First Report
of the Government
of the
Federal Republic of Germany
Pursuant to the United Nations
Framework Convention on Climate Change

Foreword

Responsible, precautionary climate protection is one of the greatest environmental policy challenges. This challenge will remain with us into the next century and beyond. Both national and international action is required if it is to be met. And every person must do his or her part in daily life.

If efforts to initiate effective measures, at all levels, are unsuccessful, considerable consequences must be expected - including an increase in average global air temperature, a rise in sea levels, shifting of climatic and vegetation zones and worsening of the world food situation.

Against this backdrop, the Framework Convention on Climate Change was signed by over 150 countries at the UN Conference for Environment and Development (UNCED), which was held in 1992 in Rio de Janeiro. Since then, it has been ratified by 92 countries and by the European Union. The Federal Republic of Germany submitted its ratification declaration to the United Nations on 9 December, 1993. On 21 March, 1994, the Convention came into force. With this agreement, the community of nations has taken a significant step towards fulfillment of its responsibility.

The present report is the Federal Government's first report in this context following the Framework Convention on Climate Change. In August 1993, a preliminary report, "Climate Protection in Germany - National Report of the Federal Government for the Federal Republic of Germany in anticipation of Article 12 of the United Nations Framework Convention on Climate Change", was presented. For the present report, that preliminary report has been updated, substantially revised and expanded.

A central feature of this report is a current inventory of emissions of climate-relevant greenhouse gases, including binding in reservoirs (forests), a description of possible consequences of climate change and a comprehensive presentation of the Federal Government's precautionary climate-protection policy. Further information on reduction of CO_2 and other greenhouse gases can be found in the "Third report of the CO_2-reduction Interministerial Working Group", which will also appear in the "Environmental Policy" series in summer 1994.

A particular difficulty in preparing this report has been that the two parts of Germany belonged to two different political blocs, until they were unified on 3 October, 1990. Consequently, the data in many areas cannot be compared; where it is not comparable, it has been presented separately - even for the period after 1990.

Germany has taken on particular responsibility as sponsor of the First Conference of the Parties to the Framework Convention on Climate Change, which will take place in Berlin from 28 March to 7 April, 1995. During this conference, we plan to urge that the Framework Convention on Climate Change be further developed and implemented.

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SUMMARY

The United Nations Framework Convention on Climate Change provides an internationally binding basis for combatting the anthropogenic greenhouse effect. With this first report of the Federal Government to the Conference of the Parties, Germany has fulfilled its obligation pursuant to the Framework Convention's Article 12.

In August 1993, a preliminary report was presented entitled "Climate Protection in Germany - National Report of the Federal Government for the Federal Republic of Germany in anticipation of Article 12 of the United Nations Framework Convention on Climate Change". The present report is an updated, substantially revised and expanded version of that preliminary report.

Until their unification on 3 October, 1990, the two parts of Germany belonged to two different political blocs; this added to the difficulty of preparing this report. As a result of the long separation, data in many areas is not comparable; where this is the case, the data has been presented separately - even for the period after 1990.

I. Inventories of anthropogenic emissions and binding in reservoirs and by sinks

Anthropogenic emissions

Table I provides a summary of emissions of the most important greenhouse gases (with the exception of chlorofluorocarbons (CFCs), chlorocarbons (CCs) and halons) in Germany in 1990.

Tab. I: Summary of emissions of greenhouse gases in Germany in 1990

Sources and sinks of greenhouse gases	CO_2 Mt/a		CH_4 kt/a		N_2O kt/a		NO_x as NO_2 kt/a		CO kt/a		NMVOC not including CFCs/CCs kt/a	
Total emissions	1 012		6 218		223		2 944		10 768		2 978	
	709	303	5 015	1 203	183	40	2 377	566	7 131	3 637	2 234	744
1.Energy-related	983		1 767		33		2 923		10 104		1 679	
	687	296	1 574	193	24	9	2 361	561	6 526	3 578	1 093	586
2.Industrial processes	29		11		100		21		664		129	
	22	7	9	2	95	5	16	5	605	59	111	18
3.Use of solvents and products					6						1 170	
					5	1					1 030	140
4.Agriculture			2 043		80		n.a.		n.a.		n.a.	

