion. Relevant efforts can include such actions as monitoring, establishment and operation of experimental plots, site-mapping, forest-plant breeding, provenance research, use of regional cultivation recommendations, study of wood-harvesting techniques and exploration of possible wood uses under new climate conditions. Furthermore, the Federal Government and the Länder should strive, in the medium term, to intensify dialogue with, and know-how transfer between, forestry experts. In the framework of the Joint Task "Improvement of Agricultural Structure and of Coastal Protection" ("Verbesserung der Agrarstruktur und des Küstenschutzes"; GAK), the Federal Government and the Länder are already promoting various measures supporting the forestry sector's adaptation to climate change – for example, supporting conversion of single-species stands into stable deciduous and mixed stands. Semi-natural forest management, which is desirable from nature conservation perspectives, is being supported via adaptation of game populations.

Measures for preventing and managing calamities are already available. At the same time, the Federal Government and the Länder should consider, in the near term, whether additional relevant measures are required – measures such as promoting water retention in areas with strongly negative water balances. And the Federal Government and the Länder should refine environmental monitoring with respect to forest health, with the aims of being able to detect changes promptly and of having enough response time to initiate pertinent measures.

6.2.7 Transport; transport infrastructure

Extreme weather conditions, including conditions involving snowstorms, icestorms, dense fog, hailstorms, heat waves, storms, torrential rainfall, flooding and low water in rivers and powerful swells at sea, can hinder transports – on roads, railways, waterways and in the air.

Climate change can bring more-frequent, strong precipitation of the sort that can hamper transports – for example, by reducing visibility and making roads slippery. Mudslides and washouts can destabilise and destroy roads and railway lines. Storms can hinder transports directly and can cause wind damage in roads, railways and power lines. Heat waves in summer months can increase accident rates, since high temperatures tend to worsen drivers' concentration.

Prolonged heat waves also can damage roads. High temperatures can soften road surfaces, enabling vehicles to wear ruts in the road that can enlarge into serious damage over time. The impacts of the heat and more-frequent precipitation that can result from climate change are considered manageable as far as the nation-wide highway system is concerned, however; modified road materials can be used to make roads more heat-resistant, and road-drainage systems can be enlarged to accommodate heavy rainfall. As climate change tends to raise winter temperatures, frost damage to roads and bridges may become less common and tend to be less severe. What is more, accident risks related to snow and ice on roads may diminish. Road systems will thus have to be carefully monitored, with the aim of detecting any unexpected (counter-) trends.

The Federal Government will review whether, and to what extent, the nation's highway infrastructure needs to be adapted, in the medium term: to longer hot periods, via modified construction materials, and to heavier rainfall, via changes in the capacities of the drainage infrastructure. The Federal Government (especially the Federal Ministry of Transport, Building and Urban Affairs (BMVBS)) will adjust applicable size regulations for the drainage infrastructure as necessary.

In the area of railway transports, climate change will tend to affect primarily the railway infrastructure. Towers of power-supply systems, and signals, will tend to be at risk from storms. Special precautions will need to be taken to prevent falling trees from blocking railway lines; i.e. trees and shrubbery will need to be cut back along lines. (In adaptation of the relevant legal framework, it must be noted that many trees that could present such risks are located on private property.)

Periods of high and low water levels in nearby water bodies can also affect railway transports. The primary threat is from flooding of railway systems, especially in areas in which railway lines are only slightly elevated above water levels.

Additional research is needed to determine whether higher temperatures will call for new maintenance technologies – to determine, for example, whether high temperatures could raise the internal tensions in seamlessly welded tracks to dangerous levels. Similar considerations apply to the possible need for additional air conditioning of vehicles and buildings.

In the interest of guarding against potentially higher risks of forest fires and of fires along railway embankments, vegetation along railway systems may have to be adapted to climate change via suitable management methods, carried out in co-operation with forest authorities.

According to recent analyses, possible climate changes present only minimal threats for air transports. At the same time, airport and air-traffic-control operations may well have to be adapted for more-frequent extreme weather.

The impacts of climate change on shipping in the North and Baltic Seas have to be considered from both regional and large-area perspectives, since ports in both seas are linked to ports world-wide via shipping lanes. Careful attention must be given to safeguarding the safety and proper functioning of shipping with respect to the possible impacts of climate change. This is also important in light of the forecasted strong growth in the quantities of freight handled by German ports. Available capacities on inland waterways could help improve links between German ports and inland areas – while also easing burdens on other transport networks (especially roads).

Climate changes – along with related changes in air and water temperatures, precipitation, ice cover, water levels, wind strengths, wind directions and sea states – directly affect maritime shipping and navigation routes. Changes related to extreme weather events are especially significant.

Ships and their movements, along with activities such as expansion, maintenance and operation of shipping lanes, are subject to water and weather conditions at sea and in coastal zones. Forecasted sea-level rises can be expected to affect ports and other maritime infrastructure. In addition, changes can be expected in currents, erosion and sedimentation in estuaries and shipping lanes, changes that need to be studied in detail. On the other hand, climate change could open up new routes for shipping, such as routes through the Arctic. Efforts must begin early to find and co-ordinate ways of using such routes optimally.

Study is required to determine whether climate-related changes will necessitate adaptations of relevant monitoring and consultation, of forecasting and warning services, of risk management, of emergency and rescue services, of ships' equipment, of expansion measures and of the maritime infrastructure.

The availability and capacity of inland waterways depend decisively on weather and water conditions in river catchment basins connected to such waterways. The most important factor consists of water levels (the water supply) in catchment basins connected to inland waterways. Water levels in catchment basins, along with water distribution throughout the year, determine runoff and water levels in rivers. Water levels in German rivers have always fluctuated considerably. Such fluctuations could increase as a result of climate change, however.

Estimates of the impacts of climate change in this context focus both on long-term changes in water levels (mean values) and on the increases in fluctuations (variability and extremes) that can influence water levels and runoff – and, thus, that could influence rivers' navigability.

In connection with the climate-related vulnerability of inland waterways, a distinction is made between a) canals (accounting for 24% of the German inland-waterway network) and dam-controlled sections and b) free-flowing waterways. In canals and dam-controlled sections of inland waterways, long-term changes in water levels are more significant than are increases in fluctuations, since water levels in such waterway sections can be stabilised via management measures.

In periods of extreme low water or high water, navigability of free-flowing waterways can be limited. In some cases, such waterways can become impassable for freighters and passenger ships. Unless suitable adaptation measures are taken, more-frequent

extreme water levels could threaten the reliability and safety of shipping on such routes, as well as the competitiveness of sectors that depend on transport of bulk goods (which sectors are the main users of inland waterways). What is more, changes in runoff regimes can affect sedimentation (morphodynamics), along with watercourse/ riparian-meadow systems, ecology and water quality. And they can affect maintenance requirements for inland waterways. Currently, the latest available and reliable scientific findings regarding the impacts of climate change are being taken into account in all maintenance and expansion measures for federal inland waterways. At the same time, forecasting of future regional development of water regimes is subject to considerable uncertainties. For this reason, relevant efforts must first be concentrated on reducing the breadth of such uncertainties, with the aim of making it possible, in the medium term, to forecast the development of water resources more reliably – and, thus, to predict impacts on the waterway infrastructure and on shipping in it. The BMVBS has initiated the KLIWAS ("impacts of climate change on waterways and shipping") research programme with a view to developing reliable adaptation strategies and measures for shipping and the waterway network.

6.2.8 Tourism sector

According to the United Nations World Tourism Organization (UNWTO), global climate change could have noticeable long-term effects on travel patterns. Such change could threaten tourism in numerous destination areas, and it could cause shifting in tourist preferences. Major changes in tourism could have considerable impacts on economic and social structures in countries that depend on tourism, especially in the areas of lodging, transport and social infrastructures in tourist destinations. In addition to having direct effects on tourist infrastructures, extreme weather events could tend to keep visitors away from affected regions.

Extreme weather changes could affect tourist enterprises' payment flows, thereby raising their borrowing and equity-capital costs. Study is needed to determine whether existing financial and insurance instruments will be suitable for efforts to address the relevant future impacts of global climate change.

Winter recreation, an economically significant tourist segment, will be directly affected by climate change. Over the past 50 years, guarantees of snow have weakened considerably in lower elevations of the Alps and of German highlands. In future, winter recreation may well be possible only at elevations above about 1,500 m in the Alps, and at elevations above 800 – 1,000 m in German highlands.

As temperatures increase, use of snow cannons, to enhance guarantees of snow and to prolong ski seasons, may no longer be possible at lower mountain elevations

As a result of such trends, ski tourism can be expected to become concentrated on higher elevations of the central Alps, areas that are highly sensitive ecologically. For this reason, the availability of alternative activities (hiking, culturally oriented travel, wellness tourism) will play an important role.

Climate change is also expected to have many impacts on coastal regions.

On the other hand, climate changes could also open up new possibilities for the tourist industry. For example, numbers of off-season visitors could increase, and tourism could shift from southern to northern regions. Many Germans normally spend their summer vacations in the Mediterranean. The stream of vacationers from central and northern Europe to southern Europe, accounting for 116 million arrivals, is the world's most important tourist stream. It accounts for 41 % of intra-European tourism.

In future, daily maximum temperatures in southern Europe can be expected to reach 40° C and higher with greater frequency during main tourist seasons. Consequently, visitors to such areas will have to expect higher heat stress, a factor that can especially affect the well-being of older people and of children. In Germany, on the other hand, higher summer temperatures and lower summer rainfall could prove beneficial for tourism – for example, by lengthening the summer tourist season. The Potsdam Institute for Climate Impact Research (PIK) expects Germany to become a more popular tourist destination. According to estimates, the numbers of tourists visiting Germany could increase by 25 to 30 %.

At the same time, summer temperatures in Germany could reach levels – at least in some years – that would prove disadvantageous for some branches of tourism.

The tourism sector depends on destinations' having a largely intact environment. A desire to experience nature and scenery is among the most important reasons why people go on vacation. At the same time, the tourism industry is partly responsible for climate change, and it must work to meet the challenges arising through such change.

Needless to say, the Federal Government's climate objectives and climate policies apply to the entire tourism sector. Environmental awareness is comparatively well developed in Germany. Tourists have become increasingly sensitive to environmental problems, and such problems have begun influencing their destination choices.

Germany will continue to be able to position itself as a travel destination with high environmental standards and high recreational value.

The Federal Government has been working to promote societal responsibility in tourism. That is why German policies relative to tourism are oriented to the ideal of sustainable development. Along with efforts to make tourism environmentally friendly, in the present context that ideal calls for more intensified promotion of environmentally friendly, nature-oriented types of tourism, and expansion of environmentally oriented tourist programmes.

In the interest of being able to provide relevant recommendations, the Federal Government is currently supporting the project "Climate trends and sustainable development of tourism in coastal and highland regions" ("Klimatrends und nachhaltige Tourismusentwicklung in Küsten- und Mittelgebirgsregionen"; KUNTIKUM). That research project, which is being carried out by the Institute for Environmental Communication (INFU; Institut für Umweltkommunikation) at the University of Lüneburg, is studying how tourism, as an economic sector that is particularly sensitive to weather and climate, can adapt to the impacts of climate change. In the effort, a collaborative research project, representatives of the tourism industry and of the tourism-policy sector are working together with scientists from the areas of economics, sustainability research and climate research. To ensure that relevant experience gained in the study regions (the North Sea coast and the Black Forest) can be made available for other tourist regions, the project is expected to develop an information and communications platform. And that platform is expected to include a further-training module.

7 Financial support and technology co-operation

From 2004 to 2008, the Federal Government again sharply increased financial support for developing countries for the purposes of reducing emissions of

greenhouse gases (GHG), adapting to climate change and engaging in technology transfer. With that support, the Federal Government is fulfilling its obligations, under the UN Framework Convention on Climate Change and the Bali Action Plan, to provide new and additional funding.

Support for adaptation, emissions reduction and technology transfer in developing countries is integrated within overarching development-policy strategies and programmes. In relevant implementation, the Federal Government is oriented to resolutions taken by the Parties to the UN Framework Convention on Climate Change, as well as to the principles of the Paris Declaration and the Accra Agenda for Action (calling for, inter alia, own responsibility on the part of partner countries, reliance on partner institutions and their procedures, co-ordination of donors' efforts, orientation to effectiveness and joint accountability on the part of partners and donors).

In the area of climate and development, the Federal Government makes use of a broad spectrum of instruments and institutions for international co-operation:

- Bilateral financial and technical co-operation,
- Multilateral co-operation in the framework of the UN Framework Convention on Climate Change, and especially via the Global Environment Facility,
- Multilateral co-operation, especially via multilateral development banks and UN organisations.

7.1 Bilateral co-operation

The Federal Government supports financing, and transfer of technical equipment, know-how and experience, for purposes of reduction of greenhouse-gas emissions and for adaptation to the impacts of climate change, in numerous different areas:

In financing of real investments, such as investments in acquisition and construction of plants and equipment that support GHG reduction or adaptation to climate change, partner countries receive support in the framework of Financial Co-operation (FC). Via FC, grants, low-interest loans and low-cost development loans for investments can be provided to national and semi-national institutions in co-operating countries. As of the end of 2007, over some 40 % of all ongoing projects in the portfolio of the KfW development bank were aimed at preventing GHG or at adaptation to the impacts of climate change.

To ensure that technological investments lead to lasting reductions of climate-harming greenhouse gases, and to mitigation of the negative impacts of climate change, the German development-co-operation sector strongly emphasises capacity building. For the group of least developed countries (LDCs) in particular, which have the least means and resources to conduct climate-protection policy and adapt to climate change, such support provides an important basis for fulfillment / use of the obligations arising from the UN Framework Convention on Climate Change and the Kyoto Protocol.

Technical Co-operation (TC) efforts provide a broad range of instruments for capacity building in partner countries: know-how transfer, organisational development, advising and training and further training for local specialists and managers (for example, for decision-makers in the political and industry realms, and with regard to environmental management issues). In addition, the Federal Government supports

partner countries in establishing and developing technology centres, research institutes and economic-promotion institutions.

Pilot and model projects can be used to introduce new technologies, thereby enabling relevant demand to reach the critical levels at which such technologies can become profitable in partner countries.

The Federal Government also promotes measures for creating enabling environments, with the aim of motivating the developing countries' private sectors to increase their investments in climate-friendly technologies adapted to climate change. Such efforts extend to standards and economic incentives for energy-efficient technologies and renewable energies, socially compatible reduction of subsidies for fossil fuels, strengthening of institutions responsible for monitoring compliance with environmental laws and advising of companies in the area of energy management. Development co-operation can contribute to such efforts via economic and sector-policy advising.

7.1.1 Cross-sectoral initiatives

Via a range of cross-sectoral initiatives, the Federal Government is supporting financing and transfer of technology, know-how and experience for developing countries, with the aims of helping such countries to reduce greenhouse-gas emissions and adapt to climate change:

- The "Special Facility Initiative for Climate and Environmental Protection" ("Sonderfazilität Initiative für Klima- und Umweltschutz"; IKLU) was established in 2008 by the Federal Ministry for Economic Cooperation and Development (BMZ) and the KfW development bank. In the IKLU framework, and from 2008 to 2011, a total of EUR 2.4 billion is being provided, in the form of low-interest loans and grants, for climate-oriented and environmentally relevant investments in developing countries. The IKLU support areas include:
    - Renewable energies: Investments in expansion of use of renewable energies, including wind energy, biomass, solar energy, geothermal energy and hydroelectric power.
    - Energy efficiency: Investments aimed at increasing energy efficiency – for example, in energy production, energy transmission and distribution and in energy use in industry, commerce and private households.
    - Industrial environmental protection: Investments for environmental protection in small and medium-sized enterprises (SMEs) and in industrial zones.
    - Energy-saving mobility: Investments in energy-efficient transport systems, such as railway and bus systems.
- Since 2008, the International Climate Initiative (ICI), an effort of the BMU, has been financing climate protection projects in developing and threshold countries and in transition countries of central and eastern Europe. The relevant support focuses include the G5 countries – Brazil, China, India, Russia and South Africa.

In the area of climate-friendly industry, the initiative is supporting a range of efforts, including improvement of energy efficiency, expansion of use of renewable energies and reduction of climate-harming greenhouse-gas emissions. Support comprises

investment measures as well as know-how transfer and advising of policy-makers in partner countries.

In the area of adaptation, suitable National Adaptation Programmes of Action (NAPAs) are being implemented in selected partner countries that are especially vulnerable to climate change. Via an integrated approach, as many adaptation issues as possible are covered, including water-resources management, optimised land use, sustainable biomass production, restoration of devastated areas, health care, disaster prevention and migration management.

In the area of climate-relevant biodiversity protection, projects are promoted for protection of carbon sinks, especially for protection of forests and other relevant ecosystems, such as wetlands. Activities in this area are helping to improve synergies between climate protection and biodiversity protection.

In each of the years 2008 and 2009, the International Climate Initiative has available funding of EUR 120 million from sale, in the framework of EU emission trading, of emission allowances to companies. The great majority of funds available under the International Climate Initiative are being implemented in bilateral projects. Projects of multilateral organisations are also supported, however.

- Via the Climate Protection Programme for Developing Countries (CaPP), an effort under the UN Framework Convention on Climate Change, and which is being carried out by GTZ (Gesellschaft für Technische Zusammenarbeit) under commission to the BMZ, the Federal Government is supporting developing countries in fulfilling their obligations under the Framework Convention and in making use of the resulting development opportunities. In addition, the Climate Protection Programme is supporting developing countries' active participation in developing international climate agreements for the period after 2012.

The Climate Protection Programme advises partner countries with regard to ways of including climate change as a focus of efforts to achieve sustainable development. In the process, conceptual and institutional integration of climate protection and adaptation measures within policy formulation, planning and funding allocations is being supported. In co-operation with partners, the programme identifies action options for affected people, economic sectors and ecosystems.

- The climate protection programme supports developing countries in building structures for the Clean Development Mechanism (CDM). In the CDM context, companies from industrialised countries invest in projects, in developing countries, for reducing greenhouse-gas emissions via use of renewable energies, enhancement of energy efficiency or prevention of methane emissions from landfills. For developing countries, the CDM also presents opportunities for modernisation of energy supply systems. The climate protection programme supports partner countries in various ways – for example, in preparing national CDM strategies, sector studies and CDM-project planning. In addition, it helps provide the institutional and organisational basis for identifying, preparing and efficiently approving and managing CDM projects. The actual project financing for emissions-reduction certificates comes from the private sector. No funding comes from the development-co-operation sector.
- In 2004, in order to help mobilise private funding for sustainable development in developing countries, KfW Bankengruppe established the KfW Carbon

Fund, a climate protection programme for purchase of certificates from the CDM and from the Joint Implementation Mechanism (JI; for certification of emissions reductions in transition countries). At the same time, the Fund facilitates purchases, by private companies in industrialised countries, of climate protection certificates from relevant projects. Projects in the areas of renewable energies and energy-efficient measures play an important role in the effort. The Fund is funded by the private sector, and not with any funding from public-sector development co-operation.

- At the end of 2008, KfW established the PoA Support Center Germany. Support Center Germany. That effort is aimed at building a portfolio of implementable Programmes of Activities (PoA) within the framework of the flexible Kyoto mechanisms, CDM and JI. In each Programme of Activities, numerous small climate protection measures are combined to form a single project. For example, programmes for large-scale purchase of energy-saving lightbulbs can be financed via PoAs.
- Proklima, a Framework Convention project of the GTZ, supports environment ministries, in over 30 partner countries, in efforts to introduce substitutes for ozone-depleting substances such as CFCs, halons and methyl bromide in developing countries. Since some of these substances have strong greenhouse-gas effects, the programme also supports global climate protection efforts. Proklima advises directly affected companies in selecting the most suitable technologies, and it organises the formalities relative to such investments. The project co-operates with technology providers, including suppliers of refrigeration and air conditioning equipment and plastics manufacturers.

7.1.2 Financing and technology transfer in the area of reduction

7.1.2.1 Energy

In its support for efforts to reduce greenhouse-gas emissions, the Federal Government's main focus is on the area of energy. The main aim of relevant activities is to improve energy supply systems in developing countries in lasting ways. In the same framework, such systems' greenhouse-gas emissions and dependence on fossil fuels are to be reduced. For this reason, in partner countries, Germany is supporting efforts to use renewable energies, improve energy efficiency and disseminate sustainable and decentralised technologies via both a) investment measures and b) know-how transfer and advising of policy-makers.

In the framework of its development co-operation, Germany has reached agreement with a total of 16 developing countries on having energy be a central co-operation focus. All in all, relevant energy-oriented projects are being carried out in over 50 countries.

In recent years, the Federal Government has launched numerous new initiatives in the energy sector and provided extensive pertinent funding:

- From 2003 to 2005, in the framework of the special programme Nachhaltige Energie für Entwicklung (Sustainable Energy for Development), which promotes development of sustainable energy systems and replacement of climate-/environmentally harmful energy systems, the Federal Government

has supported a total of 90 new energy projects, with total funding of EUR 1.1 billion. Via the action programme "Climate and Development" ("Klima und Entwicklung"), the number and scope of these projects were further increased. All in all, new commitments totalling about EUR 3 billion were made for bilateral energy projects between 2003 and 2008.

- Since 2005, in the framework of the Special Facility for Renewable Energies and Energy Efficiency (4E), the Federal Government has supported investments, in developing countries, aimed at boosting the spread of renewable energies and at improving energy efficiency. The types of renewable-energy systems being supported include wind energy and hydroelectric systems, biomass systems, geothermal energy systems, photovoltaic systems and solar-thermal systems. In the interest of improving energy efficiency, efficiency-oriented measures are being supported in the areas of electricity production, loss reduction in power transmission and efficient demand-side energy use. From 2005 to 2007, low-interest loans totalling over EUR 500 million were made available for financing resources-conserving and environmentally friendly investment projects. In 2007, as a result of the resulting strong demand from partner countries, the available loan volume in the Special Facility for Renewable Energies and Energy Efficiency was doubled, to EUR 1 billion. With that move, a total of EUR 1.5 billion are available, through 2012, for low-interest loans to state and semi-national institutions in co-operating countries, for investment purposes. In individual cases, private companies from co-operating countries are also eligible for support.
- Many developing countries lack the necessary expertise for introducing new technologies in the area of renewable energies. For this reason, the Federal Government supports partner countries in technology and know-how transfer. Since 2005, KfW Entwicklungsbank (Development Bank), working under commission to the Federal Government and the United Nations Environment Programme, has been carrying out the programme "Exploring and Motivating Sustainable Power Markets" (EMPower). EMPower is directed at market introduction of commercial photovoltaic systems and solar-thermal power stations for the power grids of developing and threshold countries. In the process, the effort is also helping to publicise the opportunities inherent in the technologies. In co-operation with energy providers, suitable sites for short-term or medium term implementation are identified.
- Via energy partnerships, the Federal Government integrates private industry in climate protection measures in developing countries. Via contacts between companies in industrialised countries and developing countries, projects can be carried out in which entrepreneurial commitment and development-policy benefits go hand-in-hand (Public-Private Partnerships; PPP). With such aims in mind, dialogue with various industry associations has been intensified. In recent years, for example, private-sector projects have been supported, in Laos, Ghana, Mali, Senegal, South Africa and Tanzania, for installation of solar power systems in rural areas. Deutsche Investitions- und Entwicklungsgesellschaft (DEG) finances private-sector investment projects, including projects in the area of renewable energies.

7.1.2.2 Transport

Economic development and poverty mitigation cannot succeed in the absence of a functioning transport system. Greenhouse-gas emissions have been growing sharply in the transport sectors of many developing countries, however. For this reason, German development co-operation is also aimed at improving transport-sector energy efficiency and at promoting cleaner types of transport systems. In developing and threshold countries, the Federal Government is supporting establishment and development of public transport systems – especially rail systems – along with improvements of transport planning in urban areas and relevant training and further training measures.

- Since 2008, working in the framework of the "Special Facility Initiative for Climate and Environmental Protection" ("Sonderfazilität Initiative für Klima- und Umweltschutz"; IKLU), the Federal Government has provided some EUR 2.4 billion in the form of low-interest loans and grants for climate-friendly and environmentally relevant investments, including investments in energy-efficient transport systems, such as rail and bus systems.

7.1.2.3 Forest conservation

Forests have great significance as both sinks and sources within the global carbon cycle. Each year, more greenhouse gases are released via forest destruction than are produced by the entire EU. The emissions involved amount to about one-fifth of global, anthropogenic greenhouse-gas emissions. Without efficient protection for tropical forests, it will not be possible to keep global warming from exceeding 2°C. In this light, the Federal Government's international forest policy is aimed at slowing deforestation and further forest degradation and at preserving forests as greenhouse-gas sinks.

- In 2008, the Federal Government, working in the framework of bilateral development-policy co-operation, provided a total of EUR 120 million for forest and biodiversity conservation. A large portion of that funding also supports climate protection.
- International Climate Initiative (ICI), the Federal Government supported some EUR 45 million worth of measures for conservation of biodiversity and of carbon sinks.
- In a number of partner countries, the Federal Government is supporting REDD pilot measures. Those pilot measures are to provide experience relative to the design of a future mechanism, agreed on under the umbrella of the UN Framework Convention on Climate Change, for Reduction of Emissions from Deforestation and Degradation (REDD).
- In addition, the Federal Government is supporting the Forest Carbon Partnership Facility (FCPF) of the World Bank. It has committed a total of EUR 40 million, from development-co-operation resources, to that effort.

7.1.3 Adaptation to climate change

Developing countries are particularly vulnerable to the adverse impacts of climate change. On the one hand, a majority of the population of developing countries depends directly on agriculture and is thus directly dependent on climate and weather conditions. On the other hand, many countries lack the technical, staff and financial resources necessary for adaptation to changed climatic conditions. Support

for developing countries in adaptation to climate change has thus been integrated within many projects in the framework of German development co-operation.

7.1.3.1 Agriculture

Soil degradation and desertification are already presenting major challenges for developing countries. Climate-related changes of temperature, evaporation and precipitation will likely exacerbate desertification in many areas. As a result, agricultural yields and income can be expected to decline, and food security is likely to be threatened. To help developing countries adapt their agricultural production to climate change, the Federal Government is supporting transfer of know-how relative to food crops, cultivation technologies and concepts for combatting desertification.

- Since 2007, and in the framework of the Advisory Service on Agricultural Research for Development (BEAF), the Federal Government has been supporting international agricultural research in the area of adaptation to climate change. In 2007/2008, projects with a total contract value of EUR 10.1 million were approved in the framework of that support. The international agricultural research institutes supported in this framework are carrying out research into cultivation methods adapted to climate change, as well as into suitable varieties of corn, rice, wheat, potatoes, cassava and other agricultural products. In addition, research is focussing on ways of improving natural-resources management in agriculture, as well as on ways of enhancing sustainable management of tropical forests. BEAF also makes experts from Germany available to a network of international research centres. Findings from the institutes' research are publicly accessible.
- Via the Convention Project to Combat Desertification (CCD Project), the Federal Government is supporting the agriculture and forestry sectors in adapting to climate change. The project advices selected partner countries in preparation and implementation of national action programmes for combatting desertification.