			1 497	546	55	25	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
5.Land use changes and forestry[1)]	(- 20)											
	(- 14)	(- 6)										
6. Waste management	n.a.		2 397		4		n.a.		n.a.		n.a.	
	n.a.	n.a.	1 935	462	4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

High-seas bunkering[1)]	8		0		n.a.		155		37		16	
	7	1	0	0	n.a.	n.a.	128	27	31	7	13	3
International air transport[1)]	11		0		n.a.		50		58		9	
	11	1	0	0	n.a.	n.a.	49	2	54	4	9	1

n.a. Not available

[1)] Not included in total emissions

Source: Federal Environment Agency

Germany	
Former West Germany	Area of the former GDR

The "IPCC Draft Guidelines for National Greenhouse Gas Inventories" were used.

Carbon dioxide (CO_2), methane (CH_4) and laughing gas (N_2O) are directly climate-relevant; nitrogen oxides (NO_x), carbon monoxide (CO) and methane-free volatile organic compounds (NMVOC), on the other hand, have an indirect effect, because they contribute to formation of ozone, which is climate-relevant, in the lower atmosphere (troposphere).

The emissions data for CO_2, NO_x, and CO can be considered well-founded, as can the data for NMVOC, with some exceptions, while the data for CH_4 and, especially, for N_2O, must be considered subject to major uncertainties.

Fig. I shows the development over time, from 1970 to 1993, of CO_2 emissions, pursuant to data from the Federal Environment Agency; Fig. II shows the development of CH_4 emissions from 1970 to 1992. The database that would permit a similar representation for N_2O is lacking.

CO_2 emissions in Germany (not including high-seas bunkering and international air transport) decreased from 1,068 million tonnes in 1987 (the reference year for the Federal Government's CO_2-reduction resolution) to 911 million tonnes in 1993. This corresponds to a 14.7% reduction within this period. In the area of the former

GDR, CO_2 emissions decreased by nearly 50% during this period (the main reasons for this decrease were economic restructuring, a reduction in population size by about 6%, a partial transfer of production to former West Germany, improvements in energy-use efficiency and a decrease in consumption of lignite, which is an intensive source of CO_2 emissions). CO_2 emissions in former West Germany were some 2% higher in 1993 than they were in 1987, but the population in the area of former West Germany also grew by some 7% from 1987 to 1993.

From 1987 to 1993, energy-related per-capita CO_2 emissions in Germany (not including high-seas bunkering and international air transport) decreased from 13.4 to 10.9 tonnes per inhabitant (a decrease of 18.7%). In the area of former West Germany, the decrease over the same period was about 4% (from 11.4 to 10.9 tonnes per inhabitant), while in the area of the former GDR it was about 45% (from 20.5 to 11.2 tonnes per inhabitant).

Methane emissions in Germany decreased by some 12% between 1970 and 1992, to 6,200 kilotonnes per year. In contrast with the decreasing emissions in former West Germany, emissions in the area of the former GDR increased until 1989. This trend was reversed in 1990, however, through a drastic reduction in livestock inventories.

Nitrogen oxide emissions in Germany decreased by some 4% between 1975 and 1991 - to 2,900 kilotonnes per year. Emissions increased until about the mid-1980s; since then, they have been decreasing.

Carbon monoxide emissions decreased relatively constantly from 1975 to 1991, reaching 9,400 kilotonnes per year, for a total decrease of 45%.

Emissions of methane-free volatile organic compounds decreased by about 11% from 1975 to 1991; in 1991 they were 2,850 kilotonnes per year.

Binding in reservoirs and by sinks

The amount of carbon stored in Germany's forests is estimated as being between 1.5 to 2.0 billion tonnes (5.5 to 7.4 billion tonnes of CO_2). The annual carbon-level increase in the existing 10.8 million hectares of forest is some 5.4 million tonnes (some 20 million tonnes of CO_2). This corresponds to an annual increase of carbon stored in forests of about 0.3 to 0.4%. The ability of these reservoirs to store additional carbon ends when forests reach maturity - and thus their maximum biomass levels - however. Currently, it is not possible to estimate when this takes place.