7.1.3.2 Water

In many regions of the earth, global warming will lead to changes in water availability. The negative consequences of such changes will vary widely from region to region. More intensive rainfall is expected primarily in tropical regions and in those higher latitudes that already receive large amounts of precipitation. Such regions will thus face added floods and high-water periods. In other regions, such as some sub-tropical dry regions, precipitation will tend to decrease. What is more, sea levels are expected to rise as a result of thermal expansion of ocean water and of melting of glaciers and ice sheets.

Overall, changes in water availability will have adverse effects in numerous different areas, including agriculture, the drinking-water supply, wastewater management, fisheries, hydroelectric power generation and inland shipping. Furthermore, the effectiveness of environmental and resources conservation, and of efforts to protect ecosystems and biological diversity, depends significantly on water cycles. The water-resources sector will thus play a key role in adaptation to climate change.

All in all, Germany's is one of the world's largest bilateral-framework donors in the water-resources sector. German commitments and involvement in this area are

based on the concept of integrated water-resources management (IWRM). They are focussed especially on the following areas:

- Water-resources management (flood management, dams and disaster prevention and trans-boundary water-resources management),
- Water supply (especially with regard to supplies of drinking water and industrial / process water; basic sanitary services; and wastewater and waste management).

7.1.4 Integration of climate aspects in planning and development of measures in German development co-operation

In 2009, the Federal Ministry for Economic Cooperation and Development (BMZ) introduced a climate-based review process to ensure that climate change is taken into account in all strategies and programmes of German development co-operation. As part of this orientation, activities in partner countries are designed with a view to ensuring that projects' positive impacts are not at risk from the impacts of climate change. In addition, measures are planned and implemented in such a way as to develop available potential, wherever possible, for limiting and reducing climate-harming greenhouse gases. In integration of climate aspects within development co-operation, the Federal Government orients its efforts to relevant international standards, such as the "Good Practice Guidance for Strategic Environmental Assessment in Development Cooperation", developed by the OECD DAC, and the "OECD Guidance on Integrating Climate Change Adaptation into Development Cooperation".

7.1.5 Tabular overview of climate-relevant bilateral development co-operation

The following tables present a list of Germany's climate-relevant bilateral development co-operation efforts, broken down by recipient countries and sectors, and covering the years 2004 to 2006.

The statistics provided are based on information provided to the OECD's Development Assistance Committee (DAC). They include all bilateral co-operation projects that have a main or significant focus on stabilising greenhouse-gas concentrations in the atmosphere. These projects have been reported to the OECD-DAC under the Rio category "climate change". In the tables below, commitments from the years 2004 – 2006 are included, broken down in accordance with the following sectors:

- Energy generation and supply: Support area 230
- Transport: Support area 210
- Forestry (and tropical forests): Support area 312
- Agriculture: Support area 311
- Industry: Support area 321
- Waste management/disposal: Support area 14050

The list also includes an additional column, with a focus on adaptation to climate change:

- Water supply and sanitation: Support area 140, but without 14050

The sector "water supply and sanitation" was included for the reason that, to date, the Rio "climate change" category does not yet include the aspect of adaptation to climate change. This presentation is in keeping with the methods used in Germany's 4th National Report to the UNFCCC. It will be retained, for the time being, until new methods for statistical recording of projects for adaptation to climate change are approved in the OECD-DAC framework.

Table 89: Germany's total bilateral support in climate-relevant sectors, in 2004 [in millions of USD]

Recipient country	1. Energy generation and supply	2. Transport	3. Forestry (and tropical forests)	4. Agriculture	5. Industry	6. Waste management/disposal	7. Water supply and sanitation
Afghanistan	2,1742						13,0451
Egypt				3,1060		1,8636	8,6967
Albania							9,6906
Argentina				0,3541			
Armenia	9,3179						
Azerbaijan							2,4848
Ethiopia				13,6042			
Bangladesh	5,7170						
Benin							20,4994
Brazil	0,0323			0,0981			7,4543
Burkina Faso				0,7009			
Chile				0,1541			
China	17,3935						
Costa Rica						4,3484	
Côte d'Ivoire			0,0347				
Ecuador							6,2120
El Salvador				0,0347			
Georgia	2,4848						12,4239
Ghana				0,1332			
Guinea							9,3179
Honduras			3,8514	0,1553			
India			3,7272	0,0957			4,9696
Indonesia					11,1815		4,9696
Yemen						0,2196	17,3935
Jordan							26,4629
Kenya	10,7144			4,9696			29,8174
Colombia			0,0447				
Lesotho				0,8697			
Madagascar			0,0434				
Morocco	137,9252			2,4848			34,1657
Mauretania							
Mongolia	1,3666						
Namibia			2,5407				
Nicaragua				0,1553			1,8636
Nigeria				0,2174			
Palestinian territories						2,5469	21,1206
Paraguay							1,8636
Peru							17,3935
Philippines				0,0882			
Zambia				0,2547			16,1511
Senegal				0,6212			
Serbia	5,1186						8,4483
Tanzania				0,3914			
Thailand							
Tunisia						5,6603	

Uganda	1,7393						14,6602
Vietnam			2,5122				
Bilateral, unspecified	8,9732	1,6151	1,4909	0,0249			
Europe, regional							0,6212
Africa north of the Sahara, regional							
Africa south of the Sahara, regional							2,4848
Africa, regional				0,2485			2,4848
America, regional	3,2302			1,8636	1,2424		
Near East, regional							1,2424
South and central Asia, regional			2,4848				
Asia, regional	1,2424		1,8636				
Oceania, regional			0,1615				
Total per support area	**207,4297**	**1,6151**	**18,7551**	**30,6253**	**12,4239**	**14,6388**	**295,9374**

Sources: Columns 1 – 6: OECD CRS database; Column 7: BMZ

Table 90: Germany's total bilateral support in climate-relevant sectors, in 2005 [in millions of USD]

Recipient country	1. Energy generation and supply	2. Transport	3. Forestry (and tropical forests)	4. Agricul-ture	5. Industry	6. Waste manage-ment/ disposal	7. Water supply and sanitation
Afghanistan	5,5928			1,4479			12,4285
Egypt	93,1891				0,1334	0,0878	
Albania	16,5169						
Algeria	0,1451						5,8414
Argentina	0,0993						
Armenia							2,4857
Azerbaijan				0,1243			
Ethiopia	0,0967						
Bangladesh	22,9978						
Benin				4,9714			2,4857
Bolivia				1,2789			
Brazil	0,5699			3,0152	0,5744	0,1849	
Burkina Faso	0,0967			4,7228			16,1571
Burundi							4,9714
Cape Verde				5,5307			
Chile				0,6214		0,0621	
China	5,2200	1,8672	20,6063			3,5802	
Dominican Republic				0,1665			
El Salvador				0,7693			
Georgia	60,1866						
Ghana			0,1559				0,9943
Guatemala			0,1268	0,5121			
Haiti				0,4263			
Honduras			0,2524				
India	0,1512		3,8777	0,1852			
Indonesia	0,6214	67,1141	2,4857	0,9384	0,1448		1,2429
Yemen						0,6214	28,3371
Jordan							21,1285
Cameroun					0,2610		
Kenya	0,0967			0,5742			
Kyrgyz	12,9578						
Colombia				0,4931			
Democratic Republic of Congo			2,4857				1,2429
Cuba	0,3713						
Madagascar	2,6020						
Mali	4,6999						
Mauretania				0,6457			
Mexico			0,0643	0,4649	0,1003	0,1936	
Mongolia	2,4857	4,9714					
Mozambique						2,4857	
Namibia	0,1582	0,1176					3,7286
Nepal	9,3214						
Nicaragua			0,0657	0,1964			
Nicaragua			0,0657	0,1964			
Nigeria	0,1451			0,2896			
Palestinian						3,1071	

territories							
Paraguay				0,9259			
Peru				0,8824			20,5071
Philippines				0,3107	0,1448		3,1071
Rwanda				0,0671			
Senegal				0,2486			
Serbia	39,7713						21,2528
Sri Lanka							27,3428
South Africa	11,8071						
Syria							41,6356
Tanzania				0,6749			
Thailand	0,0871				0,2374		
Tunisia	1,8643						7,4571
Turkey							9,3214
Uganda				0,5034			7,4571
Ukraine	0,0831			0,0621			
Uzbekistan				0,1294			
Vietnam					0,3328		
Zimbabwe				1,2063			
Bilateral, unspecified	11,8975		0,2697				5,4686
Europe, regional							6,5871
Africa south of the Sahara, regional				0,4154			
Africa, regional			3,7286				6,8357
America, regional					1,9886		
Near East, regional							3,4178
South Asia, regional							2,4857
Asia, regional				1,4664			
Central Asia, regional			2,2371				
Total per support area	**303,8322**	**74,0703**	**36,3560**	**34,2668**	**3,9175**	**10,3230**	**263,9200**

Sources: Columns 1 – 6: OECD CRS database; Column 7: BMZ

Table 91: Germany's total bilateral support in climate-relevant sectors, in 2006 [in millions of USD]

Recipient country	1. Energy generation and supply	2. Transport	3. Forestry (and tropical forests)	4. Agriculture	5. Industry	6. Waste manage-ment/disposal	7. Water supply and sanitation
Afghanistan	1,3817						4,1421
Egypt	11,6732			64,1762	0,9621		53,9726
Albania	11,2966						
Algeria					0,1677		
Angola				0,2636			
Argentina	0,2446		0,0205	0,5586			
Bangladesh	2,5104						
Benin							20,0828
Bolivia			0,0543	1,7761			11,8120
Bosnia-Hercegovina				0,0471			
Botswana	0,0586		0,0885				
Brazil	1,2131		0,5405	2,3158	0,4219	0,1106	
Burkina Faso				2,6177			
Chile	0,0581		0,0611				
China	9,0085	222,1664		0,2184			
Côte d'Ivoire				0,0352			
Ecuador			0,1183	0,5532			
El Salvador				0,4368			
Georgia				0,6276			17,5725
Ghana			0,7690	0,6596			
Guatemala				0,4356			
Guinea							6,2759
Haiti			0,3364	0,5096			
Honduras			6,9035				
India	88,7615			13,9701			
Indonesia			0,0990	0,3264	0,7710		
Yemen					0,0102		
Jordan							42,0484
Cambodia				0,3000			
Cameroun				0,3458			
Kenya				0,6929			21,0870
Colombia	0,2858		0,0353	0,9303			
Democratic Republic of Congo				0,1268			1,2552
Lesotho	0,0516						
Lebanon					0,0882		6,2759
Liberia						0,1757	
Madagascar	0,0847			5,1990			
Malawi			0,1063				
Malaysia							
Mali						0,1424	3,7655
Morocco	62,7589						29,7477
Mauretania				0,1966			
Mongolia	2,2164		0,0821				
Mozambique				0,2824			
Namibia	0,0586		0,9647				
Nepal	1,0041						

Nicaragua			0,0467	0,5071			
Niger							1,8828
Palestinian territories						0,1464	3,7655
Papua New Guinea			0,4393				
Paraguay				0,1883			
Peru	0,1179		0,0874	1,7693			
Philippines				0,1381	0,1904	0,3156	
Rwanda	0,0139			0,0439			
Zambia	0,0693						20,7104
Senegal	9,5496						
Serbia	51,4698						12,5518
Sri Lanka	2,0083						
South Africa	0,0586						
Syria					0,4519		
Tajikistan							
Tanzania	0,0957			0,5146			21,3380
Thailand				0,4268	0,2627		
Tunisia					0,0851		
Turkey							7,5311
Ukraine	2,5104						
Vietnam		12,8352	16,3173		0,6290		42,0484
Bilateral, unspecified	2,5919	1,2552	0,1779	0,1663		0,0258	
Africa south of the Sahara, regional	0,1033			0,0443			15,0621
Africa, regional				0,3803			1,8828
Asia, regional	3,1379						
Europe, regional							7,5311
Near East, regional					0,0356		
South America, regional	37,7372						
Central Asia, regional				0,5021			
Total per support area	**302,1301**	**236,2569**	**27,2479**	**102,2822**	**4,0759**	**0,9165**	**352,3417**

Sources: Columns 1 – 6: OECD CRS database; Column 7: BMZ

7.2 Multilateral co-operation in the framework of the Global Environment Facility (GEF)

The Global Environment Facility (GEF), the financial mechanism of the UN Framework Convention on Climate Change, finances the additional costs of climate protection measures, with global environmental benefits, in developing countries. Germany has a seat, and voting rights, on the GEF Council.

In the **3rd Replenishment Period** (2002 - 2006), Germany committed US$ 294 million. Of those funds, a total of 33 % were allocated to the environmental funding area of "climate change".

In the **4th Replenishment Period** (2006 - 2010), Germany committed US$ 295 million. Of those funds, 33 % have again been earmarked for climate change (US$ 97.35 million).

Table 92: Germany's contributions to the Global Environment Facility (GEF):

German contribution, 2002 – 2006	Annual average, 2002 – 2006	Annual average, 2002 – 2006, for climate change	German contribution, 2006 – 2010	Annual average, 2006 – 2010	Annual average, 2006 – 2010, for climate change
US$ 294 million	US$ 73 million	US$ 24 million	US$ 295 million	US$ 74 million	US$ 24 million

With shares of 11 % (2002 – 2006) and 12 % (2006 – 2010), Germany is the third-largest contributor to the GEF, after the U.S. and Japan.

Via the "Bonn Resolution" of July 2001, for implementation of the UN Framework Convention on Climate Change and the Kyoto Protocol, two new funds for climate protection measures were established within the GEF framework:

7.2.1 Least Developed Countries Fund (LDCF)

The LDCF finances measures in the area of adaptation to climate change in Least Developed Countries (LDCs; as per the UN definition). In 2003, Germany committed EUR 15 million to the LDCF, and in 2007 it committed EUR 25 million.

The LDCF finances preparation of National Action Programmes for Adaptation to Climate Change (NAPAs), as agreed under international law, thereby helping LDCs to build capacities in the area of adaptation. Once such a NAPA has been prepared, the LDCF also finances its concrete implementation.

In 2005, the fund began financing concrete project measures.

7.2.2 Special Climate Change Fund (SCCF)

Pursuant to a resolution of the 7th CoP, held in 2001, the SCCF finances projects and programmes in developing countries, in the following four areas:

- Adaptation to climate change,
- Technology transfer,
- Energy, transport, industry, agriculture, forestry and waste management,

- Economic diversification in countries that are strongly dependent on fossil fuels.

In contrast to the LDCF, the SCCF is open to all developing countries. It is thus more broadly aimed. Germany has been concentrating its support for the SCCF especially on the area of adaptation to climate change.

Germany has made the following funding commitments for the SCCF:

1st Replenishment, 2004: EUR 5 million

2nd Replenishment, 2006: EUR 5 million

3rd Replenishment, 2008: EUR 10 million

7.3 Project examples

7.3.1 Examples of projects for adaptation to climate change

7.3.1.1 Egypt: Water-resources management

Egypt's water resources are among the scantiest of all countries world-wide. And that problem will be exacerbated by climate change. As a result of Egypt's rapid population growth, amounting to two percent per year, and its economic development, demand for water in Egypt has been growing continually. Agriculture is far and away the thirstiest economic sector.

Germany's involvement is aimed at safeguarding irrigation agriculture in the Nile Delta, in the long term, and especially for small farmers. Efforts to that end are modernising obsolete irrigation channels and renovating drainage networks, with the aim of facilitating ongoing, efficient irrigation.

These programmes are being complemented by a GTZ project for water-resources management in agricultural irrigation. That project is supporting the Egyptian government in co-ordinating and improving advising for farmers, with the aim of achieving sustainable, cost-effective water use. For example, special model projects are being carried out to show farmers how to reduce water use on their fields.

German contribution: EUR 96 million

Planned project period: 1995 to 2013

7.3.1.2 Ethiopia: Agriculture

A total of 50 million people – two-thirds of the Ethiopian population – live in the highland regions of Amhara, Oromia and Tigray. Agricultural yields in those regions are extremely poor as a result of extensive soil erosion, deforestation and inappropriate land use. Droughts, which have been growing more frequent as a result of climate change, exacerbate such problems.

Since 1995, Germany has been supporting Ethiopia in managing its natural resources and working toward food security. On the basis of experience gained in these efforts, a strategy has been prepared, in co-operation with the Ethiopian government, for improving living conditions in Amhara, Oromia and Tigray.

As part of that strategy, soil erosion is to be reduced on steep slopes. To that end, farmers are being taught new methods of biologically oriented erosion protection and properly adapted techniques for working the soil. The natural conditions in highland regions are a rich resource that is now being used more effectively: Use of new, high-

yield plant and animal species is making it possible to intensify agriculture and boost yields. Cultivation of triticale, a wheat-rye cross, has been particularly successful. Planting of new types of trees – especially apple trees – has also been effective. To help reduce forest destruction, wide use of energy-saving ovens, and of other types of energy biomass, is being promoted.

German contribution: EUR 21.02 million (technical co-operation via the GTZ) and EUR 22.95 million (financial co-operation via KfW-Entwicklungsbank)

Planned project period: January 2005 to December 2015

7.3.1.3 Indonesia: Adaptation, and reductions in the context of urban growth

Indonesia's cities have been growing by leaps and bounds. Industry and transports have been increasing as well, thereby boosting demand for energy, along with CO_2 emissions and environmental pollution. What is more, as a result of their lowland locations, many Indonesian cities are at risk from climate-related sea-level rises.

A GTZ programme is supporting Indonesian cities in planning and implementing strategies for climate protection and adaptation to climate change. The programme has been working with the industry and transport sectors of six selected cities, in efforts to lower their emissions. Technology transfer and access to the carbon market are understood to be the keys to success. In endangered regions, the GTZ has been training municipal staff in adaptation measures and has been showing them ways of responding to possible disasters.

7.3.1.4 Mozambique: Disaster preparedness

Flooding is a common problem in Mozambique. And floods can be expected to increase as a result of climate change. In 2000, some 700 people died as a result of floods; in 2001, an additional 100 people died in flooding along the Incomati, Limpopo, Save, Buzi and Zambezi rivers. Many thousands of people lost everything in these calamities.

Since 1998, disaster prevention and preparedness have been promoted in Mozambique via various programmes. In a project with the National Disaster Management Institute (INGC), under commission to Mozambique's Council of Ministers, the German government has been promoting transfer of experience gained to date, along with institutionalisation of disaster preparedness in Mozambique.

The Munich Re Foundation has also been supporting disaster preparedness in Mozambique. Since 2005, it has been supporting relevant measures, especially measures for early warning, via project co-financing.

The catastrophic flood of 2007 thus did not find Mozambique unprepared. A functioning disaster preparedness system, including early warning systems, emergency centres and co-ordination agencies, is now in place. The National Disaster Management Institute (INGC) is able to manage emergency response and assistance measures, in connection with disasters, competently and effectively.

Political sponsor: Instituto Nacional de Gestão de Calamidades (INGC)

Total project period: January 2007 to December 2008

7.3.1.5 Peru: Adaptation strategy

For the population in the Arequipa region, in the south of Peru, climate change is no longer just some future scenario. The region's citizens and authorities alike are growing more and more alarmed as they observe the melting of the nearby Coropuna glacier. According to a study of the UN Environment Programme (UNEP), 54 percent of the glacier has already melted away. In general, loss of the glacier is forecast to exacerbate water scarcity, and to adversely affect agricultural production – and, thus, the food supply. Working under commission to the Federal Ministry for Economic Cooperation and Development (BMZ), GTZ has been advising partners in Arequipa in preparing and interpreting climate scenarios. In the effort, advising has also been provided to technicians and political decision-makers with the aim of facilitating optimal use and more equitable distribution of water resources. At the same time, the organisation's experts have been reviewing public projects for relevance to climate issues. Finally, advising has also included provision of environmentally oriented information and education. In close co-operation with schools, for example, climate change has been made a standard subject in public school curricula.

7.3.1.6 Tunisia: National adaptation strategy

With over 1,300 kilometres of coastline, and over 300 sunny days per year, Tunisia is a popular tourist destination. On the other hand, Tunisia has been, and will be, strongly affected by climate change. The expected sea-level rise is only one example of the relevant impacts. Climate change is expected to threaten tourism, agriculture, human health and the environment. Continually rising temperatures, along with further dwindling of already scarce water resources, are expected to further exacerbate the situation.

The German government has been supporting Tunisia in analysing the impacts of global warming and in developing a national strategy for adaptation of the country's agriculture and health sectors. Training events for decision-makers in relevant ministries have provided an important basis for enabling adaptation measures to find their way into the national agenda. Pilot projects and action plans have now been expanded to the areas of water, energy and tourism. National parks have been established with a view to protecting the country's species diversity, and measures to combat desertification are also helping to counter the impacts of climate change. With the help of GTZ, the Tunisian government has now created the necessary legal and institutional structures needed for an adequate response to the many challenges of climate change. The main partners in the project include the competent Tunisian ministries, the UN Development Programme (UNDP) and the Global Environment Facility (GEF).

7.3.2 Examples of projects for reducing greenhouse-gas emissions

7.3.2.1 Egypt: Wind energy

Egypt generates 84 percent of its electric power in thermal power stations fired primarily with gas and to some extent with heavy oil. Combustion of fossil fuels contributes to global warming.

The Federal Republic of Germany is supporting Egypt in the construction of a wind farm in Zafarana, about 200 kilometres south-east of Cairo. Wind speeds averaging 10 metres per second make that desert area, on the Red Sea, an ideal location for

wind turbines. The wind farm is expected to generate about 600 gigawatt hours of electrical power per year. The power will be fed into the national grid. With that ouput, the wind farm will reduce carbon dioxide emissions in Egypt by more than 360,000 tonnes per year.

The Egyptian government has announced a goal of having Egypt generate 14 percent of its required energy from renewable sources, including wind, the sun and biomass, by 2020. Additional wind parks are currently being planned. Germany is supporting these efforts with low-interest loans totalling about EUR 120 million.

German contribution: EUR 270 million

Planned project period: 1997 to 2010 and beyond

7.3.2.2 Bangladesh: Solar energy

Some 80 percent of the population of Bangladesh live in rural areas – and less than one-fourth of all households are connected to the power grid. It would be enormously costly to extend the power grid into the country's remote, poorly accessible regions. For this reason, the government of Bangladesh is supporting installation of complementary decentralised electrical systems based on renewable energies. A key element of this strategy consists of programmes, supported by German financial and technical co-operation, for providing "Solar Home Systems" to some 160,000 rural households and small companies. Such solar systems provide both light and energy to households and small companies, thereby enhancing their information and communications resources. The programmes are being supported by Germany via investment grants and funding for microloans.

Each Solar Home System consists of a photovoltaic module, a charge regulator, a battery, wiring, installation equipment and lamps. Loan-financed sales, including relevant service, are being carried out by certified private companies and non-governmental organisations. To a large extent, they are able to refinance their loans via the programme sponsor, the Infrastructure Development Company Limited (IDCOL).

German contribution: EUR 16.5 million from financial co-operation; EUR 10.245 million from technical co-operation and combined financial instruments

Planned project period: June 2006 to August 2010

7.3.2.3 Brazil: Forest conservation

In a project for tropical forest conservation in the Amazon region, Germany is pursuing a trans-boundary approach that brings all relevant interest groups together. The project partner is the Amazon Cooperation Treaty Organization (Organização do Tratado de Cooperação Amazônica, OTCA), whose members include Brazil, Bolivia, Ecuador, Guyana, Colombia, Peru, Suriname and Venezuela. An intergovernmental institution, the Organization has a political mandate to control the desired trans-boundary process.

The aim is to develop a common regional planning policy oriented to the ideal of sustainability. The policy would balance interests of commerce, infrastructure development and ecosystem protection. To assure the project's success, as many local, national and supra-regional stakeholders as possible are being integrated, including representatives of state agencies, industry associations and civil-society organisations. In the project, the Federal Government is co-operating with the Dutch government.

German contribution: Technical co-operation: EUR 7 million; financial co-operation: EUR 10 million

Planned project period: 2007 to 2012

7.3.2.4 China: Buildings

China's buildings sector, accounting for a total of 23 percent of the country's greenhouse-gas emissions, is a significant contributor to global warming. At the same time, some 50 percent of the energy consumed by the country's buildings could be saved via thermal insulation measures.

The German-Chinese project "Energy Efficiency in Modernisation of Existing Buildings" ("Energieeffizienz bei der Modernisierung im Gebäudebestand"), which is being carried out in the province of Hebei, is developing and testing suitable modernisation procedures, standards and support policies. As part of the effort, special training is being offered for decision-makers; this ensures that measures are carried out properly and thus have lasting effects. Germany's contribution primarily involves technical / structural, socio-economic and political consultation; provision of international specialists; and supporting studies, exhibitions and conferences.

Last year, in the framework of a pilot project in the city of Tangshan, three residential buildings were modernised in keeping with German concepts for integrated energy-oriented modernisation. The project is supporting introduction of the relevant modernisation concept, and it is functioning as a reference project, for political decision-makers, with regard to a reform of heating-charges allocation. And it is being closely watched by other provinces and cities in northern China.

A technical guideline for existing buildings is being adapted and revised in keeping with Chinese energy-saving policies and on the basis of relevant German experience. A team of experts from Germany is providing consultation over a period of several years. The guideline is providing the technical basis for development and planning of concepts for modernisation and refurbishment, as well as for quality assurance in connection with conversion measures.

In the framework of a feasibility study, the project is also exploring whether the Clean Development Mechanism (CDM) could also be used for co-financing of energy-oriented building modernisations.

7.3.2.5 Honduras: Forest conservation

La Mosquitia is is the largest continguous tropical forest area remaining in central America. It extends from the Caribbean coast of Nicaragua to the eastern part of Honduras. The Río Plátano Biosphere Reserve is an important part of the region. In 1982, the reserve, which covers about 7 percent of the national territory of Honduras, was declared a World Heritage Site, in recognition of its extraordinary biological diversity, by the United Nations Educational, Scientific and Cultural Organization (UNESCO).

With the help of support via German financial and technical co-operation, the state forest administration plans to preserve the biosphere reserve's core zone as an intact ecosystem. In its buffer zone and transition area, protection for the reserve is to be balanced with the interests of the local population.

As part of the project, a concept for the biosphere reserve's sustainable development was developed, in co-operation with stakeholders. Thanks to the improvements that have been achieved in the areas of forestry, pasture management, animal

husbandry, forest agriculture and coffee cultivation, farmers no longer have to encroach on intact forest areas.

Environmentally friendly tourism is to be promoted within the reserve. All in all, destruction of the Río Plátano Biosphere Reserve has been halted.

German contribution: EUR 21 million

Planned project period: February 1997 to (in all likelihood) the end of 2009

7.3.2.6 India: Energy efficiency and renewable energies

In April 2006, the Indian-German Energy Forum was established, a body that focuses on strategically relevant energy problems, including energy security, energy efficiency and promotion of renewable energies and environmentally friendly technologies. The Forum also studies the environmental policy challenges related to sustainable development. An energy programme is underway with the aim of helping electricity producers and consumers improve energy efficiency and climate protection.

Via consultation services, Indian partners in the effort are being supported in implementing an Electricity Act and an Act on Energy-Saving. In addition, private-sector consultation services are being expanded, in co-operation with the Indian Energy Ministry. Energy-services providers are assisting companies in using energy more efficiently – in lowering their electricity consumption – and, thus, their costs. Investments in relevant services and in modernisation of obsolete equipment are being encouraged, with the aim of enhancing energy efficiency.

Exemplary investments for modernisation of coal-fired power stations are being prepared. In the process, the efficiency of thermal power stations is to be improved. Plant operators are planning to restructure relevant procedures and equipment in such a way as to enable power stations to reduce their energy consumption – and, thus, to reduce their pollution levels.

German contribution: EUR 106.6 million (financial co-operation: EUR 96 million; technical co-operation: EUR 10.6 million)

Planned project period: 2003 to 2008

7.3.2.7 Cameroun: Forest conservation

Cameroun's tropical forests are part of the Congo Basin, the world's second-largest contiguous rain forest. In the framework of a national forest programme (Sectoral Programme for Forests and the Environment; PSFE), Cameroun's government is working to counter uncontrolled logging. In co-operation with all stakeholders, resources use is to become sustainable. Programme participants include hunters, users of forest products, non-governmental organisations, private companies and central and non-central administrations. Germany is supporting Cameroun in carrying out this strategy. The programme is designed to enable its various measures, ranging from measures with the local population to measures relative to government strategies, to complement each other. Via a co-operative effort, alternative sources of income are being created. With this approach, independent economic development in the country's municipalities and regions is going hand-in-hand with long-term climate protection and environmental protection. Special attention is being given to ensuring that non-governmental organisations and private companies participate in plan approval and co-ordination.

German contribution: About EUR 26 million

Planned project period: October 2003 to September 2011

7.3.2.8 Morocco: Solar energy

About half of the population of Morocco live in sparsely populated rural areas, many of which are quite remote. Any attempt to connect every house to the public electricity grid would be extremely costly and could never be carried out within the foreseeable future. On the other hand, with over 300 days of sun per year, the country has an ideal basis for generating electricity with solar systems. Such systems provide an environmentally friendly, reliable basic electricity supply. The Federal Republic of Germany is supporting Morocco in this area, within the framework of financial co-operation. Current relevant efforts are aimed at providing electricity to virtually all rural areas by the year 2010 – in part, via use of small photovoltaic systems. The electricity generated by such systems is stored in batteries that can power energy-saving lights, television sets and radios. As a result, they can meet the population's basic needs.

Private firms deliver and install the small systems on a turnkey basis. The suppliers guarantee the systems for a total of ten years, and they provide all necessary repair and maintenance services. Users pay about half of the relevant investment costs. After making a down payment, they pay off their share within ten years, in installments, thereby becoming full owners of the systems. Experience has shown that this approach meets with very high acceptance on the part of the population, since sustainable use of renewable energies improves living conditions of rural residents, most of whom are relatively poor.

German contribution: EUR 11.6 million (including a grant of EUR 5.1 million and a low-interest loan of EUR 6.5 million with interest subsidised with EUR 1.9 million in budget funds)

Planned project period: 2002 to 2009

7.3.2.9 Mexico: Waste management and energy

Mexico's population and economic growth has been creating ever-greater environmental pressures. The especially serious problems include uncontrolled disposal of household waste and hazardous waste. Only about 50 percent of municipal waste and of industrial hazardous waste is recycled or disposed of in a controlled manner. As a result, large amounts of climate-harmful methane are produced.

The focuses of German-Mexican co-operation in this area include preparation and implementation of waste-management plans and promotion of the RED GIRESOL network of multipliers. That network has assumed responsibility for advising and training the country's some 2,500 municipalities in the area of integrated waste management. Other focuses include preparation of suitable analysis instruments and building of technical capacities for clean-up of critically contaminated sites in Mexico.

Germany is also supporting Mexico in promoting use of renewable energies. The emphases of relevant consultation include policy and strategy development (including such development with regard to sustainable promotion of biofuels), restructuring of the legal framework for renewable energies and development of the market for such energies. For example, the Mexican energy efficiency agency CONAE is being supported in designing and implementing a nation-wide programme

for disseminating solar collectors for water heating. That effort is aimed at quadrupling Mexico's total installed collector area by the year 2012.

Germany and Mexico have agreed to make the experience they have gained in relevant technical co-operation available to other Latin American countries, in the form of "triangle co-operation" programmes, and to co-operate in implementing projects with third countries. As a result, financial resources and know-how are being combined in the interest of solving the region's problems – for the benefit of all stakeholders. For example, Mexican experts, working with the help of German support, are establishing a network of environmental advisors in Guatemala for the waste-management sector. Additional such agreements were concluded with Ecuador and the Dominican Republic, and implemented in 2008.

7.3.2.10 Nepal: Bioenergy

In Nepal, firewood is still the most important fuel; a full three-fourths of the country's energy needs are met with this traditional energy source. And people in rural areas rely especially heavily on wood for cooking and heating. As a result, Nepal's forests have shrunk dramatically and erosion has increased. Farm households also use cow dung as a cooking fuel, but this leads to shortages of cow dung in agricultural fertilisation. What is more, smoke from dung fires causes respiratory and eye ailments.

Since 1975, the Nepalese government has promoted construction of systems that produce biogas from cow dung. Such systems help improve the overall energy situation, conserve the country's forests and reduce the country's carbon dioxide emissions. Since 1997, the government has been supported in this regard by KfW Entwicklungsbank. The relevant funding is disbursed via the Alternative Energy Promotion Center (AEPC), which co-ordinates Nepal's policies for supporting alternative energy sources. Part of the funds are used for construction grants, while the remainder goes into a fund that supports issuance of loans for biogas-system construction.

The biogas systems are built by Nepalese companies. Each system consists of an underground container (reactor) and a pipeline system that transports the produced gas to the sites where it is burned. The gas is used to fuel stoves and lamps. Just two or three cows provide enough dung to operate a small system. The sludge left over from the fermentation process is composted and can then be used as fertiliser.

The farmers themselves commission and operate the systems. They take a 75 percent share in financing of the systems, via cash, loans or personal contributions.

To date, a total of some 189,000 biogas systems have been installed in the framework of the programme, and an additional 60,000 are to be installed by 2011. Nepal's total potential requirements for such systems are estimated to amount to over two million systems.

German contribution: EUR 22.4 million

Planned project period: 1997 to 2011

7.3.2.11 Tunisia: CDM capacity building

Working under commission to the Federal Ministry for Economic Cooperation and Development (BMZ), since 2006 GTZ has supported Tunisia in building staffing and institution capacities for entry into the CDM market. Such efforts include establishing a national CDM authority and providing advising relative to assessment of CDM-

project proposals. As soon as authorities, local project initiators and Tunisian consulting companies have the necessary CDM know-how, they can identify and tap into the country's potential for reducing GHG emissions. The number of projects approved by the national authority since the project's commencement has grown from two to 26, for a potential reduction of 46 million tonnes CO_2 eq.. These efforts have made Tunisia an attractive and competent CDM partner in the global carbon market, as well as one of the leading CDM countries in Africa.

7.3.2.12 Uganda: Energy efficiency

In Uganda, Germany has been promoting use of renewable energies and enhancement of energy efficiency, with a view to improving the country's energy sector. One of the project's important components involves encouraging large numbers of end consumers to adopt relevant modern equipment. The programme is aiming to supply modern stoves to at least 220,000 households, primarily poor family households. The stoves are expected to reduce time requirements for cooking and wood collection by 30 percent and to reduce wood consumption by 50 percent. As a result, smoke-related diseases and burns are expected to decrease by 80 percent. The programme is also expected to enable social institutions and small and medium-sized enterprises to be able to reduce their energy costs considerably. What is more, it is creating jobs, since the stoves are being produced and distributed by local companies.

The programme is expected to have significant effects in the areas of environmental and climate protection: Via use of 100,000 modern stoves, a total of 100,000 tonnes of firewood can be saved each year. That figure corresponds to the preservation of 1,100 hectares of forest. It also translates into a reduction of 150,000 tonnes in carbon dioxide emissions.

German contribution: EUR 11 million

Planned project period: 2008 to 2017

The following section presents examples of projects focussed especially on transfer of technologies for reducing greenhouse-gas emissions. (The above-described project examples, involving projects for adaptation to climate change and for reduction of greenhouse-gas emissions, also include technology-transfer components.)

7.3.3 Examples of projects for promotion of technology transfer

Project title: Turbine modernisation, modernisation of power stations			
Aim: Modernisation of turbines in six Chinese power stations			
Recipient country	**Sector**	**Total support**	**Years**
China	**Energy**	**EUR 38 million**	**Since 2004**

Description:

Since 2004, KfW Entwicklungsbank, working under commission to the German government, has been financing a range of measures aimed at improving efficiency in 20-year-old Chinese coal-fired power stations. The measures reduce the quantities of coal required per kilowatt-hour, and they decrease sulphur-dioxide emissions. Along with installation of equipment for combustion-gas desulphurisation in numerous power stations, the project's main aims included optimisation of combustion processes in six Chinese power stations. To this end, 15 vehicle-mounted (mobile) measuring units were financed. After helping to increase the amounts of energy produced in the power stations covered by the project, the mobile units were used in additional power stations, for positive results above and beyond the project's original goals. Proper, effective use of the mobile measuring systems is being supported by a development project of Gesellschaft für Technische Zusammenarbeit (GTZ).

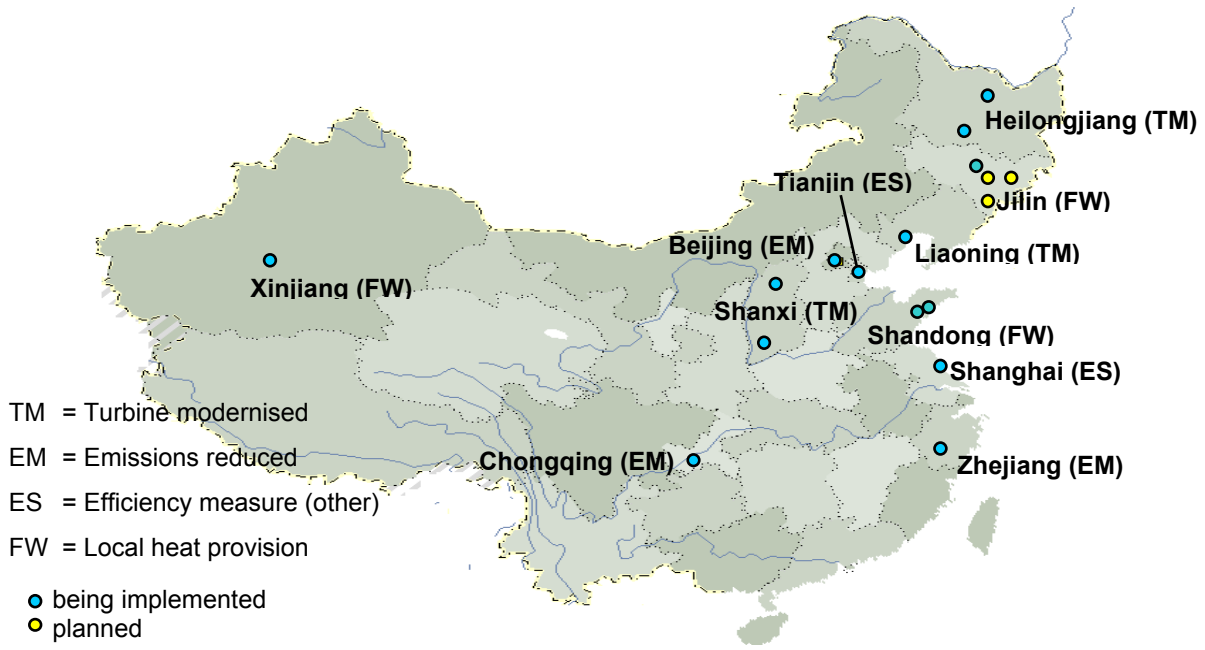

Figure: Selected projects, in co-operation with China, for promoting environmentally friendly technologies.

Key factors leading to the project's success:

In view of China's rapid economic growth, China is strongly interested in improving resources efficiency in its electricity generation. In addition, the project has been able to build on positive experience with similar technologies in Europe. A total of 75 percent of China's electricity is produced in coal-fired power stations, and most such power stations in China burn coal with a high sulphur content. Much of the sector's equipment is highly obsolete and heavily polluting. China's major cities are heavily polluted with dust and sulphur dioxide – the main cause of acid rain. Many of China's people suffer from respiratory ailments. At the same time, environmental standards for pollutants such as sulphur dioxide and nitrogen oxide have not yet been comprehensively formulated and implemented. The project can thus serve as a best-practice example and pave the way for cleaner electricity generation in China.

Technology transfer:

Desulphurisation technology; mobile measuring units for optimisation of resources use and combustion processes; modernisation of low-pressure technology and improvement of resources efficiency.

Impacts on emissions of climate gases (optional):

The turbine modernisation programme reduces the average coal consumption per turbine by 11 g/kWh. Together, the modernisations on all the turbines covered by the project will yield a CO_2 reduction of about 600,000 tonnes per year. In addition, use of the mobile measuring units holds the potential for saving up to 7 million tonnes of CO_2 per year. Consequently, the project is making a significant contribution to climate protection.

Project title: Wind energy in China / Xinxiang, Dabanchang

Aim:

Promotion of wind energy, a climate-neutral energy source, in China

Recipient country	Sector	Total support	Years
China	**Energy**	**EUR 26 million**	**Since 1999**

Description:

In 1991, the Federal Ministry of Education and Research (BMBF) established the ELDORADO programme, aimed at promoting wind energy in developing and threshold countries. One of the support projects within ELDORADO led to the first wind energy facility in China. Subsequently, in 1995, KfW Entwicklungsbank, working under commission to the BMZ, financed the construction of five additional wind energy facilities. The first of those facilities was commissioned in 1999. The last of the facilities, a 49.25 megawatt (MW) wind farm in Dabanchang, in the autonomous region Xinxiang, is to be completed by the end of 2010.

At the beginning of the project series, wind energy played no role whatsoever in China's energy mix. The first wind turbines had to be imported from abroad. In 2003, Chinese companies began establishing their own capacities for production of wind turbines. The first systems produced were produced under license to German and Danish companies. For about two years now, the number of wind turbines developed by Chinese firms has been growing continually, however. Nonetheless, German companies, such as Aerodyn Energiesysteme GmbH, are continuing to play an important role in the further development of Chinese wind energy technology.

As of the end of 2008, a total of 12.2 gigawatts (GW) of wind energy generating capacity were in place in China – a result that corresponds to an annual doubling of wind energy capacity for the past three years. Already, China's own capacities for producing wind turbines are hardly able to keep up with the strongly growing demand, and the total potential demand for wind energy in China is estimated to be over 300 GW.

Key factors leading to the project's success:

The project's major success is primarily a result of the time at which the project began. At that time, China formulated ambitious goals for installation of wind energy capacities even though wind energy was still – de facto – playing no significant role whatsoever in the country's energy mix. And the financing provided via German development co-operation, covering five wind energy facilities, played an important role in enabling China to achieve its ambitious goals for introduction of wind energy systems.

Technology transfer:

Wind-turbine technology, technical and operational know-how

Contribution to reduction of greenhouse-gas emissions: Wind energy produces no greenhouse gases in electricity generation. On the average, the energy-amortisation period for a wind turbine is less than three months. Consequently, the project is making a significant contribution to climate protection.

Project title: Geothermal power stations in Olkaria (Olkaria II, III)			
Aim: Safe, reliable electricity generation from renewable energies, in Kenya			
Recipient country	**Sector**	**Total support**	**Years**
Kenya	**Energy**	**EUR 12.8 million**	**Since 2003, (Olkaria II)**

Description:

Kenya has great potential for using geothermal energy, but it is not yet making full use of that potential. The first geothermal power station in Kenya (Olkaria I) was ordered in the late 1980s. In 1997, the German government decided to participate, via KfW Entwicklungsbank, in financing of Olkaria II (with a capacity of 70 MW). That power station was ordered in 2003, at a time when the country urgently needed additional electricity generation capacity.

The new power station was built on the basis of experience gained with Olkaria I, and thus it includes a range of technical improvements. In one such improvement, steam and water from the geothermal source are pumped back into the relevant water-bearing ground layers, to provide a closed water cycle.

Via further participation by the Federal Government, a private investor has received a loan for increasing the capacity of an Olkaria III to 48 MW. That plant is able to also tap the thermal energy in the liquid medium, while Olkaria I and II only use the steam from geothermal field.

Key factors leading to the project's success:

Most of Kenya's electrical power is generated hydroelectrically. Geothermal energy is the most suitable source for any expansion of electricity generation, since the country's hydroelectric resources have largely been tapped, and climate conditions are hindering hydroelectric power generation.

Olkaria II was ordered at a time when additional electricity generation capacity was urgently needed.

Technology transfer:

Tested, advanced technology, with modern plant control: Olkaria III is a two-phase binary geothermal power station that uses the Organic Rankine Cycle. Expanded plant size for Olkaria II and III; technical and organisational support.

Contribution to reduction of greenhouse-gas emissions:

Operation of a geothermal power station with energy from the Olkaria field produces very low CO_2 emissions in comparison to operation of fossil-fired power stations.

Project title: Climate protection programme for Croatia

Aim:

The aim of the programme, which is being carried out with the Croatian energy services company HEP ESCO, is to provide financial and technical support for professionalisation and expansion of the company's business model.

Recipient country	Sector	Total support	Years
Croatia	**Energy efficiency**	**EUR 15 million**	**Since 2009**

Description:

HEP-ESCO is a Croatian energy services company that develops, finances and carries out energy efficiency projects on a commercial basis. The company's services comprise modernisation, repair and overhaul of existing systems, to increase energy efficiency. Relevant investments are financed via savings on energy and on maintenance. Currently, the company is playing a key role in the development of an energy services market in Croatia.

KfW, under commission to the German government, has granted HEP ESCO a loan of up to EUR 15 million for financing of necessary investments.

KfW Entwicklungsbank is also supporting Croatia in the process of harmonisation with the EU in the area of energy efficiency. Finally, the effort is supporting measures to enhance public environmental awareness in Croatia.

Key factors leading to the project's success:

- HEP ESCO is a highly professional partner; in 2007, it was honoured by the *European Energy Service Initiative* as a Best European Energy Service Provider.
- The company's services have proven to be highly attractive for customers (for example, HEP pays for an initial energy audit). That attractiveness makes it possible to develop the real potential of the market for energy services.
- After investments have been made, the relevant savings are reviewed, to increase confidence in the business model.
- In addition, the relevant savings are checked via an annual measurement and verification process.
- A capacity-building component has also proved to be a decisive factor in the project's success.

Technology transfer:

Via long-term financing and institutional reinforcement, the programme is supporting HEP ESCO's efforts to expand its business model. HEP installs highly efficient equipment for its customers. That boosts technology transfer to Croatia.

The capacity-building component also strengthens technology transfer, since it helps to acquaint customers in Croatia with state-of-the-art technologies.

Project title: Support for the Vietnamese biogas-promotion programme

Aim:

Introduction and dissemination of biogas technology, in the interest of assuring the energy supply for rural households.

Recipient country	Sector	Total support	Years
Vietnam	**Rural development**	**DED support** **EUR 55,000 / year for 5 years is planned** **Total: EUR 275,000**	**DED participation since 2008**

Description:

1. Via use of biogas reactors, rural families receive cost-effective access to clean energy and organic fertiliser. The population's health situation improves, because gas stoves supplant open fires.

2. The project is aimed at poor families in rural areas, in a total of 50 provinces of Vietnam. The effort is being facilitated by the biogas programme's technical staff, at both the national and provincial levels. A German Development Service (DED) specialist is integrated within the biogas programme's technical department, which currently comprises 5 engineers and other staff. The programme is being carried out by SNV, a Dutch development assistance organisation, for the Vietnamese ministry of agriculture.

The DED specialist's contribution consists of refining technical standards, carrying out quality management at the programme level, improving training programmes for technicians in the provinces and carrying out technical backstopping.

Key factors leading to the project's success:

- State structure of incentives, via installation subsidies (about EUR 100 / system).
- Beneficial health effects from lower smoke inhalation during cooking.
- Use of fermentation residues as agricultural fertilisers.

Technology transfer:

Biogas technology replaces use of firewood in food preparation.

Contribution to reduction of greenhouse-gas emissions:
Lower CO_2 emissions from burning of wood, and lower methane emissions from animal manure.

7.3.4 Examples of private-sector projects with public financing

In addition, to financing projects with development co-operation funding, the Federal Government also supports private-sector investments in climate protection in developing countries. Deutsche Investitions- und Entwicklungsgesellschaft (DEG) makes long-term capital available to private companies for investments in developing countries.

7.3.4.1 India: Seawater desalination plant

In Chennai, India's fourth-largest city, one-third of the demand for drinking water is currently not being met. A seawater desalination plant is expected to improve this situation considerably. The plant, with a daily capacity of 100 million litres, is being built north of the city, on the Bay of Bengal. In 2008, DEG granted Chennai Water Desalination Ltd. (CWDL) a long-term loan of EUR 14 million. The total investment costs for the project amount to EUR 86 million. CWDL, an Indian-Spanish joint venture, was awarded the contract for the construction and operation of the plant via a tendering process. The plant itself, the first private desalination plant of its size and capacity, can serve as a model for other such projects.

DEG has provided CWDL with long-term capital, thereby making the project possible, a project of vital importance for Chennai's drinking-water supply. CWDL will meet about 10% of Chennai's drinking-water needs, thereby markedly improving the reliability of the overall supply. CWDL has committed itself to meeting the environmental standards of the World Bank Group. The technology being used is particularly energy-efficient; it provides energy savings of 30% in comparison to conventional seawater desalination plants.

7.3.4.2 Peru: Hydroelectric power stations

Poechos 1, a private hydroelectric power station with a capacity of 15.4 MW, is located in north-western Peru, on the border to Ecuador. Poechos 1 was financed in 2002 by DEG, in co-operation with Inter American Investment Corporation (IIC) and the Fonds Corporación Interamericana para el Financiamiento de Infraestructura (CIFI). In a first phase, the power station is supplying electricity to 20,000 people in the poor rural region in which it is located.

The Poechos reservoir was built in 1975, for purposes of irrigation and for operation of then-planned small hydroelectric power stations. At the time, no funding for construction of hydroelectric power stations was available, however. In the 1990s, following liberalisation of the electricity market, a small group of private investors revived the plan for construction of hydroelectric power stations. Sindicato Energético S.A. then constructed the Curumuy hydroelectric power station, with 12.5 MW output – Peru's first private hydroelectric power station. Poechos 1, a second, smaller power

station, was built subsequently. It also uses the existing reservoir to generate electricity. The water that runs through the plant is returned to the area's rivers and used for agricultural irrigation. In the framework of a long-term purchase contract, the electricity is supplied to the regional energy supplier and fed into the national grid. The energy supplier has constructed distribution stations for the purpose of serving households in remote regions. In 2006, DEG co-financed a second hydroelectric power station, Poechos 2, which was then also built by Sindicato Energético S.A..

7.3.4.3 Brazil: Wind farm

North-east Brazil has especially favourable conditions for electricity generation with wind energy. There, Wobben Windpower Ceará Ltda., a Brazilian subsidiary of the German company Enercon GmbH, has erected the first privately operated wind farm in Brazil. The wind farm, with 30 turbines, generates 42 million kilowatt-hours of power annually – enough to meet the needs of 8,000 households. DEG was the only lender for this investment, which also promoted technology transfer.

8 Research and systematic monitoring

Germany has a long tradition of applying science and technology in the interest of sustainability. The BMBF's framework programme "Research for Sustainability" ("Forschung für die Nachhaltigkeit"), which was approved by the Federal Cabinet in mid-2004, implements the Federal Government's "National Sustainability Strategy", which was approved by the Federal Cabinet in April 2002, via research-funding policy. It does this by approaching the topic of sustainability as a driving force for innovation on the part of the state, industry and society.

Research for sustainability, including research into the topic of "global change", is largely funded in Germany by the BMBF and the German Research Foundation (DFG). The BMBF's support is provided as project support or – in part, with co-financing by one or more Länder – as basic funding provided to institutions. In the institutional sector, climate research is supported via various institutes within the Helmholtz Association of German Research Centres (HGF), and via institutions of the Max Planck Society (MPG), Fraunhofer-Gesellschaft (FhG) and the Gottfried Wilhelm Leibniz Science Association (WGL).

In addition, various other ministries play roles as well, in the framework of their responsibilities, by supporting departmental research into climate protection and adaptation to climate change. In addition, individual research organisations and their projects are funded by other federal departments. Among such organisations are the Federal Environment Agency (UBA), funded by the BMU; the German Aerospace Center (DLR), funded by the BMWi; and Deutscher Wetterdienst (DWD), funded by the BMVBS. In the portfolio of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), an Institute for agriculturally relevant climate research has been established, under the umbrella of the Johann Heinrich von Thünen Institute (vTI). (Research funding by individual Länder is not covered by the present report.)

In spite of all uncertainties, it is now clearer than ever that the rates and intensities of change in decisive environmental parameters, world-wide, represent an unprecedented risk for the long-term stability of global societal, economic and ecological systems. As a result of their great complexity, such issues seem to lie beyond the capacities of our existing management and political instruments. Therefore, intensive exchanges between the science, industry and political (decision-maker) sectors are playing an ever-more important role in study of such integrated, trans-boundary problems – in a search for knowledge-based approaches to such major societal challenges.

This reflects the fact that the tasks and solutions involved are seldom confined, en bloc, to any single discipline. Interdisciplinary, international and intercultural dialogue is needed. For this reason, Germany recently chose the German Academy of Sciences Leopoldina (the "Leopoldina") to be the "National Academy of Sciences ", i.e. the body that now officially represents the German science sector internationally. In addition to furthering the cause of science, the Leopoldina concentrates especially on interdisciplinary observation and dissemination of scientific findings.

The Federal Government continues to be advised by the German Advisory Council on Global Change (WBGU). The WBGU regularly submits recommendations to the Federal Government for action and research. The WBGU has produced a number of

annual reports, on a range of different topics, including "The Threat to Soils" [1994], "Ways Toward Sustainable Management of Freshwater Resources" [1997], "Strategies for Managing Global Environmental Risks" [1998], "Conservation and Sustainable Use of the Biosphere" [1999], "New Structures for Global Environmental Policy" [2000], "Towards Sustainable Energy Systems" [2003], "Fighting Poverty through Environmental Policy" [2004], "Climate Change as a Security Risk" [2007] and "Future Bioenergy and Sustainable Land Use" [2008]. The reports share a common underlying theme: the complexities inherent in global interrelationships, and the resulting challenges for researchers. In special reports on "CO_2 Reduction" [1995], "Climate Protection" [1997], "Kyoto – Sources and Sinks" [1998], "Kyoto and Beyond" [2003] and "The Future Oceans – Warming Up, Rising High, Turning Sour" [2006], the WBGU has also explored central issues relative to climate change.