II. Effects of climate change and adaptation measures

Climate-modelling calculations have shown that as a result of the increase of greenhouse gases in the atmosphere, increases in global mean temperature and rises in ocean levels must be expected, along with changes in precipitation distribution and shifts in frequency of extreme weather events. Even if no reliable figures are available concerning the regional climate changes that must be expected, particularly endangered areas can be identified, on the basis of natural and anthropogenic systems' specific sensitivity to climate.

For example, pronounced consequences of the anthropogenic greenhouse effect are to be expected in the earth's semiarid regions, changes which, in particular, could lead to increases in migratory movements.

In Germany, it is mainly natural and near-natural ecosystems that seem threatened, when the country's geographic and climatic conditions are considered. Effects on water resource management and on agriculture and forestry, which are particularly sensitive to climatic influences, have a more direct influence on human living conditions. Considerable uncertainty prevails concerning further economic and social effects of climate change. This uncertainty applies to economic activities (including industry and tourism) and to quality of human life (health, food, housing, etc.)

If only for the reason that a considerable time lag can occur between greenhouse-gas emissions and the effects of climate change, precaution demands that we act, in our own interest and in the interest of future generations - even if not all questions concerning the complex scientific interrelationships, the extent and, especially, the effects of climate change, have been answered. The Federal Government considers measures for reducing emissions of climate-relevant gases to have priority. It is also emphasising research into the consequences of climate change, however, in order to develop effective strategies for adaptation to the effects of such change, which cannot be ruled out, in spite of a wide range of efforts to reduce emissions of greenhouse gases.

III. Programme of measures to reduce emissions of climate-relevant gases and for binding them in reservoirs and by sinks

The Federal Government acted early to develop a comprehensive national climate-protection strategy. The CO_2-reduction programme is the heart of this strategy.

In light of the world-wide discussion concerning the additional, anthropogenic greenhouse effect, and the resulting climate change and effects, the Federal Government is aiming to respond to this global challenge with an ambitious goal for reducing energy-related CO_2 emissions. It has prepared a comprehensive reduction concept whose measures are currently being implemented on a step-by-step basis.

By means of resolutions of 13 June, 1990, 7 November, 1990 and 11 December, 1991, the Federal Cabinet approved a comprehensive CO_2-reduction programme. Its aim in this connection is to reduce CO_2 emissions by 25% to 30% by the year 2005, in relation to the emissions volume in 1987. The Federal Government is aware of the difficulty of achieving this, a difficulty that is also due to the changed global framework. Reduction of other climate-relevant emissions - such as methane (CH_4), nitrous oxide (N_2O), nitrogen oxides (NO_x), carbon monoxide (CO) and methane-free volatile organic compounds (NMVOC) - is also taken into account in the national climate-protection strategy.

Overall, the Federal Government is aiming to achieve a reduction of all climate-relevant emissions - expressed in terms of CO_2 equivalents - on an order of 50% by the year 2005 - in relation to 1987 levels.

With its resolutions to date, the Federal Government has approved a broad catalogue of measures for exploiting the existing potential for reducing emissions of CO_2 and other greenhouse gases in the following areas:

- Private households and small consumers,
- Traffic and transport,
- Industry,
- The energy industry,
- The waste-management sector,
- Agriculture and forestry.

In addition to economic instruments, which have a special role in the CO_2-reduction programme, climate-protection instruments include regulatory requirements, information and consultation programmes and education and training.

With its resolution of 13 June, 1990, the Federal Cabinet established a CO_2-reduction Interministerial Working Group (IWG), under the leadership of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. At the same time, the Cabinet set up working groups, within the CO_2-reduction IWG framework, on the following topic areas:

- Energy supply (management: Federal Ministry of Economics),

- Traffic and transport (management: Federal Ministry of Transport),

- Buildings and structures (management: Federal Ministry for Regional Planning, Building and Urban Development),

- New technologies (management: Federal Ministry for Research and Technology),

- CO_2 reduction in the areas of agriculture and forestry, including CO_2 sinks (management: Federal Ministry of Food, Agriculture and Forestry).

In addition to the above-named ministries, the working group comprises representatives of the Federal Chancellery, of the Federal Foreign Office and of the federal ministries of Finance; of Labour and Social Affairs; of Economic Cooperation and Development; of Defence; and of Education and Science.

In the summer of 1994, the CO_2-reduction IWG will present its 3rd report to the Federal Cabinet; the findings it contains have been taken into account in the present report.

The present report contains a very comprehensive catalogue of measures. On the one hand, this catalogue provides an overview of approved and implemented measures to date; on the other, it lists measures that are currently being approved by the appropriate decision-making bodies, or whose approval is currently being prepared or is planned. This very comprehensive catalogue of measures is aimed both at the energy-supply sector and at all energy-consuming sectors. It comprises the areas of private households and small consumers, traffic and transport, industry, the energy industry, the waste-management industry and agriculture and forestry.

In addition to economic instruments, the range of climate-protection tools includes regulatory requirements, research and technology development, information and consultation programmes and education and training.

Table II provides an overview of the some 100 individual measures that are contributing to reduction of emissions of CO_2 and other greenhouse gases.

Tab. II: Individual measures of the Federal Government that contribute to reduction of emissions of CO_2 and other greenhouse gases[1])

A. Measures that have already been approved and that are being/have been implemented

Energy supply:

Measures
(1) Federal table of charges for electricity
(2) Support for local and regional energy-supply and climate-protection concepts
(3) Act on the Sale of Electricity to the Grid
(4) Elimination of the excise duty on lamps
(5) Federal Government/L@nder district-heating modernisation programme for the area of the former GDR
(6) Funding for renewable energies
(7) Energy-saving programme of the European Recovery Programme (ERP)
(8) Support for advising of small and medium-sized companies concerning energy-saving
(9) Support of the *Forum fhr Zukunftsenergien* (Future Energy Forum)
(10) Information on use of renewable energies
(11) Information on saving energy and efficient energy use
(12) Acceleration of authorisation procedures by removing wind-energy systems from the 4th Ordinance on Execution of the Federal Immission Control Act (*4. BImSchV*)
(13) Tax breaks for heat/power cogeneration plants

[1] Measures for reducing the greenhouse gases covered by the Montreal Protocol are not included here. The list also does not include additional specific measures of the Lander and of communities for reducing emissions of CO_2 and other greenhouse gases.

Traffic and transport:

Measures
(14) Increase of the mineral-oil tax
(15) Emissions-oriented motor-vehicle tax (1st phase)
(16) 1992 Federal Traffic Infrastructure Plan
(17) Increasing the attractiveness of local public transportation
(18) Lowering of NMVOC emissions from vehicle refuelling, as a result of the Gas-balance System Ordinance
(19) Programme of research into urban traffic (*Forschungsprogramm Stadtverkehr - FOPS*)
(20) Improving continuity of traffic flow
(21) Information on energy-saving and environmentally aware driving habits
(22) Research projects and information concerning urban traffic planning and decreasing traffic pollution in cities
(23) Railway structural reform
(24) Freight centres
(25) Combined transport using waterways
(26) Research programme on "Pollution in Aviation"
(27) Traffic research
(28) Deregulation of goods transports on roads by means of the Tariffs-elimination Act (*Tarifaufhebungsgesetz*)

Buildings and structures:

Measures
(29) Amendment of the Thermal Insulation Ordinance (*W@rmeschutzverordnung - WSchV*)
(30) Amendment of the Heating-systems Ordinance (*HeizAnlV*)
(31) Advising concerning energy-saving, efficient energy use in housing structures - on-site advising
(32) Tax breaks through the Support-area Act (F`rdergebietsgesetz), pursuant to the 1991 Tax-Amendment Act of 24 June, 1991 and the Act on Securing the Futures of Sites (*Standortsicherungsgesetz*) of 13 September, 1993
(33) Housing modernisation programme of the Kreditanstalt fhr Wiederaufbau (KfW) reconstruction bank
(34) The joint programme "Economic Recovery in eastern Germany"
(35) Subsidies for construction of public (low-rent) housing
(36) Programme of research into experimental city and housing planning: "Reducing pollution in city planning" (*Schadstoffminderung im St@dtebau*)
(37) Acceleration of authorisation procedures by means of the investment-facilitation and housing-construction-site act (*Investitionserleichterungs- und Wohnbaulandgesetz*)
(38) Reduction of barriers to investment in housing construction in the area of the former GDR, for cases in which ownership questions have not been settled
(39) Information for building owners, architects, planners, engineers, craftsmen