With regard to scientific issues of global change, the BMBF and DFG are advised by the German National Committee for Global Change Research (NKGCF), which co-ordinates Germany's participation in research into global environmental change in the framework of cross-programme work in the Earth System Science Partnership (ESSP) and in the four international research programmes on global change (World Climate Research Programme (WCRP), International Geosphere-Biosphere Programme (IGBP), International Human Dimensions Programm on Global Environmental Change (IHDP) and DIVERSITAS, an international programme of biodiversity science). The NGKCF's work emphases include developing cross-sectoral interdisciplinary and integrative research concepts.

Germany has great potential for making an integrated contribution to climate protection science. Germany already has an excellent research sector and an excellent scientific infrastructure. With its numerous universities and non-university research institutions, Germany's research sector is among the world leaders in climate and sustainability research and in environmental / energy technologies. In many different areas, German companies offer products and services that are state of the art with regard to environmental and energy technology.

Investments in technological progress, including investments for a sustainable energy supply and efficient resources use, will not be the sole factor safeguarding competitiveness, prosperity and living standards in Germany. In general, co-ordinated innovation policy is also needed, and it should be aimed at enhancing our understanding of climate processes, our ability to forecast future climatic conditions and our ability to take effective climate protection and adaptation measures.

In 2006, the Federal Government placed all of its technology-oriented programmes and activities under an interdepartmental umbrella, the "High-Tech Strategy for Germany". The area of "climate protection" (including environmental technologies and energy technologies) plays a prominent role in that strategy as one of a total of five main priorities. In addition, the High-Tech Strategy includes new initiatives of relevance to environmental protection and climate protection – for example, initiatives within the priority on "Mobility".

In the area of energy research, the framework for action is defined by the Integrated Energy and Climate Programme (IECP). With its Integrated Energy and Climate Programme, launched in December 2007, the Federal Government has taken important steps toward a state-of-the-art, safe and reliable and climate-friendly energy supply for Germany. At the same time, it has defined measures for ambitious, intelligent and efficient climate protection. The package comprises a total of 29 measures, aimed especially at greater energy efficiency and greater use of

renewable energies. The package combines changes in the legal framework with investments in research and development. Examples include: Amendment of the Act on the Preservation, Modernisation and Development of Combined Heat and Power Generation (Combined Heat & Power Act; KWKG); amendment of the Act on Energy Saving (Energieeinsparungsgesetz) and of the Energy Saving Ordinance (Energieeinsparverordnung; EnEV); amendment of the Renewable Energy Sources Act (EEG); the Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmG); measures for facilitating sale of biogas to the gas grid; expansion of the use of biofuels; the Act for acceleration of expansion of the high-voltage network (Gesetz zur Beschleunigung des Ausbaus des Höchstspannungsnetzes); and conversion of motor-vehicle taxation to an emissions / CO_2 basis.

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

Also in 2007, the BMBF invited a broad spectrum of stakeholders, representing the areas of science, industry and policy-making, to prepare a comprehensive climate-research strategy, a "High-Tech Strategy on Climate Protection".

Via an overarching, interdisciplinary approach, the "High-Tech Strategy on Climate Protection" brings together different measures and stakeholders in the area of climate research. An integrative part of the High-Tech Strategy for Germany, it is setting a course, via co-operation with partners in the areas of science, industry and policy, toward state-of-the-art energy-saving and resources-conserving technologies. Its central action areas include: a) Expanding the knowledge base for climate protection and adaptation; b) Carrying out R&D and demonstration projects that enhance the technological perspectives for climate protection and that strengthen German industry's position in this important, international, future market; c) Providing decision-makers in industry and the policy sector with better and more effective access to knowledge about climate change, and about its consequences; d) Taking on responsibility via international dialogue and world-wide co-operation. Balancing climate protection with economic growth and prosperity is also one of the most important aims.

That focus links the "High-Tech Strategy on Climate Protection" with the aims of other strategies for addressing climate change, such as the aforementioned Integrated Energy and Climate Programme and the "German Adaptation Strategy". The German Adaptation Strategy is aimed at protecting and enhancing the ability of natural, societal and economic systems to adapt, as well as at making use of relevant opportunities. It thus also defines concrete research activities for enhancing systems' ability to adapt.

Promotion of mature, marketable technologies relative to resources productivity and efficiency, and to climate protection, is among the priorities that the BMBF and the BMU have jointly defined in an "Environmental Technologies Master Plan". The key idea guiding the Master Plan is to find ways of usefully interlinking innovation and environmental policy and, at the same time, to develop new markets for environmental technologies.

The Federal Government's central focuses include expanding support for research and development for state-of-the-art, efficient energy technologies. The Federal Government has thus made such support a priority of its Integrated Energy and

Climate Programme. Research and development are the strategic keys to assuring a sustainable, long-term energy supply for Germany. A number of different government departments are involved in relevant implementation, each within the framework of its own competencies. The Federal Government's support policy is being co-ordinated via a "Co-ordination Platform for Energy Research Policy" ("Koordinierungsplattform Energieforschungspolitik"), established within the Federal Ministry of Economics and Technology (BMWi). The centrepiece of activities in this framework is the Federal Government's 5th Energy Research Programme.

The "Basic Research Energy 2020+" funding concept, for example, opens up long-term perspectives for assuring the energy supply. Via a broad interdisciplinary approach, this funding concept is supporting basic research, with a long-term orientation, relative to new technological options. This effort is focussed on highly efficient processes for producing, transforming, storing, transporting and using energy.

In the framework of its various programmes and measures, the Federal Government thus promotes a broad range of technologies, strategies and research relative to climate change, and it supports effective networking of research and development activities in the science, industry and policy-making sectors.

In the process, considerable efforts are being made to mobilise private-sector research capacities and capital, with the aims of accelerating key innovation processes relative to climate protection and shortening the time to market for relevant products and services. To this end, for example, a number of innovation alliances have been established within the framework of the High-Tech Strategy on Climate Protection.

Financial sector partners are also being included. In the context of the High-Tech Strategy on Climate Protection, banks, re-insurers and investors in Germany have established the Climate Chance Finance Forum, with the aim of mobilising, in co-operation with the BMBF and other federal departments, investments in resources and energy efficiency and in further development of renewable energies.

The following sections describe the Federal Government's relevant research activities in detail. Via a cross-cutting approach, these descriptions cover the following main areas:

- Chap. 9.1: Climate system, variability and interactions within the earth system
- Chap. 9.2: Monitoring and data management
- Chap. 9.3: Research into climate impacts
- Chap. 9.4: Energy and mitigation research
- Chap. 9.5: Adaptation to climate change
- Chap. 9.6: Options for economies and societies
- Chap. 9.7: International co-operation
- Chap. 9.8: The institutional research sector

In addition, the national report on GCOS[42] includes a detailed description of the topic "systematic climate observation in Germany". That description covers a broad spectrum of observation and monitoring systems for which information was available. Although that national report is incomplete in some areas, it is still currently the most comprehensive overview of climate observation systems in Germany.

8.1 *Climate system, variability and interactions within the earth system*

Climate system research and its findings play a central role in efforts to address climate change. In general, climate system research in Germany already provides a broad range of climate data, global and regional models, and scenarios and projection that can be of use in analysis, estimation and assessment of past, present and future climate conditions. Such research makes a key contribution to understanding of climate processes and interactions. Findings from such research make it possible to determine the key parameters for future developments.

In some sub-areas of the earth system, global warming could lead to irreversible crossing of critical thresholds. Very little is understood about the likelihood of such non-linear processes. Research into the climate system thus plays an indispensable role in integrated risk assessment and in the development of comprehensive, globally oriented monitoring and early warning systems.

To achieve real progress in this area, models have to be linked with measurements. In its efforts to obtain useful and meaningful measurement data, the Federal Government thus emphasises continuous, long-term observation of processes in the atmosphere, in the oceans and on land. In addition, it relies on detailed studies of key processes, such as the work being carried out with the new research aircraft "HALO" and "POLAR 5"; with "Neumayer III", a new Antarctic station; and with the "Maria S. Merian", a new research ship. Such studies complement global, ongoing routine monitoring of key parameters of the global climate system via in situ and remote monitoring procedures.

Environment protection agreements can be monitored, and climate change projections prepared, via innovative space technologies. Germany is already among the European leaders in space-based climate research and earth observation: A number of German space efforts, such as those involving the GOCE satellite, the TerraSAR-X radar satellite, the RapidEye optical satellite system, the EnMAP satellite (which is at an advanced stage of development) and new constellations of mini-satellites, are focussed on monitoring the state of polar ice caps, major continental glaciers, deserts, rain forests and oceans. The German-Dutch SCIAMACHY instrument, on the ENVISAT European environmental satellite, is monitoring the earth's ozone layer. In addition, the Climate Change Monitoring Initiative (CCI), a new ESA initiative, is expected to standardise global climate data. The European satellite system MeteoSat is being developed to the third-generation stage (MTG), under Franco-German management. That stage is expected to enter service in 2016.

[42] Germany’s report on global climate observation systems.

8.1.1 Atmosphere

Any study of the causes of climate variability calls for evaluation of directly measured data and indirectly derived data. Relevant data include data on the earth's climate as it is now, data on climate states in the earth's past and data oriented to further improvement of models of coupled systems (including oceans / atmosphere, and biosphere / land surfaces / ice surfaces).

And continuous operation of observation systems plays an indispensable role in monitoring of climate variability. EUMETSAT, the European Organisation for the Exploitation of Meteorological Satellites, an organisation in which Germany is involved, has extended its observation programme to climate monitoring. With new satellite systems oriented to long-term observation, Meteosat Second Generation (MSG; geostationary) and the Meteorological Operational satellite (MetOp; in a polar orbit), EUMETSAT is making important contributions in the area of long-term atmospheric observation for purposes of climate monitoring, with instruments that previously were available for only short periods, on research satellites. EUMETSAT and its partners within the European CM-SAF (Satellite Application Service for Climate Monitoring) consortium, which is managed by the DWD (Deutscher Wetterdienst; German weather service), are jointly developing and producing specialised products for climate-system observation.

Today, satellite data are used optimally, via data assimilation in the framework of numerical weather-forecasting systems. Such systems permit simultaneous, complementary use of virtually all data available from operational or quasi-operational atmospheric observation data. The world's most comprehensive data-assimilation system is operated by the European Centre for Medium-Range Weather Forecasts (ECMWF), in which Germany is a participant. That centre has now completed an EU-Commission-supported project in which a global analysis and forecasting system for key greenhouse gases and aerosols was developed. A key focus of the centre and of its members is on the future operation of that system.

Numerous German research institutes shared in the development and set-up of the system, which permits ongoing determination of the global distribution of climate-relevant trace gases and aerosols, and of their sources and sinks. Both the global system and several regional versions ("limited area models") are now available.

The Max Planck Institute for Meteorology, located in Hamburg, and the DWD are both participating in the EUROSIP project, sited within the ECMWF, for the establishment of a "Multi Model Ensemble Prediction System" for forecasting of the climate system's interannual and decadic variability. Along with the ECMWF, the partners in the effort include UK MetOffice and MeteoFrance. The project is aimed at closing the gaps between a) medium-range and long-range weather forecasting and b) climate projections, thereby supporting measures for adaptation to climate change.

The DWD continues to expand its support for the Global Climate Observing System (GCOS). In defining 12 national reference stations, the DWD has committed itself to long-term operation of the 12 stations, and to staff them 24 hours a day with qualified observers. The stations have been selected on the basis of their locations (North Sea, north-German plain, uplands, high mountains) and of the quality and length of their already available observation series. This selection has strengthened Germany's contribution to the GCOS Surface Network (GSN). In addition, a dense network of meteorological stations, some of which also have very long time series, supports the DWD's climate monitoring activities.

Furthermore, the DWD has been commissioned, by the World Meteorological Organization (WMO), to operate a station in the GCOS Upper Air Network (GUAN). The DWD is planning to assume the "Lead Centre" for the GCOS Reference Upper Air Network (GRUAN), thereby globally co-ordinating quality assurance of radiosonde measurements in GUAN. GRUAN, a sub-set of the GUAN stations, has particularly stringent quality requirements for execution of observations. The DWD is also making additional contributions to GCOS and to the WMC's World Climate Research Programme (WCRP).

8.1.2 Marine and polar research

The oceans are integrated within the earth's thermal and substance cycles. The main thrusts of climate-oriented marine and polar research include further study of the role of the oceans, and of polar regions, in global climate, as well as study of the impacts of climate change on marine and polar regions.

Polar regions, and certain ocean regions, are key regions with respect to global climate. Polar ice and sediments service as "climate archives" with which past climate fluctuations can be identified. It is well-known that climate fluctuations influence oceanic current systems and the mass relationships within polar ice shields. Via various atmospheric processes, carbon dioxide (a greenhouse gas) is removed from the seas in polar and subpolar latitudes and transported to deep ocean regions.

The BMBF has financed the "Neumayer III" polar station, a new Antarctic research platform. The station, a 3,300 m^2 structure made of environmentally friendly materials, was completed and commissioned in February 2009. Operated by the Alfred Wegener Institute for Polar and Marine Research (AWI), the station will enable researchers to collect geoscientific, meteorological and biological data from the south polar region. The AWI also maintains polar stations in the Arctic, and it operates the "Polarstern", an ice-breaking research ship. And in the "Maria S. Merian", an oceanographic research ship capable of operating in near-polar regions, Germany now has one of the world's most advanced research ships.

In studying the ocean-ice-atmosphere system, and its influence on global climate, German marine and polar research concentrates especially on the Weddell Sea in the Antarctic and on the Arctic Ocean, which extends from east Siberia to the north Atlantic near Spitzbergen (and is bordered by Eurasia and North America). Relevant studies are focussing especially on spreading of newly formed water masses within the world's oceans.

Via several major collaborative research projects, Germany is participating in the relevant core projects of the World Climate Research Programme (WCRP; especially ACSYS/CLIC, WOCE and CLIVAR), and of the International Geosphere-Biosphere Programme (IGBP; especially SOLAS and IMBER). Such efforts are focussed especially on study of global circulation and heat transport, of the global water cycle and of the global carbon cycle (including its associated gases).

In the framework of the International Ocean Drilling Programme (IODP) and of the European Project for Ice Coring in Antarctica (EPICA), sediments and ice deposits in key areas are being studied. Such work is yielding paleoclimatological findings relative to development of climate and of biogeochemical substance cycles over the course of the earth's history. The findings serve as building blocks for models and forecasts of future changes in the coupled ocean-atmosphere system.

8.1.3 Water cycle

The global water cycle is a key part of the climate system. To answer questions regarding the availability, quality and distribution of water in different climate zones, researchers must precisely understand the causes and consequences of global changes in the water cycle, with respect to global change. Such a framework is needed for any development of sustainable, viable strategies for management of ecosystems and societies.

Key findings in these areas have been provided by the BMBF programme Global Change and the Hydrological Cycle (GLOWA). That programme, which was launched in 2000, is currently in its completion and implementation phase. GLOWA is aimed at development of integrated strategies for sustainable, forward-looking management of water resources and water bodies, on a regional scale, taking account of global ecosystemic interrelationships and relevant socio-economic framework conditions. In case studies of varying complexity, focussing on aspects of various river catchment basins such as water availability and quality and distribution of water resources, key issues and detailed parameters of global changes in the water cycle are being identified and studied interdisciplinarily.

In various GLOWA sub-programmes, a number of river catchment basins are being studied (the Draâ [Morocco] and Ouémé [Benin] rivers, and the Volta, Danube, Elbe and Jordan rivers), taking account of the differences between the relevant climate zones involved. The following aspects are of central scientific importance:

- Natural and human-caused variability in climate and precipitation, and the influence of such variability on the water cycle,
- Interactions between the water cycle, the biosphere and land use, and impacts of land-use changes,
- Water availability and usage conflicts: Population growth, urbanisation, migration and industrialisation, and the concomitant changes in demands on water availability and water quality; interrelationships between water (availability, quality and distribution) and human health.

Work within the GLOWA funding measure is taking place via integrative and interdisciplinary collaborative research projects. The aforementioned projects are already in the second of three three-year funding phases.

Germany is also actively contributing to the Co-ordinated Energy and Water Cycle Observations Project (CEOP), the hydrometeorological research component of GEWEX, a WCRP programme focussing on the global water and energy cycle. As of last count, this "project of projects" now comprises 27 individual elements and projects.

In CEOP, regional process studies are also being carried out, including BALTEX, an international project established in 1992. The central research topics in BALTEX include the impacts of large-scale climate anomalies on climate variability in the Baltic Sea region; the influence of variability of heterogeneous land surfaces, and of the Baltic Sea and its yearly ice cover, on the water and energy cycle in the Baltic Sea region; and development of an integrated model system for taking account of interactions between the atmosphere, the Baltic Sea, the land surface, lakes and hydrological factors. In this context, new techniques for data assimilation, and for model validation with measurements from the operational measurement network, from measurement programmes and from remote sensing, are proving to be of

special methodological significance. All projects relative to the energy and water cycle at the continental scale (and, thus, also BALTEX and work of the participating German research institutions) are contributing to the Co-ordinated Energy and Water Cycle Observations Project (CEOP).

What is more, Germany is making significant contributions to CEOP via global data centres (the Global Precipitation Climatology Centre (GPCC) sited within Deutscher Wetterdienst (DWD); the Global Runoff Data Centre (GRDC) sited within the Federal Institute of Hydrology (BfG)) and via provision of comprehensive data records of the DWD's Lindenberg observatory, one of the world's ground-based reference stations for 3-dimensional hydrometeorological measurements (currently, slightly over 30 such stations are in place world-wide).

8.1.4 Land surface and land use

Increasing scientific interest is being concentrated on the interactions between land use, ecosystem functions ("services") and climate change. The reason for this is that global change, in its various forms and consequences, is having impacts on land use in most regions of the world. And climate change has been identified as a major factor behind such impacts. We still have too little understanding of how climate changes actually affect natural or cultural landscapes. In part, the reason for this is that perceptible changes in landscapes are often very difficult to correlate with individual factors. What is more, too little is still known about the relationships between climate change and ecosystemic changes or various forms of land use.

In future, it will increasingly be necessary to balance adaptation and climate-protection strategies. Agricultural activities, for example, not only are affected by climate change, they also contribute directly to greenhouse-gas emissions, especially emissions of CH_4 and N_2O; they thus contribute to climate change. In addition, NH_3 emissions indirectly affect thermal and substance cycles in the earth's atmosphere. NH_3 emissions lead to the formation of secondary aerosols, which may have significant impacts on the earth's radiation balance. Such emissions also contribute to eutrophication of natural and semi-natural ecosystems and to indirect emissions of N_2O. In natural soils, airborne nitrogen inputs can promote mineralisation of organic components. In agricultural soils, soil cultivation and fertilisation can promote such mineralisation, which leads to CO_2 emissions that, unlike other CO_2 emissions from agriculture, do not function "neutrally" in balancing (i.e. relevant accounting). On the other hand, organic carbon can be stored in soils and forests (sinks).

In the past, the BMBF's support of research relevant to climate protection, in the areas of agriculture and forestry, has been aimed primarily at improving understanding of the ways in which greenhouse gases (including CH_4) form in agriculture, as well as understanding of the potential for using forests as temporary CO_2 sinks (via afforestation). On this basis, contributions were made to new concepts for sustainable agricultural and forestry. What is more, new technologies were developed that have helped to enhance energy efficiency in pertinent value-creation chains.

The BMBF-supported **collaborative research project "Germany's forests and forestry sector in the context of global change" ("Wälder und Forstwirtschaft Deutschlands im globalen Wandel")** (1997-2001) carried out in-depth studies of possible climate-change impacts on Germany's forests and forestry sector and of the management options available for addressing such impacts. The BMBF also was early in supporting pilot projects on impacts on agriculture.

With its **funding priority "Sustainable Forestry and Timber Industry" ("Nachhaltige Wald- und Holzwirtschaft")**, the BMBF is addressing existing challenges, uncertainties and conflicts of aims in the forestry and timber-industry sectors. Germany's and Europe's forestry and timber sectors have been gaining importance as a result of growing demand for wood, in the wood industry and for energy applications. At the same time, the changing framework is creating new challenges for science and industry in this area – challenges such as structural change in the forestry sector, market globalisation and the need to prepare for the future (for example, to deal with the impacts of climate change). Over the period from 2004 to 2010, science and industry partners are jointly developing relevant solutions, preparing recommendations for sector practitioners and developing suitable products and technologies.

The BMBF's most recent initiative is aimed at providing the knowledge and decision-making foundations necessary for sustainable land management under the conditions of climate change. The complex interrelationships between climate change, land management and ecosystem services call for holistic solutions. In 2008, the BMBF launched a new funding priority to this end. In sample regions that are especially affected by global-change phenomena, that effort will work to develop strategies, options and system solutions for sustainable land management. In addition, trans-disciplinary and interdisciplinary research approaches will help to ensure that neither landscapes' key functions (ecosystem functions and services) nor pertinent economic and societal objectives are neglected in this context.

For many years, **departmental research of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV)**, especially of the Johann Heinrich von Thünen Institute (vTI; Federal Research Institute for Rural Areas, Forestry and Fisheries), and of the Julius Kühn Institute (Federal Research Centre for Cultivated Plants), has studied the interrelationships between climate, agriculture and forestry and fisheries. In the context of the main objective "Climate protection and adaptation to climate change" ("Klimaschutz und Anpassung an den Klimawandel"), within the BMELV's research plan for 2008 (ff), application-oriented and (to some extent) basic research is being conducted in the following areas:

1. Analysis of the impacts of climate change on agriculture and forestry, horticulture, fisheries, the food industry, cultural landscapes, rural areas and aquatic ecosystems, including preparation of inventories of undesirable immissions (inputs) in agriculture, forestry and fisheries.
2. Studies for characterisation, prevention and combatting of plant pests, abiotic damage agents, natural contaminants, animal diseases, zoonoses and any pertinent vectors, that have appeared, or become increasingly common, as a result of climate change.
3. Analysis, development and assessment, in accordance with economic and ecological criteria, of procedures, cultivation systems, products and services for adapting the agricultural sector to climate change.
4. Preparation of inventories of undesirable climate-relevant and air-polluting emissions from the agricultural and food-industry sectors, including studies for complete-coverage surveys of gaseous emissions from soils and vegetation cover, and for assessment of such gaseous emissions.
5. Development and improvement of procedures for reducing undesirable climate-relevant emissions from the agricultural sector.

6. Preparation of inventories relative to binding of atmospheric carbon dioxide in surface and underground biomass.
7. Development and further improvement of protection for biogenic carbon sinks, and expansion of such sinks.
8. Further development of renewable resources for sustainable, increased substitution of fossil fuels and fossil/mineral resources, and assessment of relevant technological, economic, ecological and social aspects.

In addition, the **BMELV's "Renewable Resources" funding programme** is supporting applied research, and development of innovative usage concepts, relative to renewable resources for energy-related and substance-based applications.

8.1.5 Models and forecasts

Findings relative to climate trends, including both short-term and long-term trends, are of great societal relevance. Since climate modelling is currently the only available instrument for attempts to forecast future climate, any improvement in the conclusiveness of findings from climate-modelling is of central significance.

Climate forecasts are based on sophisticated numerical climate models designed to represent global atmospheric and oceanic circulation as precisely as possible. For such models, the German High Performance Computing Centre for Climate- and Earth System Research (DKRZ), which was established in 1987 and is financed by the BMBF, provides computing resources to other German research institutions. In 2009, a new supercomputer will be installed at that centre, to enhance execution of the complex calculations required for detailing scenarios in future global and regional climate models. The new supercomputer will provide higher resolution within the models, thereby increasing detail and precision in future climate models and scenarios. The DKRZ co-ordinates the European Climate Computing Network (ECCN), a network of Europe's most important climate computing centres, including the Hadley Centre and Météo France. DKRZ and the Hadley Centre jointly co-ordinate execution of model calculations for the IPCC.

The tools DKRZ uses for its climate simulations include the ECHAM model, which was developed in co-operation with the Max Planck Institute for Meteorology (Hamburg), and has been used in the IPCC's status analyses. Simulations with coupled ocean-atmosphere circulation models support studies of climate variability and for detection of the climate "signal" within the "noise" of climate variability. The central focus of such efforts is, and has been, the question regarding the anthropogenic "fingerprint" in climate records since the beginning of the industrial revolution. Studies with coupled climate models and model validations have also been carried out in projects of the DEKLIM German climate research programme. The available experimental data (from data networks, measurement campaigns, paleoclimatology, remote sensing) have been used for purposes of model validation. Conversely, models have been used for reconstructing and interpreting current and past climate conditions.

Since the 1990s, regional climate modelling, which yields forecasts of possible regional climate trends (which global climate modelling does not do) – for example, at the level of individual Länder – has also been an established part of German research. The Regional Climate Modelling (REMO) and Climate Local Model (CLM) models have been continually improved and updated. In December 2008, so-called "consortial calculations", which were carried out with the CLM and which contain

different runs with scenarios for the period until 2100, were made available for unrestricted use. With these simulations, which include several runs with the IPCC's A1B and B1 emissions scenarios, it became possible, for the first time, to determine the climate-change signal's inherent uncertainties for all regions in Europe.

Methodological refinement of existing model hiearchies is oriented to concrete applications. Additional relevant work, especially involving further quantification of uncertainties, and higher spatial and chronological resolutions, is already underway. For example, a BMBF funding announcement of spring 2009 is aimed at making medium-term – and, especially, decadic – forecasts possible for the first time.

Two time scales are particularly important with regard to execution of efficient and concrete precautionary measures:

a) The medium-term scale for the coming decade. In this period, cost-effective adaptation policy is to be developed, and urgent measures (early actions) are to be identified and implemented.

b) The long-term scale for the second half of the century. Measures for adaptation to the most extreme impacts are to be planned and implemented in connection with the EU's aimed-for 2 C target.

At present, available weather and climate forecasts do not cover the medium-term – i.e. decadic – period. And yet precisely that time scale is especially important with regard to cost-effectiveness considerations. For natural climate variations could mask, or modulate, long-term anthropogenic climate changes. It is thus vitally important to determine the climate's natural variability and to take account of it in the climate models. Climate models thus need to have at least a short-term climate "memory". In addition, the Max Planck Institut for Meteorology and the DWD are participating in the EUROSIP project, which is being carried out at the European Centre for Medium-Range Weather Forecasts (ECMWF). Additional efforts to improve forecasts are focussing on improvement of mathematical methods and of the climate models themselves (for example, with transition from hydrostatic models to non-hydrostatic ones), with the aim of taking account of processes that today's climate models cannot include.

For even more specific forecasts, the space-time scale must be considerably finer, however, since the questions being raised in connection with medium-term climate forecasts also have to with changes in extreme events. Spatially more differentiated forecasts are required to reveal even medium-level, "smaller" changes, which will also call for adaptation measures, and which can differ widely from region to region.