New technologies:

Measures
(40) Specialised programme on environmental research and technology
(41) Research into, and technical refinement of, power-plant and firing-plant technology, especially clean coal-firing technology
(42) Research and development concerning gas and steam turbine power plants
(43) Research and development concerning use of renewable energies
(44) Programme for promotion of photovoltaic systems
(45) Support for testing wind-power systems: "250 MW Wind"
(46) "Solarthermie 2000" solar-energy promotion programme
(47) Research and development concerning use of solar energy
(48) Research and development concerning secondary energy systems integrated with renewable-energy systems
(49) Research and development concerning efficient energy use
(50) Nuclear energy research/reactor-safety research
(51) Nuclear-fusion research
(52) Research into thermal treatment of waste
(53) Test project entitled "Generation of heat and power from renewable raw materials"
(54) Geothermic energy

Agriculture and forestry:

Measures
(55) Joint task "Improvement of Agricultural Structure and Coastal Protection"
(56) Bonuses for land set-asides
(57) Improvement of animal digestive efficiency as part of animal husbandry, in order to reduce methane emissions
(58) Support for extensive methods of agriculture
(59) Conservation of existing forests
(60) Support for new afforestation
(61) Forest-management measures
(62) Tax exemptions for pure rape methyl ester (RME)
(63) Agency for renewable raw materials (*Fachagentur Nachwachsende Rohstoffe*)
(64) Proposal for a fertilizer ordinance

Waste-management sector:

Measures
(65) Ordinance on packaging
(66) Technical Instructions on Municipal Waste Management (*TA-Siedlungsabfall*)
(67) Technical Instructions on Waste, Part 1
(68) Waste Management and Product Recycling Act

Overarching measures:

Measures
(69) Improvement of training and continuing training for architects, engineers, technicians and craftsmen
(70) Support programme of the Deutsche Bundesstiftung Umwelt (DBU)
(71) Investment programme for reducing environmental pollution (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
(72) Environmental programme of the Kreditanstalt fhr Wiederaufbau (KfW) reconstruction bank
(73) Environmental programme of the Deutsche Ausgleichsbank
(74) Environmental protection guarantee programme: liability exemption in connection with the supplementary loans programme III (*Erg@nzungsdarlehen III*) for subsidising manufacturers of preventative environmental protection technology
(75) Federal/L@nder joint task "Improvement of the regional economic structure"
(76) Financial support of the economic infrastructure in the area of the former GDR - improvement of the regional economic structure in connection with support for municipal infrastructures
(77) Advising concerning thrifty, efficient energy use, provided by the *Arbeitsgemeinschaft der Verbraucherverb@nde (AgV)* consumer associations' working group, on commission to the Federal Ministry of Economics
(78) Support for advising of small and medium-sized companies concerning environmental protection and energy use
(79) Orientation advising on environmental protection for small and medium-sized companies (area of the former GDR)
(80) Orientation advising on environmental protection for communities in the area of the former GDR
(81) Community loan programme - area of the former GDR
(82) Air quality control programme of the European Recovery Programme (ERP)
(83) Technical information concerning efficient energy use and use of renewable energies

Measures
(84) Studies on optimising the CO_2-reduction programme
(85) Amendment of the Fee Table for Architects and Engineers (HOAI)
(86) Research into specific approaches to regulatory tools
(87) System analysis within the Instruments for Climate-gas-reduction Strategies (IKARUS) project
(88) Environmental certification mark (*Umweltzeichen*)

B. Measures that are currently being approved by the relevant decision-making bodies, or whose approval is currently being prepared or is currently planned:

Energy supply:

Measures
(89) Amendment to the Energy Management Act
(90) Proposal for an Ordinance on Heat Use

Traffic and transport:

Measures
(91) Raising of the minimum EU levels for mineral-oil tax
(92) Emissions-related motor-vehicle tax (2nd phase)
(93) Tolls for use of certain roads
(94) CO_2 emissions of new motor vehicles
(95) German railways' site concept
(96) Use of modern information technology for preventing and regulating traffic (telematics)
(97) Taxation of aircraft fuels
(98) Amendment of the Common Rules of Procedure (*Gemeinsame Gesch@ftsordnung*) of the federal ministries
(99) Introduction of traffic-effects studies
(100) Shifting of international transit traffic from roads to railways and to ships

Buildings and structures:

Measures
(101) 2nd Ordinance for Amendment of the Ordinance on Small Combustion Plants (1st Federal Immission Control Ordinance)
(102) Instruments for increasing energy efficiency of existing buildings
(103) Special relevant privileges accorded within the building code
(104) Standardisation of authorisation practices for renewable energy systems

Overarching measures:

Measures
(105) Improvement of the framework for vocational training and for continuing education and training
(106) Support for provision of information concerning third-party financing models
(107) Introduction of an (at-least) EU-wide CO_2/energy tax that has a neutral effect with regard to competition and total tax-revenue volume
(108) Law on mandatory labelling with regard to energy consumption (product labelling)
(109) Planning of the parliament and government district in Berlin with regard to environmental protection requirements, especially climate-protection requirements

An important factor in the success of climate-protection policy in Germany will be whether all those involved truly cooperate. The Federal Government alone will not be able to locally implement such an intensive programme - a programme that affects economic and social structures. For this reason, the climate-protection strategy must be diffused to all the various levels, and to each individual involved. The Federal Government is of the opinion that the effort to accomplish this, which has been underway since 1990, has been extremely successful.

Gradually, the L@nder are also preparing their own Land-specific climate-protection programmes. An important reason why such programmes must be developed and implemented is that in many areas the L@nder have executive competency.

Since 1990, many communities have begun developing and implementing community CO_2-reduction concepts, often on the basis of existing energy-supply concepts. To date, far more than 100 such concepts have been developed. Increasingly, head community associations are giving greater attention to this topic. In addition, communities are organising themselves, on the European level, into an international climate-protection alliance. This alliance has the extremely ambitious goal of reducing CO_2 emissions in its member communities by 50% by the year 2010, in relation to 1987 levels.

In November 1991, central German industry associations presented a paper describing an initiative for world-wide precautionary measures to protect climate. In this paper, German industry emphasises that it is willing to do its part to combat the greenhouse effect. The paper also makes clear that industry considers self-commitment declarations and compensation solutions to be effective climate-protection instruments. Since 1992, the Federal Government has been conducting intensive discussions with industrial representatives concerning the specific details of this initiative paper.

Other groups that have been very intensively discussing climate protection include unions, environmental protection associations, consumer organisations, churches and other groups that play an important role in society. The aim of these initiatives is to make it clear to each person that he or she can make a decisive contribution to combatting the global greenhouse effect.

IV. Emissions scenarios

The development of energy-related and non-energy-related emissions of methane (CH_4), nitrous oxide (N_2O), nitrogen oxides (NO_x), carbon monoxide (CO) and methane-free volatile organic compounds (NMVOC) until the year 2005 was estimated. For the case of energy-related emissions, two existing studies were used as a basis that do not conform completely with the CO_2-reduction programme. For the non-energy-related emissions, the current framework is used as the basis for forecasts. Table III lists the emissions reduction for these greenhouse gases (both energy-related and non-energy-related) until the year 2005, in relation to 1987 (where data is available) and 1990 emissions levels. Further reductions of greenhouse-gas emissions can be achieved through additional measures.

Tab. III: Changes in emissions of the greenhouse gases CH_4, N_2O, NO_x, CO and NMVOC by the year 2005, in relation to 1987 and 1990 levels, and according to trend estimates (energy-related and non-energy-related emissions)[1]

	Emissions change in %	
	1987 - 2005	**1990 - 2005**
Methane (CH_4)	- 50	- 48
Nitrous oxide (N_2O)	n.a.	- 25
Nitrogen oxides (NO_x)	- 36	- 25
Carbon monoxide (CO)	- 58	- 51
Methane-free volatile organic compounds (NMVOC)	- 47	- 43

[1] Further reductions of greenhouse-gas emissions can be achieved by means of additional measures.
n.a. = No figures provided, because the relevant data is incomplete.
Source: Federal Environment Agency

V. Research and systematic observation

Research into climate systems, and into the consequences of climate change, is among the emphases of German environmental research. Climate-system research is seeking to obtain reliable statements concerning the development of global climate and, especially, concerning development of regional climate. The purpose of research into the consequences of climate change is to estimate the possible effects of climate change. As part of such research, the interactions between climate and sensitive natural and civilisation-built systems are being studied.