8.2 Monitoring and data management

8.2.1 Systematic observation

Observations relative to the condition and development of each individual sub-component of the climate system continue to be required. In addition, information is needed about natural and human-used systems and structures that will be affected by climate changes or by global changes in general. Such observations are being obtained via in situ and remote-sensing monitoring procedures with earth-observation systems. The relevant remote-sensing procedures include procedures with ground-based, airborne, sea-based and space-based systems. A complete picture can be obtained only via integration of findings from all observation procedures. To describe the condition and the development of the climate system, one especially requires maximally complete, reliable and long-term records of internationally defined Essential Climate Variables (ECVs). A more complete description of German contributions to the global climate-observation systems is provided in a separate report (National Report on GCOS[43]).

In Germany, a national GCOS co-ordinator position has been established within the DWD. That co-ordinator serves as a liaison between the relevant national institutions and organisations and the global GCOS programme.

In terms of their focus and organisation, many of the aforementioned observation systems are involved both with research and with routine, operational observation. This complicates the task of differentiation and makes some descriptive overlapping unavoidable.

German institutions such as the DWD and the AWI are extensively involved in international measurement networks for atmospheric observation (World Weather Watch Programme (WWW) and Global Atmosphere Watch (GAW) of the WMO); for oceanic observation (Global Ocean Observing System (GOOS) of the Intergovernmental Oceanographic Commission (IOC) of UNESCO)); and for observation of land surfaces (Global Terrestrial Observing System (GTOS) of the Food and Agriculture Organization (FAO). Together, the climate-observation components of these sub-systems make up the GCOS.

In Germany, observation of atmospheric ECVs is carried out primarily by the DWD. The AWI also carries out relevant activities, as do the Länder (with regard to chemical ECVs). Along with traditional in situ measurement procedures, remote-sensing procedures are also used, such as ground-based radar (for example, for observation of precipitation) and satellite-based sensors (for determination of various ECVs). Germany has a long tradition of meteorological in situ observation. Collection of climatological data began at the end of the 19th century. Only since German reunification (1990) have such data been collected and archived in accordance with a common standard, however. Thanks to intensified use of automatic stations, data now collected have chronological resolutions of 1 to 10 minutes. The numbers of DWD-operated ECV stations vary from ECV to ECV. For measurement of precipitation, a total of 2004 observation stations are currently being operated. The DWD has established 12 national reference stations with assured long-term operation. In addition, the DWD has a dense network of meteorological stations with long time series, and it maintains two meteorological observatories that carry out

[43] Germany's report on global climate observation systems.

comprehensive long-term monitoring of physical and chemical processes in the atmosphere, thereby playing a special role in this context. Significantly, all data undergo strict quality checks.

Since early 2008, Germany (AWI) has also been responsible for operation of the World Radiation Monitoring Center (WRMC). In addition, the DWD and the AWI contribute to the GCOS Surface Network (GSN) and the GCOS Upper-air Network (GUAN).

Satellites have become indispensable sources of data. EUMETSAT (located in Darmstadt) is responsible for planning and operating meteorological satellite series in Europe. Germany, represented by the DWD, is the largest partner in EUMETSAT; it participates intensively in decisions on current and planned satellite systems. EUMETSAT has created special facilities to provide satellite products for various applications. These are known as "Satellite Application Facilities" (SAF). They are charged with developing, archiving and continuously providing application-oriented satellite products.

The DWD is responsible for satellite-based climate monitoring (CM-SAF) – especially in Europe, but also outside of Europe. It is supported in this task by five national European weather services. The CM-SAF has commenced its routine operations. From satellite measurement data, high-quality products are produced (such as indexes relative to cloud cover and moisture distribution). Those products, in turn, are used internationally in climate monitoring and in further analysis of the state of the atmosphere. Further details are available in the pertinent report of EUMETSAT[44].

German contributions to monitoring of oceanographic ECVs are provided by numerous institutions. With such efforts, such institutions support the Global Ocean Observing System (GOOS). The relevant institutions include the Federal Maritime and Hydrographic Agency (BSH), the AWI, the Centre for Marine and Atmospheric Sciences (ZMAW), the DWD, the Leibniz Institute of Marine Sciences (IFM-GEOMAR), the Institute of Environmental Physics (IUP; University of Bremen) and others. The measurement platforms used include research ships (such as the "Polarstern") and merchant ships, drifting and anchored buoys and remote-controlled vehicles. In addition, activities are partly funded via research funding and partly carried out within the framework of operational tasks. For example, Germany contributes some 50 ARGO Floaters per year, carries out about 550 observations in the framework of the Ship Of Opportunity Programme (SOOP) and, in the framework of the WMO's Voluntary Observing Ships (VOS) programme, equips a fleet of about 850 merchant ships with meteorological instruments. Responsibility for co-ordinating the relevant oceanographic observations, and co-ordination responsibility with respect to GOOS, lies with the Federal Maritime and Hydrographic Agency (BSH).

Numerous national institutions are also involved in monitoring terrestrial ECVs. In this manner, Germany also contributes to the Global Terrestrial Observing System (GTOS), whose climate component is part of the GCOS. For example, two global data and data-product centres operated by Germany, the Global Runoff Data Centre (GRDC) and the Global Precipitation Climatology Centre (GPCC), make valuable contributions to the Global Terrestrial Network for Hydrology (GTN-H) and the Global Terrestrial Network for Runoff (GTN-R). Furthermore, Germany contributes to the

[44] EUMETSAT plans to prepare its own comprehensive report, in keeping with 11/CP.13, and to submit that report via its host country, Germany.

Global Terrestrial Network for Glaciers (GTN-G) and the Global Terrestrial Network for Permafrost (GTN-P). What is more, the DWD carries out observations of plant phenology. Germany does not have a central co-ordination agency for GTOS, however.

Satellites offer unique advantages in identification and assessment of changes in the climate system. The provide continuous, complete-coverage and near-real-time data, even for regions that are poorly covered by other measurement systems. Some parameters can be determined only with the help of satellites. Germany is the largest partner in all European satellite programmes of ESA, the EU and EUMETSAT that are of relevance to climate monitoring. In addition, Germany uses its own satellites, in the framework of its national space programme, to help observe the climate system. At the German Aerospace Center (DLR), it operates the World Data Centre for Remote Sensing of the Atmosphere (WDC-RSAT).

Experimental ("Earth Explorer") and pre-operational satellites (such as ENVISAT, which carries a wide range of sensors for observing land, oceans and the atmosphere) of the ESA earth-monitoring programme play a special role in study of processes within the climate system. The German-Dutch SCIAMACHY instrument, on the ENVISAT European environmental satellite, helps to monitor the earth's ozone layer, for example. In addition, ESA has launched a major new programme for generation of GCOS-conformal "essential climate variables" from satellite data.

Operational satellite programmes play an important role in meeting the need for long-term measurements for detection of climate changes. EUMETSAT operates the geostationary METEOSAT satellites and the polar-orbiting METOP satellites, all of which were developed and built by ESA. METEOSAT has been observing the atmosphere above Europe, Africa and the Atlantic since 1977. Since 2005, it has also been monitoring the atmosphere above the Indian Ocean. The second-generation METEOSAT system, with a total of 4 satellites and with considerably improved performance, has been in operation since 2002 and is scheduled to remain in operation until about 2019.

Germany plans to participate in the continuation of the METEOSAT programme. Equipped with further-improved technology and with new instruments, the third generation of the METEOSAT series is slated to take over operation from the current second generation as of 2016 and to provide meteorological data until 2030.

EUMETSAT launched its first operational polar-orbiting satellite, METOP-1, in 2006. The 3 METOP satellites, which are to operate until about 2018, are part of a joint long-term system with U.S. satellites. Planning for the METOP successor satellites, which are to be approved in 2011, has already begun. In addition, EUMETSAT is participating in JASON, a Franco-U.S. satellite-altimetry programme that is helping to measure sea levels.

With the GMES programme (Global Monitoring for Environment and Security) / Copernicus, which was jointly initiated by ESA and the EU, Europe is assuring the long-term continuity of climate-oriented monitoring, especially as carried out by satellites. At the end of 2008, the second part of the relevant ESA programme was approved; that part will complete installation of the GMES space component by about 2015. The EU is responsible for operation and structure of services. The GMES system and GALILEO are the most important European contributions to the Global Earth Observation System of Systems (GEOSS).

Germany is also contributing to climate-system observation via efforts in its national space programme. Since 2007, data from the German TerraSAR-X radar satellite, for example, have been used for study of ice surfaces and of a wide range of other climate parameters. As of the end of 2009, the TanDEM-X mission will produce a global digital elevation model that will serve as an important basis for many climate-relevant studies. In addition, the RapidEye satellite fleet, which will soon be launched, the EnMAP satellite, which is at an advanced state of development, and new types of minisatellite constellations will monitor the condition of polar ice, of the major continental glaciers, of deserts, of rain forests and of oceans.

In recent years, increased carbon dioxide emissions from combustion of fossil fuels, along with changes in land use, have led to a rapid increase of CO_2 in the atmosphere (cf. the 2007 report of the Global Carbon Project). For this reason, CO_2 monitoring will also be an important task for earth-observation systems (for example, the Integrated Carbon Observation System (ICOS)[45]).

A new dimension in aircraft-based atmospheric research will be opened up with the High Altitude and Long Range Research Aircraft (HALO). The aircraft was built by Gulfstream, under commission to the DLR. The BMBF provided EUR 47.5 million for construction of the aircraft – or 70 percent of the total relevant costs of EUR 67 million. The remainder, EUR 19.5 million, is being provided jointly by the Helmholtz Association (HGF) and the Max Planck Society (MPG). HALO was delivered to Germany in December 2008, following extensive phases of testing. Now it is being operationally managed by the German Aerospace Center (DLR), and German environmental and climate researchers have prepared numerous proposals for missions that can be carried out only with HALO. The first scientific studies with the aircraft are planned for August 2009. In operations, HALO will climb to the lower stratosphere, thereby enabling German and international scientists to carry out studies of unprecedented quality. The research focuses for work with HALO include studies of precipitation formation (including transport of moisture and cloud water), an important factor in climate and in development of extreme weather events; self-cleansing processes in the atmosphere; and chemical and dynamic processes in the transition zone between the troposphere and the stratosphere.

8.2.2 Data and information management

Germany has a range of information systems that support data searches by providing data catalogues and meta-databases. Some of these systems can be accessed directly via the Internet. A federal / Länder working group has been charged with co-ordinating and harmonising the development of environmental information systems.

The central point of access to the "Geodata Infrastructure Germany" (GDI-DE) is the portal GeoPortal.Bund, which has been developed, and is operated, by the Federal Agency for Cartography and Geodesy (BKG) under commission to the Federal Government's "Interministerial Committee for Geoinformation" ("Interministerieller Ausschuss für Geoinformationswesen"; IMAGI). In terms of its structure and implementation, at the national level it has reached the state of development that is being aimed for at the European level, in the framework of the European Spatial Data Infrastructure (ESDI), and at the global level, via GEOSS. Provision of environmental data in Germany is governed by the Geodata Access Act (Geodatenzugangsgesetz

[45] http://icos-infrastructure.ipsl.jussieu.fr/

(GeoZG) of 10 February 2009, Federal Law Gazette I p. 278). Progress in data provision is oriented to the schedule for the European INSPIRE Directive.

The GeoPortal.Bund portal, which is continually being expanded, provides access to information systems for the area of "geoinformation". The following section presents a number of these:

In the German Oceanographic Data Centre (DOD), the Federal Maritime and Hydrographic Agency (BSH) collects oceanographic data obtained by German institutions. The Marine Environmental Database (MUDAB) project is being carried out jointly with the Federal Environment Agency and the central database of the Federal / Länder measurement programme for the North and Baltic Sea marine environment.

Deutscher Wetterdienst (DWD; German meteorological service) operates the German High Performance Computing Centre for Climate- and Earth System Research (DKRZ). That centre archives meteorological observations, and statistical indexes for the various measurement-station networks, as derived from such observations, for the territory of the Federal Republic of Germany. The time series for such data reach back to the 18th century. Meteorological observatories also collect data relative to special physical and chemical questions. Such national data are complemented by global data records as maintained by international data centres: global precipitation analyses maintained by the GPCC; climate-monitoring products, derived from satellite data, at the CM-SAF; and global maritime data, at the Global Collecting Centre (GCC). In addition, the Climate Data Centre (CDC) is being established, a central portal for access to all such databases.

Along with archiving national climatological data, the DWD collects and archives international data disseminated via the Global Telecommunication System (GTS), in the framework of the WMO's World Weather Watch Programme. In co-operation with the Japan Meteorological Agency (JMA), the DWD also operates a centre for monitoring the availability and quality of climate data from the stations in the "GCOS Surface Network" (GSN) (the DWD is responsible for precipitation data, and the JMA monitors temperature data). With the help of external support from atmospheric physicists, the Federal Environment Agency is setting up one of three centres, world-wide, for assuring and checking data quality in the framework of the Global Atmosphere Watch (GAW).

To improve provision of climate-relevant data, a network of national databases and an information system are being established, under the direction of the DKRZ. All authorities, scientific institutions and major research organisations that have climate-relevant data will participate in the system.

Paleoclimate databases are operated by the AWI (via the PANGAEA information system, in which the University of Hohenheim's paleoclimate database (PKDB), inter alia, has been integrated) and by the German Research Centre for Geosciences (GFZ).

The interdisciplinary German Environmental Information Portal (PortalU) provides central access to environmental data of public organisations and institutions. The portal, a co-operative effort of the Federal Government and the Länder, is administrated, with respect to both content and technical aspects, by the Coordination Center PortalU sited within the Lower Saxony Ministry for Environment and Climate Protection. In addition, databases of the Federal Environment Agency are also integrated within PortalU. These include:

- The UFORDAT environmental research database;
- The Library Catalogue (OPAC, with the ULIDAT environmental literature database);
- The Joint Substance Data Pool of the Federal Government and the Länder (GSBL);
- The environmental sample bank of the Federal Government and the Länder (UPB)
- The Federal Environment Agency's environmental data catalogue.

Other examples of information systems that provide data about the condition of the environment in Germany include the LANIS Landscape Information System of the Federal Agency for Nature Conservation (BfN), relevant information systems of the Federal Agency for Agriculture and Food (BLE) and the various relevant Länder information systems.

National area-data relative to soil that have been prepared in close co-operation with the geological services of the Länder (SGD) are archived and made available in the Soil Information System FISBo BGR (Fachinformationssystem Boden) of the Federal Institute for Geosciences and Natural Resources (BGR). Such data are used in virtually all supra-regional and national development and consultation projects in the context of land use and land-use changes. The data are continually updated, checked for quality and harmonised internationally in the framework of international co-ordination in Europe.

Germany has the following data and information systems of relevance to international activities:

The Applied Remote Sensing Cluster of the German Aerospace Center (DLR) stores, manages and evaluates satellite remote-sensing data. The DLR agencies within the Cluster are involved in numerous national, European and international activities for provision of satellite-based climate variables. Such activities include those relative to data systems that are part of important ground segments, including those of ERS-1/2, ENVISAT/SCIAMACHY and METOP, activities of the World Data Center for Remote Sensing of the Atmosphere (WDC-RSAT) and development of algorithms for climate variables. Users can obtain the DLR's products via the "DLR-EOWEB", for example, which is accessible via the Internet.

In the WCRP framework, two international centres for data relative to the global water cycle have been established in Germany (both are important components of the GCOS and the GEOSS):

- The Global Precipitation Climatology Centre (GPCC), which provides global precipitation analyses for climate monitoring and climate research purposes, has been established within the Deutscher Wetterdienst (DWD).
- The Global Runoff Data Centre (GRDC) has been established within the Federal Institute of Hydrology (BfG).

Central archives for globally collected data have been established at the Leibniz Institute of Marine Sciences (IFM-GEOMAR; for marine research, in the framework of JGOFS, an IGBP core project) and at the AWI (for paleontological data). In a special analysis centre (SAC) at the Max Planck Institute for Meteorology (MPI-Met), and in co-operation with the Federal Maritime and Hydrographic Agency (BSH), data

assimilations (dynamic interpolations of data, using global models) are carried out in the framework of WOCE, a WCRP core project.

8.3 Research into climate impacts

Reliable analyses of climate impacts on regions, sectors, companies or economies now often serve as bases for, and integral parts of adaptation research. In carrying out such analyses, adaptation researchers draw on approaches and methods from climate-system research and research into the impacts of climate change.

Findings from research into the impacts of climate change, which studies the interactions between climate changes and natural systems and human society (socio-economic systems), provide the scientific basis for concrete measures for adaptation to climate change. In the long term, they also provide the basis for controlling human influences on the climate system.

Important foundations for this area have been laid by the BMBF's DEKLIM German Climate Research Programme. In one of the pertinent funded projects, for example, preventive risk management and coastal protection management along the German North Sea coast was studied in light of climate change. Also in DEKLIM, the interactions between climate changes and natural and societal systems were studied, with respect to selected topics, with the aim of providing networked information, for orientation and action, relative to the causes and impacts of climate change. To that end, close links had to be established between "classical" climate and climate-impacts research and socio-economics. The necessary methodological steps in the process included integrated modelling of the various systems considered, with the help of socio-economic models, and taking account of non-quantifiable expert knowledge.

The primary aim in the BMBF funding priority "Global Change in the Water Cycle" ("Globaler Wandel des Wasserkreislaufs") is to find solutions to the unprecedented challenges arising via regional impacts, driven by global environmental changes, on use and management of water resources. In addition, the effort is also aimed at developing scientifically founded, integrative strategies for assuring water availability and quality and for safeguarding water distribution. In the process, the effort is taking account of global ecosystemic interrelationships and socio-economic parameters that arise via climate variability and precipitation variability, as well as via impacts of biosphere / land-use interactions on water cycles and water availability and via usage conflicts.

In 1992, the Potsdam Institute for Climate Impact Research (PIK) was founded. At that institute, natural scientists and social scientists develop interdisciplinary insights that provide a robust basis for decisions in the political, economic and societal realms. The PIK's most important tools include system and scenario analyses, quantitative and qualitative modelling, computer simulation and data integration. The PIK maintains numerous national and international co-operative relationships. In the framework of its departmental research, the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) carries out climate-impacts research with a focus on agriculture and forestry, horticulture and viticulture and fisheries. Its areas of activity are listed in Chap. 9.1.4.

KLIWAS, a research programme of the Federal Ministry of Transport, Building and Urban Affairs (BMVBS), is exploring possible climate impacts on major rivers, and coastal waters, that are used as waterways. As to its approach, the programme applies an integrated perspective, taking account of ecology, economics, water

quality and water-body health and the many purposes for which federal waterways are used. The programme also applies a strict multi-model approach; it takes account of, and assesses, all climate models available for Europe (as well as models from ENSEMBLES, an international project). The programme's aim is to provide a maximally reliable information base for assessment of various options for adaptation to climate change.

8.3.1 Ecosystems and biodiversity

Early efforts to promote climate research in Germany already included a focus on the biosphere, with respect to the impacts of climate change and in connection with modelling of the global carbon cycle. Initially, such studies were empirical and relied heavily on aggregation (for example, they relied, inter alia, on statistical models of net primary production of biomes).

No reliable conclusions about the biosphere's long-term reactions to climate change can be drawn without ecosystemic studies. Terrestrial ecosystem research studies the structure, function and dynamics of representative ecosystems, such as forests, savannas, rivers and lakes, agricultural landscapes and urban-industrial landscapes. Marine ecosystems are studied in the framework of marine research (see below). Ecosystem research provides important information about the sensitivity of vital ecosystems to climate changes. At the same time, it also explores possibilities for sustainable use and shaping of such ecosystems, especially with regard to problems of global change. By integrating findings from a range of different fields, such research aims to provide early detection and identification of potential risks, as well as to develop relevant options.

With regard to study of climate impacts on ecosystems, the BMBF has funded projects in a number of contexts, including the DEKLIM German Climate Research Programme; the funding priority *Biodiversity and Global Change* – BIOLOG; the priority *Biosphere Research - Integrative and Application-oriented Model Projects* – BioTeam; and German-Brazilian co-operation projects in the Brazilian coastal rain forest (Mata Atlântica). The BMBF also works in particularly affected regions of Africa and Brazil, with the aims of contributing to climate protection at the global level and of improving human living conditions. In the BIOTA Africa projects, for example, approaches and concepts for renaturation of degraded soils in semi-arid regions are developed. In Kenya, Ethiopia and Brazil, sustainable concepts for use, regeneration and afforestation of forests are being developed.

Ecosystem research oriented to climate impacts is funded institutionally within the Helmholtz Association's "Earth and Environment" research field, inter alia within the HGF programmes „Biogeosystems: Dynamics, Adaptation and Adjustment" and "Marine, Coastal and Polar Systems". Other German institutions, apart from the Helmholtz Association, that are involved in ecosystem research, and that focus on aspects of climate change, include:

- The Bayreuth Institute for Terrestrial Ecosystem Research (BITÖK)
- The Forest Ecosystems Research Center at Göttingen University (FZW)
- Forschungsverbund Agrarökosysteme in München (FAM; Agro-ecosystem research network)
- Projektzentrum Ökosystemforschung in Kiel (ÖZK; Project centre for ecosystem research)

- Leibniz Centre for Agricultural Landscape Research (ZALF)
- Johann Heinrich von Thünen Institute (Federal Research Institute for Rural Areas, Forestry and Fisheries)
- Julius Kühn Institute (Federal Research Centre for Cultivated Plants).

During the period covered by the report, research funded by the **Federal Agency for Nature Conservation (BfN)**, in the framework of the BMU's environmental research plan, into the interactions between biological diversity and climate change, and into the relevant options and requirements, was considerably intensified. In 2008, in the framework of a research campaign funded via the Federal Government's climate protection initiative, 20 new individual projects were initiated (and thereby added to relevant ongoing projects).

BfN-funded research into climate impacts helps to improve the database for documentation of existing climate-change impacts on ranges of animal and plant species (especially birds) in Germany, and it facilitates modelling of expected future changes. One project for modelling the impacts of climate change of flora in Germany has already been completed. A number of projects have also studied indirect impacts of climate change on biological diversity, including existing and possible future consequences of expanded use of renewable energies (including bioenergy and hydroelectric power) and of adaptation of other sectors' activities to climate change.

In addition to developing strategies and recommendations for prevention of adverse direct and indirect impacts of climate changes on biological diversity (inter alia, in biotope networks, protected-area management and landscape planning), research funded by the Federal Agency for Nature Conservation (BfN), into relevant options, focuses on identification of possible synergies between nature conservation, climate protection and adaptation of other sectors to climate change. In the process, the potential for natural habitats and habitats used in environmentally compatible ways (such as wetlands, riparian meadows, forests, urban open and green areas) to provide ecosystemic "services" for climate protection and for protection against adverse climate impacts is considered from both scientific and socio-economic perspectives.

Internationally, German ecosystem research is integrated within the UNESCO "Man and the Biosphere" (MAB) programme and within IGBP core projects.

8.3.2 Coastal regions

In most cases, coastal regions are used intensively. At the same time, they are highly significant with regard to the functioning of the global ecosystem. Around the world, coastal areas are subject to strong usage pressures and to impacts of climate change. Many such areas are at risk of losing their ecological and economic functions in the near future. In the interest of countering such risks, coastal regions' resources need to be managed in keeping with sustainability principles. At the same time, the interrelationships between a) economic development and resources consumption and b) the ecological condition of coastal regions and their prevailing socio-economic conditions need to be taken into account. Increasingly, the impacts of climate change are also having to be considered in this context. Integrated Coastal Zone Management (ICZM) is one internationally recognised systematic approach for sustainable use of coastal regions that takes account of such circumstances.

In this context, German climate research concentrates especially on German and European coastal regions. The central research tasks include:

- Description of recent and past changes in coastal climate, and of such changes' impacts on climate-sensitive systems/uses/aspects, such as ecosystems, land and sea use, water quality and tourism.
- Derivation of scenarios for possible future developments.
- Description of the sensitivity of selected coastal regions, in terms of security with respect to geological risks (especially storm surges), and in terms of the proper functioning of coastal ecosystems.
- Derivation of suitable strategies for adaptation to changed conditions and risks.

The BMBF project network "Climate Change and Preventive Risk and Coastal Protection Management on the German North Sea Coast" (KRIM), which was funded in the framework of DEKLIM, carried out comprehensive, interdisciplinary studies of climate changes in coastal regions, on the basis of eight representative, differently structured, coastal sections in the Weser-Jade area. That work focussed especially on the consequences (with respect to vulnerability and adaptability) of accelerated sea-level rise, and of considerably more powerful extreme events (storm surges), for the natural and societal structures in the study area. The results were compiled in a decision-support system that is also to serve as a tool for public discussion regarding ways of dealing with the impacts of climate change.

In the institutional funding sector, the GKSS Research Centre in Geesthacht co-ordinates research into climate impacts on German coastal regions, as funded via sub-programmes of the Helmholtz Association programme "Marine, Coastal and Polar Systems". The pertinent research activities include analysis of past changes, derivation of suitable scenarios and study of the climate sensitivity of coastal ecosystems. Relevant research with a focus on the Baltic Sea is carried out primarily by the Leibniz Institute for Baltic Sea Research Warnemünde (IOW). What is more, German researchers have participated in EU projects (FP6) that have generated scenarios, using global and regional climate models, for possible future climate conditions on European coasts (the scenarios were calculated in connected models for storm surges, currents and sea states).

Furthermore, climate impacts and adaptation options in German coastal regions are explored in the BMVBS research programme "KLIWAS" and in individual research networks within "KLIMZUG", a current BMBF funding priority.

8.4 Energy and mitigation research

The Federal Government's overarching energy-policy objective is to achieve a sustainable energy supply system that fulfills the criteria of reliability, cost-effectiveness and climate / environmental compatibility. The Federal Government's climate protection objectives also include extensive reductions of greenhouse-gas emissions and of primary energy consumption.

8.4.1 Energy research – an overview

The real keys to these objectives are innovative energy technologies – both on the supply side, where energy is produced, and on the demand side, where it is consumed. The Federal Government has thus made research and innovation a central priority of its energy policy. The Federal Government's central focuses include expanding support for research and development for state-of-the-art, efficient **energy technologies.** Research and development are the strategic keys to assuring a sustainable, long-term energy supply for Germany. A number of different government departments are involved in relevant implementation, each within the framework of its own competencies. The Federal Government's support policy is being co-ordinated via a **"Co-ordination Platform for Energy Research Policy"** (**Koordinierungsplattform Energieforschungspolitik")**, established within the Federal Ministry of Economics and Technology (BMWi).