The Federal Government is also sponsoring research into means of easing the effects of climate change. These efforts are aimed at providing the necessary action-oriented knowledge, and technology, in the areas of environmental protection and energy, for reduction of greenhouse-gas emissions. They are also focused on identifying options for action to deal with the effects of climate change. Table II (especially in its "New Technologies" section) lists specific measures for supporting research into means of easing the effects of climate change.

But more than scientific and technological solutions to environmental problems are now required, if environmental problems are to be permanently solved; for this reason, overall efforts are increasingly also incorporating social and economic approaches.

The Federal Republic of Germany's research programmes have been incorporated into major international programmes such as the World Climate Research Programme and the International Geosphere and Biosphere Programme.

The comprehensive measurement programmes that are also being carried out through international cooperation (such as within the Global Atmosphere Watch or the establishment of the Global Climate Observing System) provide an important basis for assessing the current state of the climate system and of anthropogenic influences on it. Data centres and databases are currently being established that will provide relevant collected data to the public in a suitable form.

VI. Training, education and public awareness

Because global climate change is a long-term process, education, training and promotion of public awareness are of central importance. The entire population has a responsibility to translate its high level of environmental awareness into an appropriate willingness to act and cooperate in avoiding future environmental damage. This is why the Federal Government and the L@nder are conducting a campaign of intensive environmental information. The topic of environmental protection has been solidly integrated into school education, which lies within the responsibility of the L@nder. A range of training and education measures focusing on climate protection has been carried out by the Federal Government and other sponsors. Table II lists individual measures for providing environmental information, training and education.

VII. International cooperation in the areas of technology and finance

The Federal Government strongly supports adherence to the guidelines set forth in the Rio Declaration, and is orienting its bilateral and multilateral cooperation in the area of development to the aim of implementing the Declaration's Agenda 21.

Bilateral cooperation

In the area of energy, a focus of the Federal Government's cooperation in the area of development, some 13 billion DM were provided between 1961 and 1993, within the framework of financial cooperation; some 1.1 billion DM were provided within the framework of technological cooperation. Of this funding, some 2.5 billion DM were spent on hydroelectric power generation; some 500 million DM were spend on other renewable energies. In addition, the Federal Government spends 300 million DM annually in helping other countries conserve their tropical rain forests. The Federal Government is also supporting developing countries' measures to reduce methane emissions in connection with the keeping of livestock, as well as studies in such countries on reducing methane and laughing gas emissions in rice cultivation.

In 1992, the Federal Government also created a consultancy assistance programme for central and eastern European countries. By 1993, over 150 projects in the area of environmental protection had been carried out within this programme. In addition, some 41 million DM was spent in 1992 and 1993 on selected environmental-protection projects in central and eastern Europe.

In 1992, the Federal Government made available 5 million DM in special funding; these funds are being used to help some 10 developing countries prepare their national reports.

Multilateral cooperation

In a pilot phase lasting from 1991 to 1993, and which was supported with approx. 1 billion DM worth of special-draft loans (central fund plus co-financing), the Federal Republic of Germany paid 147 million US$ into the central fund of the Global Environmental Facility (GEF). For the period lasting from mid-1994 to mid-1997, the Federal Republic of Germany has committed itself to payment of 240 million US$ (ca. 12% of the total volume of some 2 billion US$) into this fund.

The Federal Republic of Germany strongly supports taking an internationally coordinated approach. It is cooperating within the European Union (EU) and in multilateral government organisations such as the Organisation for Economic Cooperation and Development (OECD), the International Energy Agency (IEA), the United Nations Environment Programme (UNEP), the UN's Economic Commission for Europe (ECE), the World Meteorological Organisation (WMO) and the Intergovernmental Panel on Climate Change (IPCC), and it is making substantial contributions to these organisations' initiatives in the area of climate policy.