The 5th Energy Research Programme will serve as the basis for the Federal Government's support policies in the coming years. The aim of the programme is to advance the transition, via innovation and technical progress, to a sustainable energy supply. In order to address the growing energy-policy and climate-policy challenges, the 5th Energy Research Programme, "Innovation and new Energy Technologies", has been extended two years, so that it now runs until 31 December 2010. In addition, the programme has been financially reinforced (2009/2010 budget: about EUR 1.15 billion), and its priorities have been redefined, as follows:

- Climate protection and energy efficiency: Within the technology programme, the BMWi is recombining its funding measures within the area of non-nuclear energy research, and is increasing relevant funding. The primary pertinent aims are to achieve short-term to medium-term success, via concentration on applied R&D and demonstration projects. The programme includes the following priorities: "Power-station technologies (COORETEC)", "CHP, district heat", "fuel cell, hydrogen", "efficient electricity use, storage systems", "energy-optimised construction" and "energy efficiency in industry, commerce, trade and services". The programme also includes measures for supporting research into safety and final storage for the nuclear sector.
- Renewable energies: The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has expanded its research support in the area of renewable energies, and has set relevant new priorities. In keeping with offshore wind energy's relevance to the Federal Government's aims for expansion of renewable energies, funding for wind-energy research has been greatly increased. The research initiative "Research at alpha ventus", via which comprehensive R&D activities in the first German offshore wind farm are being supported, is playing a central role in this connection. In addition, a new priority has been defined, "Optimisation of power supply systems with regard to expansion of renewable energies". This effort is focussed on projects involving

integration of growing amounts of fluctuating power inputs from wind-energy and photovoltaic systems within the electricity grid.

- "Bioenergy": The aims of "Renewable resources" ("Nachwachsende Rohstoffe"), a funding programme of the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV), are to provide a sustainable supply of renewable resources and to study alternative sources of such resources. With innovative technologies for converting biomass for purposes of energy and substance recovery, in biorefineries and "white" biotechnology systems, the potential for industrial use of renewable resources is being further expanded.

  The bioenergy research sector has been reinforced by the German Biomass Research Centre (Deutsches Biomasseforschungszentrum; DBFZ), which the BMELV established in 2008 in Leipzig. The new centre is studying technical, economic and ecological issues related to biomass use in energy production. In a "National action plan for substance recovery from renewable resources " ("Nationaler Aktionsplan für die stoffliche Nutzung nachwachsender Rohstoffe"), which the BMELV submitted for 2009, relevant measures will be combined and refined. The National Biomass Action Plan of the BMELV/BMU is highlighting the potential of biomass with regard to a sustainable energy supply.

- "Basic Energy Research 2020+" ("Grundlagenforschung Energie 2020+"): Via a broad interdisciplinary approach, this new BMBF funding concept is supporting basic research, with a long-term orientation, relative to new technological options. This effort is focussed on highly efficient processes for producing, transforming, storing, transporting and using energy. Examples of its priorities include development of next-generation renewable-energies technologies – for example, in the area of thin-film photovoltaics; biomass conversion for energy production; solar-powered, biomimetic production of hydrogen; and development of technologies for storing CO_2 from coal-fired power stations. Energy research conducted by the Helmholtz Association plays an important role in this effort. The BMBF's funding priority "Bioenergy 2021 – Research for the use of Plant Biomass", which is part of Basic Energy Research 2020+, is oriented to pertinent central recommendations made by the German Advisory Council on Global Change (WBGU).

- Climate protection, resources conservation, sustainable construction: The Federal Ministry of Transport, Building and Urban Affairs (BMVBS) has launched the research initiative "Future of Building" ("Zukunft Bau") with the aim of improving energy and resources efficiency in the construction sector. The initiative brings together application-oriented research in the construction sector. The building sector, with its heating/cooling and water-heating requirements, accounts for a total of 40 % of Germany's energy needs. A total of 50 % of all raw material requirements occur in the construction sector, and the building sector is responsible for 60 % of all waste production. In light of current scenarios for the future, advanced building-sector technologies urgently need to be developed, tested and applied. The key areas within the "Future of Building" research initiative of the BMVBS include improvement of energy and resources efficiency. The research programme's clusters include energy efficiency; renewable energies in the building sector, calculation tools, new concepts and prototypes for energy-saving construction, "zero" and "plus" building concepts, new materials and techniques, sustainably oriented construction and construction quality.

8.4.2 Key technologies and cross-cutting technologies for climate protection

Research and development in the area of key technologies make essential, fundamental contributions to solution of climate protection challenges. Such R&D makes it possible to improve climate protection in numerous applications in the areas of energy, mobility and production. For example, new high-tech materials can be used to make vehicles lighter, batteries stronger and buildings more environmentally friendly. Advances in microsystem and information and communications technology improve control systems – and, thus, the energy efficiency – of production and energy systems. The following key and cross-cutting technologies are being supported via programmes and measures of the BMBF:

- Information and communications technologies (the "ICT 2020 – Research for Innovation" programme)
- Optical technologies (the "Optical Technologies" funding programme)
- Production technologies (for example, the funding priority "Resources-efficient Production")
- Materials technologies ("WING – Innovations in materials, for industry and society")
- Biotechnology ("Biotechnology Framework Programme")
- Nanotechnologies ("Nano-Initiative – Action Plan 2010")
- Microsystem technology ("Microsystem Technology Framework Programme")
- Innovative services ("Innovations with Services" programme)

The important instruments in this connection include innovation alliances and promotion of "classical" collaborative research projects with partners in research and industry.

Innovation alliances are a new type of research-policy and innovation-policy instrument. Each such strategic co-operation between industry and science is oriented to a specific area of application or to a specific future market. Innovation alliances can develop considerable economic leverage effects. The relevant aim is: for each euro from the Federal Government to leverage five euros from industry. One emphasis of the BMBF's innovation alliances is the area of climate and energy research. In this area, the following innovation alliances have been launched:

- *Organic Photovoltaics* (OPV) (energy generation / photovoltaics): This effort is focussed on improving the efficiency and durability of solar cells made from organic materials. Such solar cells are a cost-effective alternative to today's solar cells.
- *OLED Initiative* (energy efficiency / lighting): Organic light-emitting diodes convert electricity into light extremely efficiently, and they can be produced as thin, flexible layers.
- *CarbonNanoTubes (CNT) (*climate / chemistry): This effort is working to harness the amazing properties of carbon nanotubes (CNT). In particular, CNT applications in the areas of energy technologies (such as fuel cells, energy-storage systems, wind power, solar cells) and environmental technologies (such as water desalination) are being explored.

- *Lithium-ionen battery (LIB 2015):* Energy storage / automotive, renewable energies: This project is working to develop a new generation of powerful batteries for use in electric or hybrid vehicles, as well as for energy storage in connection with renewable energies.

8.4.3 ICT-based energy system of the future – E-Energy

In April 2007, the BMWi launched the technology competition "E-Energy: ICT-based Energy System of the Future". This competition is aimed at development and testing of integrated concepts for the establishment of (about 3 to 5) "E-Energy model regions". The work involved consists of R&D projects that, via regional innovation clusters, develop the modernisation potential inherent in state-of-the-art information and communications technologies (ICT), and in applications and services that build on ICT, throughout the entire value-creation chain in the electricity sector – i.e. throughout the spectrum that includes generation, transport and distribution and consumption. This approach is expected to mobilise a financing framework amounting to about EUR 100 million, to which the BMWi will contribute funding of up to EUR 40 million, for a period of up to four years.

The topic focuses of E-Energy include introduction of seamless (i.e. free of media discontinuities) electronic business and legal transactions and end-to-end integration and use of digital technologies for optimising the entire electricity supply system. The effort thus calls for innovative ICT-based technologies, services and business models that promise to have especially lasting and broad-based effects – and thus will attract strong public interest.

With its "E-Energy" funding priority, the BMWi is focussing on current challenges in the electricity sector: With increasing energy-market liberalisation, and energy-generation decentralisation, entirely new, highly distributed (in future) value-creation processes and structures form. In addition, environmental problems, fuel scarcities and price increases increase pressures for energy efficiency. Online-based processes with which energy producers, network operators and customers can network and interact can help boost energy efficiency, supply reliability and environmental compatibility. At the same time, the "E-Energy" innovation area will open up completely new options and markets for the ICT industry.

On a basis of analyses, experts' assessment and technical discussions, the BMWi has made "E-Energy: ICT-based Energy System of the Future" a new focus of ICT technology policy within the "High-Tech Strategy for Germany" and the Federal Government's action programme "Information Society 2010".

8.4.4 Mitigation in industrial processes and products – integrated environmental protection

In the **action area "Concepts for Sustainability in Industry and Commerce" ("Konzepte für Nachhaltigkeit in Industrie und Wirtschaft") within the BMBF's framework programme "Research for Sustainability"**, efforts in topic areas other than "climate protection strategies" (other areas such as "requirements areas and relevant value-creation chains", "resources-oriented production systems", "key technologies for system change"), can also contribute, directly or indirectly, to climate protection.

Preventive, integrated environmental protection is often more effective, and more comprehensive, than any after-the-fact measures. In addition to technical aspects,

such environmental protection takes account of the pertinent legal and societal framework and of the demand side – within the meaning of economically oriented sustainability. The technology-oriented area of research support with regard to sustainable business focuses on optimisation of integrated environmental protection in connection with production processes and products, as well as on closing of relevant cycles. Such optimisation aims for the following:

- Avoidance, from the outset, of product-related and production-related emissions (exhaust, waste, wastewater);
- Minimisation of inputs of resources and energy in production, use and disposal of products.

All in all, the BMBF funding priority "Concepts for Sustainability in Industry and Business", within the framework programme "Research for Sustainability", and with the programme "Innovation as the Key to Sustainability", is contributing to sustainability and, in some ways, contributing directly to climate protection.

In the BMBF funding priority "Concepts for Sustainability in Industry and Business", bionics also plays an important role in development of innovative approaches. Bionics taps into living nature's own vast storehouse of ideas, in the hope of finding new types of solutions to application-oriented (usually technical) problems. Bionic approaches often yield considerable reductions in energy and materials consumption, even in areas in which conventional methods have provided only minimal progress. The BMBF funding measure **"BIONA – Bionic Innovations for Sustainable Products and Technologies"**, which the BMBF established in 2006, primarily supports collaborative research projects involving partners from research institutions and business enterprises, especially projects that seek to borrow principles, from nature's own "pool of ideas", for saving energy and resources, and thus make important contributions to sustainable business and to industry-based climate protection.

The **BMBF funding initiative "KMU-innovativ",** a programme for funding cutting-edge research by SMEs that was launched in 2007, provides contributions to sustainability and climate protection**.** With this cross-departmental initiative, the BMBF is working to strengthen innovation on the part of small and medium-sized enterprises (SMEs), in cutting-edge research. At the same time, it is aiming to make research funding, in the framework of its specialised programmes, more attractive especially for SMEs who are submitting their first applications. To that end, the BMBF has simplified and streamlined the relevant application and approval procedures and expanded its advising services for SMEs. Plans call for expansion, within the framework programme, of "KMU-innovativ" (a pilot programme), to the extent the relevant topics are suitable for such expansion.

Technologies for resources and energy efficiency, and for climate protection, are being promoted as one of (currently) six technology areas within the "KMU-innovativ" initiative. Within this focus area, the funding measure is not restricted as to topics. In addition, it is aimed at all innovative SMEs, regardless of industrial sector. In funded projects within the "resources and energy efficiency" priority topic, SMEs – working either alone or in co-operation with other companies or research institutions – are already developing concrete contributions to sustainable resources use.

The BMBF funding priority "klimazwei": Research to date in the areas of climate change, climate impacts and identification of relevant options has produced a wealth of orientational and actionable knowledge for the areas of policy, industry and

society. In keeping with the thinking behind the framework programme "Research for Sustainability", which the Federal Government approved in mid-2004, such knowledge now needs to be put into practice. That aim is being furthered by the BMBF funding measure "Research for Climate Protection and Protection against Climate Impacts", which has a dual approach, with two complementary thrusts:

- Prevention or mitigation of climate impacts that are caused by human action and that are damaging for society and the environment;
- Adaptation to climate change and to extreme weather events (cf. the Chapter "Adaptation to Climate Change").

Also in connection with emission trading, which began in February 2005, German industry is now incurring considerable costs in connection with achievement of the national reduction objective. The mitigation-oriented research topics being funded in "klimazwei" thus comprise a broad spectrum of implementation-oriented research aimed at supporting entrepreneurs' own initiative in the areas affected by emission trading. The projects are sited in such areas as "transport and logistics", "information and communications" and "industrial production and processes".

The measure is oriented to development of new technologies, procedures and strategies for achieving significant reductions of emissions of climate-relevant gases. Along with carbon dioxide, the gases covered include all other climate-relevant gases pursuant to the classification used in the Kyoto Protocol. Leading research institutes and business enterprises, from a range of different areas, are involved in the projects. During the period 2006 to 2009, funding covers a total of 40 projects, with a total funding volume of EUR 38 million.

"Technologies for Sustainability and Climate Protection – Chemical Processes" (BMBF)*:* Projected scenarios for development of atmospheric CO_2 concentrations indicate that strategies for reduction of energy-based CO_2 emissions will not suffice, by themselves, to stop climate change. As a result, additional measures for reduction of greenhouse-gas emissions will have to be considered – measures such as use of CO_2 as a resource. This will necessitate development of new, highly efficient, climate-friendly technologies for

- Resource-oriented use of CO_2;
- Reduction of greenhouse-gas emissions from production, via use of functional liquids as aids in synthesis, processing procedures and production processes;
- Enhancement of energy efficiency in production, via improved processes and equipment;
- Chemical-industry innovations as a basis for developments, in other industrial sectors, for CO_2 separation and activation.

Currently, two pilot projects ("Dream Reactions" – use of CO_2 as a resource; CO_2 as a polymer component) are being funded. As of spring 2009, a relevant funding announcement was being prepared.

8.4.5 Mobility and climate protection

Overview: Transport growth, in both individual transports and transports of freight and goods, is creating major challenges for transport infrastructures, logistics systems and transport technologies. A range of studies predict that freight-transport

volumes will increase by some 70 percent from 2004 to 2025. At the same time, the available space for roads, railway lines and freight-handling centres is limited. What is more, traffic jams cause considerable economic damage – damage that could be alleviated by intelligent traffic-management concepts.

Demographic change is going to affect transport and infrastructure systems. While reductions in transport volumes are expected in some regions, freight transports will increase dramatically in large population centres. In addition, individual mobility patterns in urban areas will change radically. As transports grow, the relevant environmental-policy and climate-policy challenges grow as well: Already, transports are responsible for about 20 percent of Europe's CO_2 emissions and account for about 70 percent of its oil consumption. What is more, transports generate noise that can have negative impacts on health.

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

With its High-Tech Strategy, and the Federal Government's comprehensive package of measures within the Integrated Energy and Climate Programme, Germany has taken the steps necessary to reduce its greenhouse-gas emissions by 40 percent by 2020. The human stress generated by automobile traffic is to be sharply reduced. Relevant efforts will apply especially to that sector's resources and land consumption, its noise and its carcinogenic emissions. In the framework of the Integrated Energy and Climate Programme, therefore, and with effect as of 1 July 2009, motor-vehicle taxes for new automobiles will be based on CO_2 emissions. With this move, the Federal Government is providing an incentive for purchases of automobiles with low fuel consumption (which are also cheaper to operate). At the same time, the government's economic-stimulus packages are providing important impetus for purchase of modern, "greener" automobiles. Those persons who purchase a new car by 30 June 2009 are exempted from motor-vehicle taxation. In addition, all those persons who purchase vehicles meeting the "Euro 5" or "Euro 6" emissions standards will be exempted from motor-vehicle taxes until the end of 2010.

In the interest of the long-term future of mobility, alternatives to the conventional internal combustion engine, powered by fossil fuels (petrol, diesel fuel, natural gas), have to be found. The future belongs to electrically powered vehicles, i.e. fuel-cell, hybrid and electric vehicles. Such vehicles help reduce dependence on oil imports, and they contribute significantly to reductions of emissions of CO_2 and other pollutants.

For these reasons, the Federal Government is seeking to make Germany the lead market for electromobility. With its **"National Electromobility Development Plan"**, it plans to create a relevant interdepartmental action framework. At the same time, via the second economic-stimulus package, the Federal Government is providing EUR 500 million for application-oriented research in the area of mobility. The areas being supported include environmentally compatible engine technologies, and capacity

development in the electrochemical sector and in industrial production of lithium-ion batteries and concrete preparation of the electromobility market in model regions.[46]

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

The **research area "Sustainable Solutions via Innovative Transport Technologies"** provides the basis for research activities relative to reduction of ozone precursor substances, soot particles, CO_2, other greenhouse gases and noise. Nature and landscapes are to be protected, and the quality of life in population centres is to be improved. The relevant emphases include development of alternative vehicle and power-train concepts; study of pollutant formation, as a basis for optimisation of engine combustion; active safety and assistance systems; and source-oriented noise reduction. In optimisation of conventional vehicles, energy savings are also to be achieved via technology transfer from projects in the BMBF's materials research programme. An important new funding priority in this area is the lead vision "Transport Management 2010" ("Verkehrsmanagement 2010").

"Indirect emissions reductions", achieved via avoidance of transports, reorganisation and public awareness measures, are also being promoted in **other research fields**.

The **priority "Transport management systems of the future – Innovative transport management in dynamic networks" ("Verkehrsleitsysteme der Zukunft – Innovative Verkehrsgestaltung in dynamischen Netzen")** is aimed at using telematics applications to optimise road, railway and air transports and to efficiently link different modes of transport. In future, it is to become easier to choose the optimal mode of transport, in both passenger and goods transports. And travel times are to be shortened and resources are to be conserved.

With regard to growing goods transports on roads, efforts in the **research area "More capable transport systems for a dynamic economy" ("Leistungsfähigere Transportsysteme für eine dynamische Wirtschaft")** are focussed especially on finding new ways of having railways and ships gain larger shares of the transport market. In addition, the problem of the growing environmental stresses caused by goods transports on roads are to be addressed via efforts to enhance vehicle-capacity use and to optimise routing and operational logistics. The priority "Optimal transports in closed-cycle and waste management" ("Optimale Transporte in der Kreislauf- und Abfallwirtschaft") is identifying significant potential for lessening the transport loads on roads.

[46] Cf. also the following more detailed discussion of electromobility.

In the **action area "Faster, more convenient and more environmentally friendly, with trams and busses" ("Schneller, bequemer und umweltfreundlicher mit Bahnen und Bussen")**, operational and organisational innovations, and new vehicle and transfer technologies, are to be used to enhance the efficiency and attractiveness of local public transportation, in the interest of environmentally compatible, smoothly flowing transports. In "Understanding mobility better" ("Mobilität besser verstehen"), research activities (inter alia) in the area of recreational and vacation transports are being promoted. Such transports account for about 50% of total automobile transports (in terms of passenger-kilometres). In addition, new ways of structuring vacation transports are to be found.

In the framework of **promotion of transport-reducing structures and substitution of physical transports,** housing, workplaces, recreation and shopping are to be more effectively linked. Support for strategies that reduce transports, and reduce transport costs, focuses on the causes of transports and can contribute significantly to climate protection. This aspect serves as a programmatic interface to the research programme "Construction and Housing" ("Bauen und Wohnen").

8.4.5.1 National Hydrogen and Fuel Cell Technology Innovation Programme (NIP) / Electromobility

The above section provided an overview of the topic "mobility and climate protection". The following section, presented for reasons of timeliness, details activities in the areas of hydrogen, fuel-cell technology and electromobility.

In May 2006, the Federal Government, represented by the BMVBS, BMWi, BMBF and BMU, initiated the National Hydrogen and Fuel Cell Innovation Programme (NIP). The programme fits with the Federal Government's "fuel strategy" and is an element of Germany's "High-Tech Strategy".

In terms of its nature and structure, the NIP is a "strategic alliance" of the policy and industry sectors, aimed at **preparing the market** for hydrogen and fuel-cell technology in Germany. The NIP is focussed on making decisive progress in such market preparation. For this reason, along with research and development, the programme is especially funding major projects for product demonstrations. The NIP is slated to run until 2016, and it has a total budget of EUR 1.4 billion, of which the Federal Government is contributing EUR 700 million (BMVBS: EUR 500 million / BMWi: € 200 million). The public-sector funding is conditioned on industry's willingness to at least match that funding in participating in NIP implemention. In February 2008, the Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie (NOW; national organisation for hydrogen and fuel-cell technology) was established for purposes of controlling and co-ordinating the NIP. The sole NOW shareholder is the Federal Government, represented by the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) (www.now-gmbh.de).

A **national development plan**, jointly developed by the political, industrial and scientific sectors, describes the planned programme of work in detail. It is focussed especially on goal-oriented research and development and on demonstration projects.

Along with industry and the science sector, the **Länder** play a decisive role in implementation of the NIP. The commitment of Germany's Länder and regions, and of participating industry, will serve as a central basis for decisions on concrete development projects. Research, development and demonstration projects are to be

based on extensive experience gained in regions. In addition, they should make use of, or build on, existing activities.

The NIP is closely integrated within European efforts relative to hydrogen and fuel-cell technology. Such efforts are a welcome complement to the efforts being made in Germany.

Hydrogen and fuel-cell technology has already reached a mature level of development. This has been shown by the numerous successful demonstration projects that have been funded for a year via the **National Hydrogen and Fuel Cell Innovation Programme (NIP)**. Activities in these areas now need to prepare for market introduction, since electromobility, using fuel cells or batteries, is an important option for the mobility of tomorrow.

The NIP comprises a broad spectrum of hydrogen and fuel-cell developments for mobile, stationary and portable applications. Along with promoting numerous, different individual projects and small collaborative research projects, funding measures focus especially on **lighthouse projects**, which are large, often cross-sectoral collaborative research projects.

Outstanding fuel-cell projects include the lighthouse projects Clean Energy Partnership (CEP), for the transport sector, and the Callux project, in the area of fuel-cell use for efficient building energy systems.[47] The CEP is demonstrating how mobility can function without fossil fuels, and without CO_2 and other pollutant emissions, and can be quiet. A fleet of hydrogen-powered automobiles in Berlin and Hamburg is to be enlarged to over 50 vehicles by 2010, and the pertinent fuelling-station network is to be suitably expanded. Further considerable expansion of the fleet after 2010, to a size of several hundred vehicles (both busses and automobiles), is being planned. The participants in CEP include automakers, oil and energy companies, the gas industry, technology companies and transport companies (www.cleanenergypartnership.com). Both NIP projects are among the world's largest field tests.

As of July 2009, industry, together with relevant scientific institutions, had submitted to Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie GmbH (NOW; founded in February 2008), for NIP funding support, a total of 158 sketches for demonstration projects in the area of hydrogen and fuel-cell technology. The submitted project applications represent a total volume of EUR 720 million. The volume of funding to be provided by the NIP amounts to EUR 345 million (48 percent). Since the beginning of 2009, an additional 73 project sketches, representing a volume of EUR 190 million, were submitted – the financial and economic crisis notwithstanding.

Electromobility – battery-powered drive systems: In the long term, the prospects for individual auto-mobility depend on whether new, environmentally friendly and resources-conserving vehicle concepts can be developed and introduced to the market in significant numbers. Vehicles with electrical or partly electrical drive systems can be of substantial value in this context. Like use of fuel-cell vehicles, use of battery-powered vehicles reduces dependence on oil imports, and it reduces CO_2 emissions (thanks to such vehicles' energy efficiency). What is more, such vehicles can use the entire spectrum of renewable energies and can help reduce pollution and

[47] Also: "Callux" in building energy systems, with energy suppliers and fuel-cell manufacturers as partners.

noise levels in population centres. Storage of electrical energy is one of the keys to efficient, climate-compatible energy use. Integration of electric vehicles' electrical storage systems / batteries within power grids, as decentralised storage units, can help stabilise such grids (by reducing the fluctuations caused by use of renewable energies) and thus can enhance the overall efficiency of the power supply.

In the area of electromobility, a second pillar, i.e. a pillar in addition to the hydrogen and fuel-cell programme, now needs to be established (as has been done in similar programmes in the U.S. and Japan): promotion of battery-powered drive systems. Working on the basis of the **"National Electromobility Development Plan"**, science, industry and policy-makers now need to develop a concerted strategy, covering the entire spectrum from basic research to market introduction. In the process, attention will be given to the entire pertinent value-creation chain – including materials, components, fuel cells, batteries and the entire system and its uses. Key relevant facts and figures were discussed with industrial and scientific stakeholders at a national strategy conference on electromobility that was held in November 2008 in Berlin.

On 25 March 2009, acting on the basis of a battery-technology programme prepared by the BMVBS, BMWi, BMBF and BMU, the Budget Committee approved EUR 500 million for electromobility within the framework of the second economic-stimulus package.

Research funding and technology development relative to electromobility – measures of the BMBF: Since 2007, the BMBF has provided extensive funding for research and development in the area of of electromobility; in co-operation with industry, these efforts have provided over EUR 1 billion. The aim of such efforts is for one million electric cars to be on Germany's roads by 2015. Key relevant BMBF projects being financed from the current budget include:

- *Innovation alliance for lithium-ion batteries:* This effort is aimed at the development of a new generation of powerful, yet affordable batteries by 2015. The first relevant projects began in March 2009. All in all, the BMBF is providing EUR 60 million, while industry is providing EUR 360 million.
- *Innovation alliance for automotive electronics:* This effort is aimed at the development of innovative energy-management systems and integration of the various components [*battery, electric motor, auxiliary systems*]. The BMBF is providing up to EUR 100 million, while industry is providing over EUR 500 million. All in all, some EUR 600 are being mobilised.
- *Funding activities in the area of lightweight construction:* A central aspect in developing electric vehicles is to reduce vehicle weights (to increase vehicles' ranges). To date, EUR 22 million are available for this effort. Plans call for a programme for development of safe, affordable lightweight structural systems for electric vehicles.

In its second economic-stimulus package (Konjunkturpaket II; KoPa II), the Federal Government is providing an additional EUR 500 million in the area of mobility through the end of 2011. The BMBF is implementing the following three measures, within the EUR 500 million programme, that have a total volume of EUR 119 million:

- *Establishment of centres of competence for electrochemistry at higher education institutions, in co-operation with the Helmholtz Association of German Research Centres (HGF):* Germany needs to be among the world leaders in electrochemical research if it wishes to make full use of its own

potential and opportunities for electromobility. Support is being provided for establishment of electrochemical research centres (HGF Labs) that receive funding from both universities and non-university research institutions.

- *Establishment of a competence network for electromobility systems research within the Fraunhofer Gesellschaft:* Support is being provided for the establishment of an electromobility network with special focuses on vehicle design, energy and infrastructure and societal acceptance. In the network, industry and science partners will jointly develop solutions in those areas.
- *Development of technologies for industrial production of 1st-generation Li-ion cells / battery systems for vehicles:* The BMBF is supporting industry in developing capacities for production of Li-ion cells / batteries for vehicles. A key aspect of this effort is that the new battery concepts will be developed and implemented in Germany, meaning that relevant value addition will take place in Germany.

Model regions and infrastructures for electromobility – measures of the BMVBS: The Federal Ministry of Transport, Building and Urban Affairs (BMVBS) is providing EUR 115 million for development of electromobility in model regions. Along with concepts for electric cars, concepts for introduction of electromobility in utility vehicles in commercial/industrial applications (for example, waste pickup), in delivery with light utility vehicles and in local public transportation are to be promoted in a total of eight regions (Berlin/Potsdam, Bremen/Oldenburg, Hamburg, Munich, Rhine-Main, Rhine-Ruhr (including Aachen), Saxony (especially Dresden and Leipzig) and Stuttgart). The key aspects also include development of a user-friendly, safe infrastructure for charging vehicles. Electromobility will develop in certain clusters. By promoting electromobility in model regions, this programme is focussing precisely on the relevant cluster level. The regional-level approach promotes a logical mode of development in electromobility: interaction between a) global approaches and global players (such as vehicle makers, suppliers, energy suppliers, etc.) and b) the local level, with locally based partners (such as municipalities, municipal utilities, etc.).

In the model regions for electromobility, electromobility is to be developed via a holistic approach, with various integrated focuses. The focuses include:

- Integration of, and co-operation with, producers, users, services providers, infrastructure operators and local stakeholders (municipalities, etc.);
- Promotion of a broad range of uses and products (automobiles, utility vehicles, local public transportation and two-wheeled vehicles);
- Study of electromobility patterns in everyday applications;
- Integration of different modes of transport (road – railway) and linking of different modes of transport with modern mobility services, such as car-sharing, etc.;
- New business models – for example, for the charging-station infrastructure;
- Use of co-ordinated concepts, and avoidance of stand-alone solutions;
- Regional emphases in value creation with electromobility, including the areas of relevant market preparation and development;
- Encouragement of regional stakeholders, and use of the creativity inherent in regional initiatives;
- Consideration of relevant aspects of urban and city planning.

Another important aspect is that all model regions need to be centrally co-ordinated. This will ensure that proposals are efficiently co-ordinated, will prevent double-funding, will ensure transparency and will generate widely applicable findings.

A battery centre will be developed, to carry out independent tests with new high-performance batteries (including crash tests). This will ensure that all necessary safety tests with future battery systems can be carried out in Germany. The BMVBS is providing total funding of EUR 20 million for this purpose. In future, the international competitiveness of German manufacturers and suppliers will depend even more strongly on innovation. Electric motors will play an ever-stronger role in such innovation: in hybrid cars with combinations of electric motors and conventional internal combustion engines; in plug-in hybrids with electric motors; in electric-only cars; and in hybrid cars with combinations of electric motors and fuel-cell systems. In all such approaches, we need high-performance batteries suited for automotive applications. Germany still has a technological gap in this area, a gap that needs to be closed, in co-operation with science and industry.

In addition to the funding being provided in the NIP framework, the Federal Government plans to provide EUR 15 million for up to 25 new hydrogen fuelling stations. In doing so, the BMVBS is providing start-up financing for development of a hydrogen infrastructure in Germany. This will ensure that as of 2015, when mass-production of hydrogen-powered vehicles is expected to begin, adequate numbers of fuelling stations will be available.With this joint project, industry is highlighting its clear commitment to commercialisation of hydrogen and fuel-cell technology.[48]

8.4.5.2 Measures in the area of ship and air transports (BMWi)

Ship transports: In the interest of making Germany a centre for maritime high-technology, the Federal Government, with its research programme "Shipping and Maritime Technologies for the 21st Century", is relying especially on research and innovation. The aims of the programme, which is being managed by the Federal Ministry of Economics and Technology (BMWi), include improving ships' energy-efficiency, enhancing flexibility in series production of ships and developing innovative freight-handling technologies. In collaborative research projects, most of them industry-led, business enterprises are working in co-operation with higher education institutions and research institutes, toward joint development goals.

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

Air transports: For years, the aviation industry has enjoyed above-average rates of growth. In 2007, its total revenue surpassed the EUR 20 billion mark. Eurocontrol, the European Organisation for the Safety of Air Navigation, is predicting that air traffic in Germany alone will double by 2025, with respect to 2003.

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[48] The new funding programmes complement the National Hydrogen and Fuel Cell Innovation Programme (NIP) in the area of electromobility (EUR 500 million from BMVBS; EUR 500 million from industry).

Growth in air traffic could well have impacts on climate, the environment and on flight safety. The European research agenda "ACARE-Vision 2020" is focussed on such challenges. In addition, Germany's current fourth aviation research programme (Luftfahrtforschungsprogramm IV; LuFo IV) is supporting the German aviation industry, in co-operation with researchers, in providing the necessary technological basis for meeting such challenges.

Relevant research activities are focussed, inter alia, on the area of "environmentally compatible air transport": Via technological measures in the areas of aircraft engines and aviation physics, external noise levels are to be cut in half, and fuel consumption – and, thus CO_2 emissions – are also to be reduced by about 50 percent. Such efforts are focussed especially on innovative lightweight structures, on engines and on on-board systems. In the longer term, new aircraft concepts (such as flying wings) are to be studied.

8.5 Adaptation to climate change

In recent years, issues of adaptation to climate change have become an integral part of the research funded by the BMBF, the BMVBS and the BMU. In the process, applied research relative to adaptation to climate change has been going hand-in-hand with development of improved scenarios / projections of possible future climate conditions, including forecasts of extreme weather trends. In consideration of adaptation and climate protection strategies in global, economic and sectoral contexts, more effective methods and infrastructures need to be created for precisely and comprehensively assessing the consequences (costs, risks, structural change) of various strategies.

In the main, "adaptation" refers to management of climate impacts on people and the environment, on prosperity and living standards and on economic and social development. The prerequisites for such management include a better understanding, and better assessment, of the risks involved, as well as an understanding of the available social and economic resources and of the necessary conditions for adaptation. Addressing these needs involves:

- Identifying regional and sectoral impacts of climate change,
- Identifying relevant gaps in knowledge, and
- Developing strategies and technical solutions for adaptation measures.

On 17 December 2008, the Federal Cabinet approved the "German Strategy for Adaptation to Climate Change". The measures already underway (or completed) for promoting research into adaptation to climate change include:

In the BMBF funding priority **"Risk Management of Extreme Flood Events (RIMAX)"**, improved instruments for flood-risk management were developed and implemented via an integrated effort involving different fields and stakeholders. From 2005 to 2008, projects were funded relative to management of extreme flood events – events of the sort that occur only once every hundred years (or are even rarer) and cause enormous economic damage.

The impacts of climate change, and relevant adaptation requirements, will appear on many different levels. Climate change can affect inland and maritime shipping, including the functioning of waterways, thereby affecting the reliability of such environmentally friendly transports. For example, changes in extreme hydrometeorological situations could trigger a chain of events that would necessitate adaptations in the planning basis for waterway management. For this reason, in 2007, the BMVBS commissioned its specialised authorities, Deutscher Wetterdienst (DWD), the Federal Maritime and Hydrographic Agency (BSH), the Federal Institute of Hydrology (BfG) and the Federal Waterways Engineering and Research Institute (BAW), to examine findings of climate-impacts research with regard to waterways and shipping in Germany and to develop relevant adaptation strategies. To that end, in early 2009 the departmental research programme (co-ordinated with the BMBF and the BMU) "**KLIWAS - impacts of climate change on waterways and shipping – development of adaptation options"** ("**Auswirkungen des Klimawandels auf Wasserstraßen und Schifffahrt - Entwicklung von Anpassungsoptionen")** was launched. Over the next five years, work in the KLIWAS task spectrum will comprise 31 projects, in a total of 5 collaborative research projects.

The BMBF funding measure **"klimazwei – research for climate protection and for protection against climate impacts" ("Forschung für den Klimaschutz und**

Schutz vor Klimawirkungen") is focussed on development of practically oriented strategies for addressing climate change. In this framework, from 2006 to 2009 research projects are being funded that will either develop methods for reducing greenhouse-gas emissions (reduction and mitigation) or study ways of adapting to unavoidable climate change (adaptation). The areas covered by the joint research groups in adaptation research range from strategies in agriculture (for example, optimised cultivation methods, plant-breeding measures and suitably adapted forest management) to innovation in building systems and water-resources management. Other focuses include development of overall strategies for individual cities and regions; decision and early warning systems; and suitable ways of communicating climate-related risks.

The new **BMBF funding priority "KLIMZUG – addressing climate change in regions in future-compatible ways" ("Klimawandel in Regionen zukunftsfähig gestalten")** is pursuing a spatially oriented approach. This funding measure is aimed at ensuring that expected climate changes, and related extreme weather events, are taken into account in regional planning and development processes. This orientation is expected to enhance regions' future competitiveness, as well as to advance regions' development and use of new technologies, procedures and strategies for adaptation to climate change.

A total of seven projects are being funded in this measure, which is scheduled to run from 2008 to 2013. The funding measure has a total budget of EUR 75 million. The projects bring together partners from the areas of policy, administration, industry and science. Partners in the effort plan to develop new technologies, strategies and recommendations that will promote their regions' conditions for living and working in a changed climate. The KLIMZUG projects include:

- "REGKLAM" – Development and Testing of an Integrated Regional Climate Change Adaptation Programme for the Model Region of Dresden
- "KLIMZUG North Hesse" – Transdisciplinary Network for Climate Adaptation in the Model Region of North Hesse
- "North-West 2050" – Prospects for Climate-Adapted Innovation Processes in the Model Region Bremen-Oldenburg
- "INKA BB" – Innovation Network for Climate Change Adaptation in the Berlin-Brandenburg Region
- "DynAKlim" - Dynamic Adaptation of Regional Planning and Development Processes to the Effects of Climate Change Using the Example of the Emscher-Lippe Region (Ruhr basin)
- "KLIMZUG-NORD" - Strategic Approaches to Climate Change Adaptation in the Hamburg Metropolitan Region
- RADOST - Regional Adaptation Strategies for the German Baltic Sea Coast.

This funding measure especially emphases regional aspects, since global problems such as climate change have to be addressed at the regional and local levels. Regional administrative organs maintain infrastructures, monitor planning procedures, decide on environmental regulations (or at least are responsible for their implementation at the local level). Future-compatible "local action" gives regions competitive advantages. At the same time, it even helps to highlight Germany's specific strengths, such as its strong innovation resources and its leadership in climate protection, in an international framework.

Refinement of the sectoral approach is considered to be a necessary next step in strategic development of the area of adaptation in the framework of BMBF research funding. Currently, relevant topics are being prepared, and the sectors on which research needs to be concentrated are being identified. In the process, special priority is being given to sectors' specific requirements and to inclusion of entire value-creation chains. Both sectoral and regional adaptation strategies depend heavily on methods and indicators for assessing adaptation capacities and evaluating the success of complex adaptation strategies.

(The focus areas of the BMELV's departmental research, with regard to adaptation of agriculture and forestry, horticulture and viticulture, fisheries and the food industry to climate change are listed in Chap. VIII 1.4).

8.6 Options and perspectives for the economy and for society

A broad spectrum of funding measures is aimed at promoting economic, social and institutional innovation in addressing climate change, as well as at supporting use and dissemination of innovative technologies and concepts. In order to encourage producers and consumers to endorse such aims, new business and production models, innovative products and attractive services are to be developed and introduced. Such efforts also include first-time use of innovative technologies.

And such efforts take account of both individual lifestyles and needs and the economic and political interrelationships of a globalised economy. The necessary knowledge basis for such efforts is obtained via analysis of available options, and decision situations, of producers, citizens and consumers and political and other societal stakeholders.

8.6.1 Environmental innovation programme – use of innovative technologies for climate protection

Climate protection – including projects in the areas of renewable energies and energy efficiency – has long been a key funding priority in the Environmental Innovation Programme ("Umweltinnovationsprogramm"; UIP) of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)[49]. That programme has been in place since 1979. Via the BMU's Climate Initiative, which was financed through sale of emission allowances, this funding priority was expanded last year also in the framework of the Environmental Innovation Programme and provided with added budget funding of EUR 15 million, funding that is also available in 2009.

In the Environmental Innovation Programme, funding is provided for first-time, large-scale use in Germany of innovative technologies, and of process combinations, for reducing environmental pollution. Projects carried out as a result tap into the extensive CO_2-reduction potential inherent in expansion of use of renewable energies, as well as in enhancement of energy efficiency in companies and in the building sector. This funding priority will remain in place in the coming years, and it will be expanded.

[49] An important aspect of the Environmental Innovation Programme is that it does not support research projects or R&D, etc.. In supports first-time, large-scale use of innovative technologies within the meaning of investment support. In addition, from a standpoint of budget law, the national and international climate initiative is not a research item but an investment item.

For example, a funding priority on "IT goes green" has been established. This initiative's core effort consists of establishing a consulting office, within the BITKOM industry association, charged with initiating innovative projects, in the areas of energy-efficient computer centres, use of thin-client technologies and introduction of highly efficient ICT infrastructures, that can be supported in the framework of the Environmental Innovation Programme. Such initiation is to be carried out via independent technology consultation, process support and relevant communication. The funding priority was initiated in recognition of the fact that the ICT sector's electricity consumption and related CO_2 emissions will increase sharply in the coming years unless it increases its efficiency. The energy consumption of just the computer centres in Germany is equivalent to the annual electricity production of four medium-sized power stations – and that consumption is increasing. The funding priority is aimed at making use of this enormous emissions-reduction potential.

Municipalities also have opportunities to enhance their energy efficiency and energy savings markedly. The areas in which they can do this include street lighting and illumination of public spaces and buildings. Municipalities' lighting systems, many of which are outdated, consume three to four billion kilowatt-hours of electricity annually. That figure corresponds to CO_2 emissions of over 2 million tonnes per year, and those emissions could be cut in half with technology available today. This is the focus for the BMU-initiated national competition "Energy-efficient City Illumination" ("Energieeffiziente Stadtbeleuchtung"), which has been in progress since 2008. That competition offers municipalities the opportunity to propose environmentally friendly, energy-saving and cost-saving illumination concepts. The most innovative concepts are to be honoured in 2009 and then implemented, with funding from the Environmental Innovation Programme.

In addition, a number of projects for introduction of innovative energy efficiency technologies in companies and municipalities are being supported.

8.6.2 The German Climate Initiative: Funding programme for further development of the national segment

In the initial phase of the Climate Initiative, the BMU has introduced various support guidelines and projects for municipalities, industry and consumers, in the context of the Initiative's national segment. The BMU intends to reinforce impetus for the Climate Initiative's strategic development by promoting suitable scientific projects. Relevant scientific support is to include existing programmes and projects, along with any relevant new funding programmes and other strategic individual projects, for development of energy efficiency and for expanded use of renewable energies, and for use of synergies between the two areas.

Funding is concentrated on studies in the following areas:

- Potential for technical, cost-effective reductions, especially in municipalities (including municipal utilities and housing-construction companies), in business (industry, commerce, trade, services) and in private households,
- Obstacles to achievement of such potential reductions, and measures to overcome such obstacles,
- Efficient funding measures for developing the largest possible potential reductions, for the various relevant groups. In addition, the various instruments are to be linked (instruments such as information provision, legal provisions and consultation) and stakeholders are to be effectively networked,

- Analyses of the potential effects of new funding measures (in the areas of climate protection, employment, innovation and costs),
- Issues relative to EU subsidy law; to any required notification of the EU Commission regarding measures, to subsidy policies and the financial constitution; and to a general funding framework for the entire industry and trade sector, for further development of the Climate Initiative,
- Financial issues relative to financing of innovations in the area of climate protection;
- Social, public, economic and political acceptance of funding measures under the Climate Initiative, and efficient communication and information strategies with respect to addressees and societal stakeholders;
- Overarching aspects relative to the further development of the Climate Initiative, and to scientific and political exchanges.

8.6.3 Climate Service Center (CSC)

Decisions regarding adaptation measures are already being made, or prepared, on many different levels. Often, such decisions are based on simple assumptions about how the climate will change in future. And yet climate is an extremely complex process in which many sub-processes interact, in ways that can be approached only statistically. While climate forecasts for specific regions and time periods can be derived from regional climate models and scenarios, all of the available methods in this context have their own strengths, weaknesses and uncertainties. This can be confusing for those who attempt to base specific adaptation measures on climate-research findings. As a result, the Federal Ministry of Education and Research (BMBF) has made improving information and advising services one of its central tasks.

Since 2005, the "Adaptation Service Group" ("Service-Gruppe Anpassung"; SGA) at the Max Planck Institute for Meteorology in Hamburg has been working to provide a standard, unified foundation for methods and data that have to do with climate change. The SGA is also seeking to promote dialogue between climate-system / adaptation researchers and stakeholders in practical realms. In addition, it assists responsible / competent parties in understanding the performance and characteristics of climate models, data and scenarios.

In a carefully considered approach, the Climate Service Center closes the gaps between climate-system researchers and users of climate data. Via close co-operation with relevant research institutions, such as the Max Planck Institute for Meteorology, Deutscher Wetterdienst (DWD) and the "Kompetenzzentrum Anpassung" (KomPass; "Competence Centre on Climate Impacts and Adaptation") sited within the Federal Environment Agency, the CSC is being established at the GKSS Research Centre in Geesthacht. The centre will open officially in July 2009. The CSC will make climate findings available, from different sources, and will help users in interpreting and using such data. The data will be processed so as to enable climate-research findings to enter into political processes, strategic planning and investment decisions. In addition, it will provide a broad basis for intensifying climate-impacts and adaptation research.

8.6.4 Dialogue with the financial sector

One of the emphases of the Federal Government's climate policy is to develop financing options and investment strategies for addressing climate change and for tapping into potential markets. To this end, the BMBF has approached financial-industry partners in an effort to stimulate investments in resources efficiency and energy efficiency, in further development of renewable energy sources and in adaptation measures.

In 2007, banks, re-insurers and investors in Germany established the "Climate Change Finance Forum". In the same context, a programme of work was developed, in co-operation with the BMBF and the "Sustainable Business Institute" at the European Business School (EBS) in Oestrich-Winkel. That programme of work has the following emphases:

1. Information systems relative to climate trends and weather extremes
2. Market-oriented information systems
3. Economic analyses
4. Methods development
5. Co-operation between investors and innovators
6. Best practice

The programme is designed to structure the Finance Forum's work process and to develop and support innovation-policy dialogue between the financial sector, the real economy and the Federal Government. In the process, the financial sector is to be enabled to adjust to climate change and to make its own contribution to implementation of climate protection and adaptation strategies.

8.6.5 Economic aspects of climate change

Research into the economic impacts of climate change, and into the economic conditions under which instruments and measures for climate protection are effective, is also being expanded in the framework of the BMBF's research support. For purposes of assessing the effects of climate protection / adaptation instruments and measures, instruments are to be developed, and improved, for assessing the opportunities and risks for individual sectors and economic areas, economies and global value chains. A pertinent announcement is currently being prepared and is to be issued in the second half of 2009.

The concept currently includes the following topic areas:

- Economic consequences of climate change
- Industrial commitments to climate protection and adaptation
- Climate policy: Design and effects

This measure is designed to provide a scientific foundation for robust avoidance and adaptation strategies and to make it possible to harmonise the Federal Government's climate-policy objectives with economic aspects such as competitiveness, prosperity and growth.

8.6.6 Social-ecological research

The primary aim of the funding priority "Social-ecological Research" is to develop, in co-operation with various societal stakeholders, strategies and options for implementing the National Sustainability Strategy. In the process, it focuses on problems that arise in humans' relationships to their natural and social environments. The possibilities for shaping and structuring such relationships are being studied from an interdisciplinary perspective. In this work, findings relative to the social dimension of sustainability (i.e. values, interests and options of involved stakeholders) are placed on an equal footing with scientific findings.

A number of topic priorities with climate-relevant projects have been completed. Current efforts include:

- Projects within the topic priorities "From knowledge to action – new ways to sustainable consumption" ("Vom Wissen zum Handeln – Neue Wege zum nachhaltigen Konsum") and
- Announcements from spring 2009 relative to the areas of the "social dimensions of climate protection and climate change" and "economics for sustainability".

Since spring 2008, six collaborative research projects with direct relevance to energy / climate are being funded, with a total funding volume of EUR 5.4 million, within the topic area "**From knowledge to action – new ways to sustainable consumption"**. These projects are focussed on the following issues:

- Development of policy instruments for promoting electricity saving,
- Study of obstacles that make it difficult for consumers to behave in climate-friendly ways,
- Development of feedback instruments that promote sustainable electricity consumption via intelligent metres,
- Development of an integrated policy and consultation approach relative to energy-oriented building modernisations,
- Analysis of households' choices relative to sustainable energy consumption in residential buildings
- Analysis of changes in user behaviour in public buildings
- Development of an interventional instrument for promoting energy-efficient user behaviour

In spring 2009, an announcement was published, in the framework of social-ecological research, in the area of **"The social dimensions of climate protection and climate change"**. The central focuses of this effort include enhancing understanding of the social factors and impacts connected with climate change. In addition, it is aimed at supporting design of climate protection and adaptation measures that avoids exclusion and promotes acceptance. The funding initiative is explicitly aimed at strengthening capacities in the social sciences and humanities with regard to climate research.

In the framework of the funding priority "**Economics for Sustainability"**, since 2006 economic research projects have been supported that can contribute, scientifically and effectively, to specification, refinement and implementation of sustainability concepts. With their expertise in issues of evaluation, and in analysis of innovation

processes and of efficient institutions, the economic sciences make valuable contributions to the Federal Government's sustainability strategy, thereby usefully complementing relevant environmental-technological and social-ecological research.

Currently, on the basis of a first announcement, a total of 8 joint research groups and 8 individual projects are being funded, with a funding volume of EUR 7.4 million, in which strategies for sustainable development are being designed from an economic perspective. In part, these strategies are oriented directly to the topic area "climate and energy". Relevant examples include: a) Development of an integrated assessment, allocation and optimisation model for national emissions management; b) Derivation of climate policy recommendations via analysis of long-term investment decisions in the electricity sector; and c) Assessment of the potential of, and limits to, bioenergy within a sustainable energy concept.

A second announcement of spring 2009 is aimed at further, concrete development of existing economic research approaches in the area of sustainability, on the basis of predefined minimum methodological standards, to yield a theoretically and empirically founded system of sustainability economics. The thematic focus for the announcement consists of issues of differentiation, of new forms of control in the relationship between markets and the policy sector, of the social dimension of sustainability and of intragenerational and intergenerational fairness.

8.6.7 Measures in the BMU's departmental research (environmental research plan)

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) requires scientific foundations and aids for its decision-making in implementation of its environmental policy objectives. From 2006 to 2009, numerous research projects were initiated in the framework of the ministry's environmental research plan. All in all, 48 projects are being funded in the area of climate research (reduction measures and technologies), with a total funding volume of about EUR 7.5 million. Among these are:

- Instruments for achieving thrifty, efficient energy use and for increasing the market shares for renewable energies in developing and threshold countries; sample cases with respect to the UN's handling of the topic of energy (CSD); Project volume, EUR 95,000;
- Climate regime options as of 2012: Potential for reduction of global greenhouse-gas emissions: Analysis and evaluation of potential for reductions for achieving the 2°C target, with respect to environmental effectiveness, costs and institutional aspects;
- Sectoral emissions-reduction approaches, as a participation option for threshold countries in a climate regime after 2012.

8.6.8 Institute for Advanced Sustainability Studies (IASS)

On the basis of recommendations made at "Global Sustainability – a Nobel Cause", a Nobel-laureates' symposium held in Potsdam, of the results of the Federal Government's Climate Research Summit, as set forth in the High-Tech Strategy on Climate Protection, and of a resulting proposal of the Alliance of German Science Organisations, the BMBF and the State of Brandenburg are supporting the establishment of an interdisciplinary institute, the Institute for Advanced Sustainability

Studies (IASS), in Potsdam, for research into the areas of climate, the earth system and sustainability.

The founding director of the new institute is Prof. Klaus Töpfer. The IASS provides an environment that facilitates cutting-edge research for addressing climate change, for obtaining a better understanding of the Earth System and for initiating sustainable development. The IASS invites outstanding scientists from throughout the world, ranging from promising young scientists to Nobel laureates, to reside as "fellows" for a limited period at the IASS and take part in cutting-edge interdisciplinary encounters and joint scientific work. The IASS seeks to build bridges between scientists and stakeholders in the areas of policy, industry and society, thereby advancing the society's understanding of the possibilities and necessary measures for managing global climate change.

The IASS' start-up phase, within the framework of joint project support by the Federal Government and the State of Brandenburg, begins in spring 2009. The first fellows will take up their work in fall 2009.

8.7 International co-operation

Research cannot function solely on a national level. Climate research and climate policy provide probably the best indications that research frameworks cannot be defined solely on a national level. The Federal Government thus expressly upholds the principle that acceptance of global responsibility is a necessary basis for achieving the ideal of sustainable development.

At the same time, Germany will continue to have to orient itself in light of the excellent research centres in the U.S. and Japan, and with respect to its European partners. Germany will need to also forge and expand research alliances even further afield, however, if it is to play a role in solving global problems.

8.7.1 (Dialogue for Sustainability [D4S]

German research and technology can contribute significantly to solutions for global challenges. To develop successful solution concepts, it must work jointly with developing and threshold countries. Developing and threshold countries have been growing their scientific competence and expertise. They play a decisive role in efforts to address global challenges – climate change, environmental destruction, water scarcities, energy and other finite resources (such as raw materials and biodiversity). Scientific co-operation can help solve local problems in other countries. At the same time, it can develop growing markets for German industry.

For this reason, the BMBF has acted, in co-operation with the BRICS countries (Brazil, Russia, India, China, South Africa), to develop the "Dialogue for Sustainability [D4S]". The dialogue is being structured in accordance with resolutions taken by the G8 summit at Heiligendamm in 2007. As a result, it is oriented to central issues such as socially oriented structuring of globalisation, and innovation and energy efficiency for reducing CO_2 emissions.

The "D4S" is also contributing significantly to implementation of the Federal Government's strategy for internationalisation of science and research (February 2008). The D4S takes a cross-cutting approach to priority topic areas and focuses on the following aims:

1. Reinforcing research co-operation with the world's best,
2. Developing innovation potential internationally,
3. Strengthening education and R&D co-operation with developing countries, in lasting ways,
4. Taking on international responsibility, and tackling global challenges.

The concrete strategic aims of the "D4S" include:

- Strengthening bilateral scientific-technological co-operation, in sustainability-relevant topic areas, with the BRICS countries;
- Helping to structure international research agendas (G8+5) by adding new topics;
- Implementing jointly designed research and development projects and disseminating the relevant findings.

The first central results that have been achieved include the following:

- "Joint Declarations" were concluded, at the ministerial level, with India, South Africa, Brazil and China (an agreement with Russia is slated for fall 2009).
- Bilateral agreements for implementing concrete research and technology co-operation were signed or prepared.
- The dialogue is visibly enhancing Germany's presence in important, emerging knowledge and growth markets: Conference series with Brazil, India and South Africa have already begun (and such series with Russia and China are being planned).

8.7.2 International Climate Initiative

In the framework of the International Climate Initiative, since 2008 the BMU has supported climate protection projects in developing, threshold and transformation countries. In the process, both projects for emissions reduction (mitigation) and for adaptation to the impacts of climate change are being supported. The Climate Initiative is being funded with proceeds from sale of emissions allowances. A total of EUR 120 million are available annually. The emphases of support via the International Climate Initiative include:

- Structural change for a sustainable energy supply (especially renewable energies and energy efficiency)
- Adaptation to the impacts of climate change
- Protection of natural habitats and carbon sinks, and
- Advising of policy-makers, and capacity building.

In 2008, when the structures for the International Climate Initiative were established, a total of 98 projects, in nearly 50 countries, were selected and funded. For these projects, most of which are multi-year projects, the BMU has committed funding of about EUR 175 million.

The funded projects are aimed at improving structures and capacities in the target regions. They are also designed to serve as good-practice examples, with transferable, externally useful results. An overarching aim is to use pilot projects to illustrate how national energy and climate policies can be designed in sustainable ways.

In addition, the BMU is seeking to use the International Climate Initiative to provide new impetus for international climate negotiations. This is achieved by providing efficient support, for partner countries, that encourages such countries to make their own contributions in the framework of a climate agreement. In addition, the globally unprecedented mechanism for financing the Climate Initiative – use of proceeds from sale of emissions allowances – can serve as a model for innovative financing strategies for the future climate protection regime.

8.7.3 The BMBF funding priority "Research for the Sustainable Development of the Megacities of Tomorrow"

Cities take up 2% of the earth's land-surface area. At the same time, they are responsible for three-fourths of global energy consumption and fossil-fuel requirements. Cities produce about 78% of global CO_2 emissions and 85% of total anthropogenenic greenhouse-gas emissions. According to estimates of the World Bank, cities will account for 80% of the future growth of developing and threshold countries. Companies and city dwellers alike can profit from such growth. On the other hand, such growth presents challenges: Cities have to provide infrastructure (such as housing, transport, energy, water, etc.) and social services (such as health-care, schools, work, etc.). Such infrastructure and services have to be maintained, added and financed.

The BMBF funding priority "Research for the Sustainable Development of the Megacities of Tomorrow" is focussed on the topic of "energy-efficient and climate-efficient structures in urban growth centres". It is designed to show that economic growth and climate protection are not mutually exclusive. In addition, the priority is helping to gradually bring developing and threshold countries into international climate protection efforts.

The relevant approach is not oriented to isolated, individual problems. Instead, it is comprehensive, action-oriented and requirements-oriented. Via a rounded concept, with a long-term focus, interdisciplinary studies are looking at the ecological, economic and social aspects of the development of energy-efficient and climate-efficient structures in urban growth centres.

A total of ten bilateral trans-disciplinary research teams are working for Lima (Peru), Casablanca (Morocco), Addis Abeba (Ethiopien), Gauteng (South Africa), Tehran/ Karaj/Hashtgerd (Iran), Hyderabad (India), Ho Chi Minh City (Vietnam) and Urumqi, Shanghai/Fengxian and Hefei (China). These teams are developing strategies and implementation for mitigation and adaptation in the following areas: Water-resources management, transport/mobility, energy supply/energy management, construction/housing/city planning, waste management, urban agriculture and resources conservation. Overall, they are seeking to provide well-adapted technologies.

8.7.4 "Renewable Energies Export Initiative"

With its "Renewable Energies Export Initiative", the BMWi is supporting export of technologies for use of renewable energies. This effort is helping to speed use of, and international market penetration of, innovative technologies in the area of energy efficiency and renewable energies. In the interest of developing new opportunities for sales, supply, co-operation and investments, support is focussed especially on information and consultation measures, as well as on measures for initiation of contacts, and preparation of business, with foreign companies in the renewable energies sector. Such activities include provision of information about target markets, informational events, joint stands at foreign exhibitions, selective business travel abroad and co-operation events with foreign companies in Germany. The support is aimed at small and medium-sized producers and sellers of plants, equipment and services in the area of renewable energies.

8.7.5 Integration of research activities within international programmes

Germany, and especially the **DWD, the country's national meteorological service**, supports important international programmes for the international climate monitoring system: GCOS (GSN with pertinent Monitoring Centre, GUAN and GRUAN lead centre); GOOS and programmes of WMO Global Atmosphere Watch (GAW Global Station Zugspitze-Hohenpeißenberg, in co-operation with the Federal Environment Agency); the Baseline Surface Radiation Network (BSRN); the Global Collecting Centre for marine observations (GCC) of the Marine Climatological Summaries Scheme (MCSS); and projects of the World Climate Research Programme (WCRP), such as the Global Energy and Water Cycle Experiment (GEWEX). Its support includes active contributions (Global Precipitation Climatology Centre (GPCC), GEWEX Water Vapour Project (GVaP), GEWEX Atmospheric Boundary Layer Studies (GABLS), Co-ordinated Energy and Water Cycle Observation Programme (CEOP)).

Since 1989, the Global Precipitation Climatology Centre (GPCC), sited within the DWD, and the Global Runoff Data Centre (GRDC), within the Federal Institute of Hydrology (BfG), have made German contributions to international climate research, in the WCRP context, and to global climate monitoring, in the GCOS context. In co-operation with other European national meteorological services, the DWD is establishing a Regional Climate Centre (RCC) for Regional Association VI of the WMO (the DWD is managing the effort).

The **BMBF supports integration of German global-change research** in international programmes, thereby enabling participating scientists to participate and contribute at the national level and in organisation of relevant international co-operation.

- The funded institutions include the international secretariats of IHDP, IGBP (Stockholm) and DIVERSITAS (Paris), the secretariat of the ESSP Global Water Systems Project and the START secretariat in the U.S..
- The German IPCC Contact Point, established by the BMBF and the BMU, helps to ensure that results of German climate research enter into the IPCC process and into the Fifth Assessment Report. The work of Prof. Dr. Ottmar Edenhofer, Co-Chair of Working Group III of the IPCC, is supported via a funded "Technical Support Unit" located at the Potsdam Institute for Climate Impact Research (PIK).
- The BMBF has provided a total of EUR 2.5 million for development of the United Nations University Institute for Environment and Human Security (UNU-EHS), which was founded in 2003 in Bonn. UNU-EHS is one of the United Nations University's 13 research and education centres around the world.

8.8 The institutional research sector

Germany's weather and climate research sector is well-developed. In it, a broad range of research institutions has long been carrying out internationally outstanding work. For example, the DWD's globally unparalleled long measurement series, along with complete-coverage information derived from them, were able to provide indications of climate change at an early stage. Climate research, at the top international level, is being pursued at over ten university institutions; in the Max Planck Institutes for Meteorology (Hamburg), Biogeochemistry (Jena) and Chemistry

(Mainz); at various centres of the Helmholtz Association (HGF) and at institutes of the Gottfried Wilhelm Leibniz Science Association (WGL); and with the help of the German High Performance Computing Centre for Climate- and Earth System Research (DKRZ).

Current efforts call for non-university research institutions for which the Federal Government provides institution financing or co-financing (HGF, MPG, FhG, WGL) to be integrated even more strongly in research policy co-operation with research funding organisations. In addition, such institutions' co-operation with higher education institutions is to be promoted. For example, project-funded activities are to be complemented by institutionally funded, programme-oriented research of the HGF.

A number of **Helmholtz Centres** are contributing expertise to the HGF's "Earth and Environment" research field, which is of relevance in the present context:

- Alfred Wegener Institute for Polar and Marine Research (AWI)
- German Aerospace Center (DLR)
- Jülich Research Centre (FZJ)
- Karlsruhe Research Centre (FZK)
- German Research Centre for Biotechnology (GBF)
- German Research Centre for Geosciences (GFZ)
- GKSS Research Centre in Geesthacht (GKSS)
- GSF National Research Centre for Environment and Health (GSF)
- UFZ Centre for Environmental Research, Leipzig-Halle (UFZ).

The **HGF research field "Earth and Environment"** is divided into six programmes of relevance to the topic of climate change:

- Geosystem: The Changing Earth (co-ordination: GFZ)
- Atmosphere and Climate (co-ordination: FZK)
- Marine, Coastal and Polar Systems (co-ordination: AWI [coastal: GKSS])
- Biogeosystems: Dynamics, Adaptation and Adjustment (co-ordination: FZJ)
- Sustainable use of landscapes (co-ordination: UFZ)
- Sustainable Development and Technology (co-ordination: FZK)

The HGF "Atmosphere and Climate" programme comprises studies of the complex interactions in the atmosphere and of atmospheric processes of exchange with other geo-compartiments; relevant tasks in this area include organisation of large field experiments (including planning and operation of the scientific infrastructure), operation of atmospheric simulation chambres and research aircraft and planning and execution of satellite experiments.

In its climate-relevant sections, the HGF "Geosystem: The Changing Earth" programme contributes to understanding of climate variability and of climate-relevant substance cycles; its tasks include explanation and modelling of relevant geoprocesses, monitoring of status and trends (including paleoclimatology) and using large-scale scientific infrastructure for earth observation (via international co-operation).

The HGF programme "Marine, Coastal and Polar Systems" comprises (inter alia) studies of the seas' influence on climate and of the influence of climate change on coastal regions. The HGF programme "Sustainable Use of Landscapes" is concerned, inter alia, with the topic "consequences of climate change for land use".

Activities within the framework programme are linked with the HGF's programme-oriented research, especially with the programme areas "Earth and Environment", "Energy" and "Key Technologies", in such a manner that the HGF is able to contribute infrastructure services and long-term and broadly based studies.

A number of other institutes in the **Gottfried Wilhelm Leibniz Science Association (WGL)** also enrich the German climate research sector with their expertise:

- Institute of Atmospheric Physics (IAP), Kühlungsborn: Physics of the middle and upper atmosphere
- Institute of Marine Sciences (IFM-GEOMAR), Kiel: Ocean circulation and climate dynamics, marine biogeochemistry, marine ecology
- Institute for Tropospheric Research (IfT), Leipzig: Tropospheric research, transformations of trace substances, atmospheric substance exchanges, aerosol interactions with clouds and radiation
- Institute for Baltic Sea Research Warnemünde (IOW): Baltic Sea research, transport and transformation processes in the sea, marine communities and substance cycles, changes in marine ecosystems
- Potsdam Institute for Climate Impact Research (PIK): Climate impact research, systems analysis, global change and natural systems, global change and social systems
- Centre for Agricultural Landscape and Land Use Research (ZALF), Müncheberg: Agricultural and landscape research.

The **Fraunhofer-Gesellschaft (FhG)** conducts research in all fields of engineering. It co-operates closely with industry with regard to applications. The FhG contributes to efforts to mitigate climate change and its impacts primarily via work toward conversion of the energy sector. The key topics for the "Fraunhofer Energy Alliance" include development of efficiency technologies, use of renewable energies and, recently, technical preparations for greater use of electromobility. In addition, that group, consisting of 13 institutes, studies topics in the areas of buildings, intelligent energy networks, storage technology and microenergy technology. The members include the following Fraunhofer institutes:

- Building Physics (IBP), Stuttgart
- Chemical Technology (ICT), Pfinztal
- Factory Operation and Automation (IFF), Magdeburg
- Interfacial Engineering and Biotechnology (IGB), Stuttgart
- Integrated Circuits (IIS), Erlangen
- Systems and Device Technology (IISB), Erlangen
- Information and Data Processing (IITB), Karlsruhe
- Ceramic Technologies and Systems (IKTS), Dresden
- Silicate Research (ISC), Würzburg

- Silicon Technology (ISIT), Itzehoe
- Solar Energy Systems (ISE), Freiburg
- System and Innovation Research (ISI), Karlsruhe
- Environmental, Safety and Energy Technology (UMSICHT), Oberhausen

Currently, **departmental research of the BMELV** is carrying out some 70 research projects that are directly contributing to the topic area "climate protection and adaptation to climate change" (for a detailed description, cf. Chap. VIII 1.4). The following federal research institutes, and their own institutes, are worthy of being highlighted in this context:

Johann Heinrich von Thünen Institute (vTI; Federal Research Institute for Rural Areas, Forestry and Fisheries)

- Institute of Agricultural Climate Research
- Institute of Agricultural Technology and Biosystems Engineering
- Institute of Biodiversity
- Institute of Wood Technology and Wood Biology
- Institute of Rural Studies
- Institute of Sea Fisheries
- Institute of Forest Ecology and Forest Inventory

Julius Kühn Institute (JKI; Federal Research Centre for Cultivated Plants)

- Institut für Pflanzenbau und Bodenkunde (Institute of Plant Cultivation and Soil Science)
- Institut für Züchtungsforschung an landwirtschaftlichen Kulturen (Institute of Breeding Research with Agricultural Crops)

In addition, the BMELV's departmental research is currently carrying out some 60 additional research projects in which climate protection or adaptation to climate change are treated as (important) sub-aspects. Such projects are in progress at the aforementioned research institutes, and at the Friedrich Loeffler Institute, Federal Research Institute for Animal Health (FLI), the Max Rubner Institute, Federal Research Institute of Nutrition and Food (MRI) and the economic institutes of the vTI.

Among the **departmental research institutions of the BMWi** that engage in environmental and climate research, the following are worthy of special mention in the present context:

- the Federal Institute for Geosciences and Natural Resources (BGR; www.bgr.bund.de), the ministry's centre of excellence for geosciences, and
- Geologischer Dienst des Bundes (Federal geological service).

The BGR's core topics include energy resources, mineral resources, groundwater, soil and subsoil (with regard to storage and industry applications). Within these core areas, it also concerns itself with climate-relevant topics, such as CO_2 storage, polar research, and climate impacts on groundwater and soil.

9 Education, training and efforts to promote public awareness

9.1 Public awareness efforts of the Federal Environment Agency

The following section provides information about selected projects of the Federal Environment Agency, in the areas of education, training and efforts to promote public awareness, that directly or indirectly use the topic of climate protection as an example.

The included projects either have been designed by the Federal Environment Agency's own specialised units (at their own initiative) or have been carried out within the last 4 years in the framework of the Agency's R&D research plan or efforts to promote relevant associations.

In recent years, the Agency has expanded its available range of media-based information with regard to climate protection.

The Internet portal http://www.umweltbundesamt.de/klimaschutz/index.htm provides a wide range of information about climate change and climate policy:

- Numerous brochures and background papers on selected topics describe the latest relevant scientific findings and the current status of climate policy. Concise and clearly written, they are well suited as information for a general audience.
- A discussion platform that examines skeptics' common arguments and holds them up for comment by experts from various climate science fields. With its answers to frequently asked questions, this discussion platform is especially suited for readers with an interest in climate protection.
- Presentation of current research findings, in part with explanatory graphics.

The Agency has set up a separate Web page for the Competence Centre on Climate Impacts and Adaptation (KomPass); this of course also provides information abut climate impacts and adaptation: http://www.anpassung.net/cln_117/sid_58D8774E3403DC7FF620A6740C8444E1/DE/Home/homepage__node.html?__nnn=true .

The Federal Environment Agency has carried out various projects in the framework of its support for relevant associations. The following is mentioned because of its special public impacts:

In the project "Informationsarbeit zu Klimawissenschaft" ("Information about climate science"; FKZ 685 04), carried out from 2007 to 2008, Germanwatch provided timely, targeted information about the latest findings of climate science, as presented in the IPCC's Fourth Assessment Report. Throughout the project period, a diverse range of current information was provided to a broad audience in the areas of policy, industry and society.

9.2 General policies relative to education, training and promotion of public awareness

9.2.1 Climate protection as a topic in education for sustainable development

In the 1990s, as the demands of international environmental policy grew, environmental education in Germany developed into "education for sustainable development". With this conceptual development, education is better able to present complex topics such as climate protection. Providing such education calls for scientific and technical expertise, an understanding of relevant economic and social mechanisms and the ability to take the dimension of intragenerational and intergenerational fairness into account in problem-solving.

Many concepts, projects and teaching materials have been developed in the framework of education for sustainable development, and continue to be refined. While such resources can differ widely in terms of their basic thematic approaches, they all tend to share an orientation to the topic of climate protection, especially in connection with renewable energies. Education for sustainable development helps people to view climate protection as a key future issue; to understand pertinent globally networked mechanisms; and to learn about the available options. It is aimed at enabling people to apply such understanding in their various roles – as consumers, as workers and as administrators, etc..

Chapter IX of the present report provides a first overview of selected activities in this area in Germany, with a special focus on the national level. (Any complete survey would be an extremely difficult undertaking in Germany, with its federal system and its many state and non-state stakeholders in formal and non-formal education areas.).

9.3 Education in schools and training programmes

9.3.1 School education

9.3.1.1 Scientific literacy, illustrated with the topic of climate protection

The educational materials relative to the topic of climate protection that are presented at www.bmu.de/bildungsservice also build on the results of this model programme for designing school curricula about sustainability topics. Some of these materials are available in English. Education for sustainable development is important in and of itself. At the same time, such education covers a number of topics – such as climate protection – that provide an outstanding basis for many types of general education. The topic of climate protection is evocative and timely, and it provides an excellent context for teaching technical and scientific skills and building scientific literacy. (Scientific literacy was tested (in 15-year-olds) in the OECD's Programme for International Student Assessment (PISA)). These educational materials on climate protection combine two useful qualities: firstly, they are high-quality, scientifically up-to-date and service-oriented materials for education about climate protection; secondly, they provide examples, ideas and encouragement for ways of using the

topic of climate protection, in the context of education for sustainable development, as part of general education.

9.3.1.2 Online resources provided by the BMU's education service

Using teaching materials of the BMU, and in the framework of the project "Naturwissenschaften entdecken!" ("Discover science!"), the "Schulen ans Netz e.V." ("Schools go online") organisation has developed various interactive learning modules. The materials are designed largely for self-learning. Highly interactive, and with attractive multimedia presentation, the materials encourage users to explore the topic further on their own. Users can place their work results (via drag & drop) in a virtual "backpack" for later reference as necessary. Such aspects encourage users to go over the material repeatedly and deepen their understanding. Users also can easily add their own content (text and images).

In addition, users can save all their work when they complete a learning unit. That way, they can easily pick up later right where they left off. These features are not only useful for learners. They also support teachers in producing individualised learning modules by adding, saving and providing their own exercises and other digital materials. The following modules were produced in 2008/2009: "Patient Weltklima" ("Ailing global climate"), "Superstars der Erneuerbaren Energien" ("Renewable energy superstars"), "Lebensstil und Wasser" ("Lifestyles and water"), "Ein Fluss ist mehr als Wasser" ("A river is more than water"), "Artenvielfalt Weltweit" ("Biodiversity world-wide").

9.3.1.3 Media resources for schools and educational institutions

In 2008, the BMU made the films "Eine unbequeme Wahrheit" ("An Inconvenient Truth"), "Königreich Arktis" ("Arctic Kingdom"(, "Unsere Erde" ("Our earth") and "Über Wasser" ("About water") available to all educational media centres, along with licenses for non-commercial, non-public showings by schools. The films support study and discussion of topics such as climate protection, and they complement the broad range of educational materials provided by the ministry. Supporting teaching materials for classroom instruction were prepared for all films. They can be downloaded free of charge in the Internet.

9.3.1.4 The action programme "Climate protection in schools and educational institutions"

In December 2008, the BMU launched its largest climate-protection-promotion programme to date for schools and educational institutions. The BMU's programmes for the education sector are aimed at enhancing awareness about climate change on the part of teachers and pupils alike. They are also designed to teach, to motivate (for participation in solutions) and to encourage schools and educational institutions to develop their own significant potential for reducing CO_2 emissions.

Via the budget item "Klimaschutzschule" ("climate protection in schools"), the BMU provides over EUR 3.4 million to schools, from funding for the National Climate Initiative, to promote ideas and projects that contribute to CO_2-emissions reduction. According to calculations of the German Energy Agency (dena), Germany's 34,000 schools use up to 70 percent more energy than comparable municipal buildings use.

For this reason, the BMU has made a point of including schools and educational institutions in the National Climate Initiative.

9.3.1.5 "Aktion Klima!"

The "Aktion Klima!" ("Climate campaign!") programme of the organisation BildungsCent e.V. is the first of three support programmes. The aim: to reduce schools' CO_2 emissions by having their teachers and pupils change a number of everyday habits. Under the programme, up to 1,000 schools can receive up to EUR 500 in support. The programme also provides free "climate protection cases", with energy measuring devices and teaching materials, and "school-garden boxes" with supporting materials. On online climate protection handbook is available to help students and teachers prepare "project days".

Plans in the context of "Aktion Klima!" call for preparation of a self-learning module for teachers, covering the topic of emission trading. The module features an overview text with which teachers can quickly acquaint themselves about the subject.

9.3.1.6 "Solarsupport"

The "Solarsupport" ("solar support") project of the Independent Institute for Environmental Concerns (UfU) is designed to make renewable energies "visible". Its aim is to equip 400 solar systems in place at German schools with visualisation equipment, data loggers and weather stations. The idea behind the project is that public display and storage of energy data for their schools' own systems, along with provision of suitable teaching materials, will motivate teachers to bring the topics of climate protection and renewable energies into their classrooms.

The data loggers and weather stations help to make students more aware of the systems. Suitable materials on the topic of "weather" are available for all types of schools and all grade levels. The project, which facilitates use of weather data in the classroom, is designed to interest students in weather and climate – and, thus, in the topic of climate change. In an added touch, energy yields of all participating schools are entered into an atlas of climate protection at schools.

9.3.1.7 "Energy savings account for schools"

The "Energiesparkonto für Schulen" ("Energy savings account for schools"), a project of co2online gGmbH, makes energy and water consumption visible, thereby making it easier to lower costs for heat, electricity and water. It provides forecasts of a school's pertinent expenditures in the coming months and years. At the same time, it shows how much energy was saved in the past year and how much CO_2 was avoided. It also provides information about energy-price changes and their impacts. The "Energiesparkonto für Schulen" project will be published at www.energiesparkonto.de at the end of 2009. A version of the energy-saving account is also available for private households.

9.3.1.8 Vocational training

Vocational training plays a special role in promoting climate protection as a part of sustainable development. For many young people, vocational training proves to be a final opportunity to engage in systematic learning. In such learning, they prepare for their working lives in areas such as production, logistics and administration – and, ultimately, for their roles as consumers in their private lives.

The Federal Government has initiated and financed an extensive series of stakeholder conferences in this context. For both specific occupations and for the relevant workplace as a whole, such conferences have defined the competencies young people need to acquire to become part of a sustainable economy. For example, specialised conferences on the topic of "training and renewable energies" were held in September 2007 and June 2008. Such efforts contribute significantly to climate protection.

Integration of such content within training regulations, which are the basis for in-company vocational training, is an important ongoing task. Training in the areas of sustainable development and climate protection has already been made a standard part of training for a number of new and newly structured occupations.

In addition, for a number of years the BMU has promoted various projects concerned with aspects of education, training and qualification relative to renewable energies.

9.3.1.9 Wissenschaftsladen Bonn e. V.: "Work and Training for Renewable Energies"

Market segments for renewable energies have been experiencing strong employment growth. According to estimates, the sector could have up to 500,000 jobs in 2020 and up to 710,000 jobs in 2030. A 2007 status report prepared by Wissenschaftsladen Bonn, with the financial support of the BMU, on "Ausbildung und Arbeit für Erneuerbare Energien" ("Training and Work for Renewable Energies") presents companies' growth expectations for the sector (cf. http://www.jobmotor-erneuerbare.de/download/Statusbericht-AA-EE.pdf).

At the same time, many companies expect a growing imbalance between job growth and availability of suitable specialists. In some employment segments, so the expectations, it may prove difficult to fill the many new jobs with qualified specialists. Wissenschaftsladen Bonn e. V. monitors the labour market by tracking visible job growth via empirical surveys of job advertisements / announcements in newspapers and online resources. Information about the 2007 status report "Training and Work for Renewable Energies", about a renewable energies job and education fair, about overviews of relevant study programmes and certified further training in the renewable energies sector and about labour-market monitoring in the period 2006 – 2008 is available at: www.jobmotor-erneuerbare.de.

9.3.1.10 Jugendwerkstatt Felsberg e. V. – information campaign about renewable energies in crafts: Hotline for further training for crafts – renewable energies

Via a telephone hotline and e-mail, this efforts answers queries regarding further training in the area of renewable energy technologies. It is aimed at the crafts sector, since solar, wood and wind energy are growth areas that need workers from the crafts sector.

The renewable energies sector has been needing more and more workers. The hotline was thus established to offer people in the crafts sector (either self-employed or not) independent information about further training opportunities in the area of renewable energy technologies. (Cf. www.EnergiederkurzenWege.de).

9.3.1.11 Natur und Umwelt GmbH: "Trainees full of energy"

The model project "Azubis voller Energie" ("Trainees full of energy"), which was completed in May 2008, was aimed at interesting trainees in the renewable energies

sector. Persons who undergo the dual system of vocational training normally have little or no contact, in their training, with the topics of environmental protection / sustainability. The model project thus provided a framework in which trainees could undertake their own environmental protection activities in their companies.

In the project, trainees from various firms were brought into contact with trainees from the renewable energies sector. Project groups were then formed in which trainees reviewed their own companies with regard to energy efficiency measures and use of renewable energies. The overall aim of the effort was for trainees to analyse the potential for saving energy in their own companies and to prepare proposals for relevant measures.

The model project proved especially successful in that not only did the project teams all prepare proposals and measures, in many cases the proposals and measures were actually implemented.

9.4 Efforts to promote public awareness, including campaigns

9.4.1 Climate protection campaign

Since 2006, the BMU has repeatedly conducted advertising campaigns and issued publications about climate protection. Examples include the 2006/2007 advertising campaign "Klimaschutz beschäftigt uns" ("Climate protection concerns (employs) us") and the magazine "Ohne Eis kein Eisbär" ("Where there is no ice, there are no polar bears"), which appeared in May 2007. The issue of climate change also played an important role in the context of the 2007/2008 campaign on biological diversity (a pertinent UN conference was held in May 2008 in Bonn). In January 2009, the third edition of the brochure "Klimaschutz lohnt sich" ("Climate Protection Pays Off"; also available in English) appeared. The campaign "www.mein-umweltblog.de", conducted in 2008/2009, was aimed at the web 2.0 community. In addition, the Web site www.bmu.de/klimaschutz is continually being updated.

During the 2008 Christmas shopping season, the BMU conducted a broad-based campaign that urged consumers to purchase energy-efficient home appliances: "Schlauer schenken und Geld sparen" ("Give wisely and save money"), conducted in co-operation with the German Energy Agency, consumer organisations and Stiftung Warentest.

Since 2009, the BMU, working in the framework of the Climate Initiative (which is funded with proceeds from sale of emission allowances), has supported various relevant public awareness measures – including a Web site for the Climate Initiative.

9.4.1.1 Act on the Promotion of Renewable Energies in the Heat Sector (EEWärmeG)

Since January 2009, the "Act on the Promotion of Renewable Energies in the Heat Sector" ("Erneuerbare-Energien-Wärmegesetz") has been in force in the Federal Republic of Germany. This Act requires owners of new buildings to rely on renewable energies for specified shares of their heating needs. Via an information campaign, including advertising banners, advertisements in newspapers and industry publications and a special Web site, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) informed citizens about the Act's provisions and about the many support opportunities available for use of solar-thermal systems, pellet-fired heating systems and heat pumps.

The aim behind the Act is for renewable energies' share of Germany's heat supply to climb to 14 percent by 2020 (the current level is seven percent). The Web site www.waerme-mit-zukunft.de provides information about the provisions of the "Act on the Promotion of Renewable Energies in the Heat Sector" and about the attractive relevant support opportunities available.

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