The Federal Government took an active role in preparing the resolutions of the EU's Joint Environmental and Energy Council of 29 October, 1990, 13 December, 1991 and June 1992, as well as the various Council resolutions concerning the European Union's CO_2-reduction strategy. Within the EU framework, it continues to support passage of an effective joint CO_2-reduction strategy.

The European Commission's proposal for a Council directive on the introduction of a tax on CO_2 emissions and energy, dated 4 June, 1992, is a focus of current discussion. The Council is still deliberating intensively on this proposal. The Federal Government considers the introduction of an (at least) EU-wide CO_2/energy tax, neutral with regard to competition and total tax-revenue volume, to be a necessary instrument for achieving goals in this area - both national and European goals. During its EU presidency, the Federal Government continues to pursue the issue of the above-mentioned CO_2/energy tax.

VIII. Outlook

The Federal Government plans to concentrate its future work within the Interministerial Working Group on CO_2 reduction on the following areas of action:

- Reduction of CO_2 emissions,
- Reduction of methane emissions (CH_4) from energy production, energy transport, energy distribution and energy use; from agriculture; from waste treatment; and from wastewater treatment,
- Reduction of nitrous oxide emissions (N_2O),
- Reduction of the precursor substances of tropospheric ozone, i.e. of nitrogen oxides (NO_x), carbon monoxide (CO), methane-free volatile organic compounds (NMVOCs) and
- Reduction of emissions of other greenhouse gases (including CF_4 and C_2F_6).

The results achieved to date, in sum, have noticeably reduced Germany's share of world-wide greenhouse-gas emissions. The aim of the Federal Government's climate-protection programme is to reduce Germany's share of anthropogenic emissions by about half, by the year 2005 - based on 1987 levels. World-wide, these efforts are without parallel, and the Federal Government expects that other countries will follow Germany's example.

The Federal Government will continue to take an active role in implementing national and EU-wide climate-protection strategies, and in efforts to achieve a globally coordinated strategy for combatting the anthropogenic greenhouse effect. This applies especially to implementation and promotion of further development of the Framework Convention on Climate Change. The 1st

Conference of the Parties, to be held in Berlin from 7 April to 28 May, 1995, will be an important step in these efforts.

1. Introduction

The United Nations Framework Convention on Climate Change provides an internationally binding basis for combatting the anthropogenic greenhouse effect. This report describes how the Federal Republic of Germany is fulfilling its obligations under the Framework Convention on Climate Change. It is the Federal Government's first report to the Conference of the Parties pursuant to the Framework Convention's Article 12.

In August 1993, a preliminary report was presented entitled "Climate Protection in Germany - National Report of the Federal Government for the Federal Republic of Germany in anticipation of Article 12 of the United Nations Framework Convention on Climate Change". The present report is an updated, substantially revised and expanded version of that preliminary report.

1.1 The greenhouse effect

1.1.1 The natural greenhouse effect

The earth receives energy through the sun's radiation - mainly within the visible spectrum. To maintain an energy balance, the earth must release an equivalent amount of energy into space. The energy the earth returns to space is longer-wavelength thermal radiation. The greenhouse effect occurs because the absorptive behaviour of the atmosphere's components, especially with respect to trace gases, differs in different spectral regions. Virtually none of the incoming visible light is absorbed, while the earth's returned thermal radiation is absorbed, to varying degrees, by a range of trace gases - i.e. this thermal radiation is prevented from returning, to a certain extent, by an insulating layer. To maintain an energy balance nonetheless, the earth must have an appropriately higher temperature. In brief, this is the physical basis for the greenhouse effect.

The earth's actual energy balance is more complicated than described above, however; for example, part of the incoming radiation is scattered by air molecules or reflected by clouds or the earth's surface, and some thermal radiation is absorbed and then re-emitted.

If the energy balance between incoming and released radiation is considered, without taking the greenhouse effect into account, a mean temperature for the earth is obtained of -18°C. The reason we instead find a mean temperature of +15°C is the natural greenhouse effect, caused by the atmospheric components water vapour, carbon dioxide, methane, laughing gas and ozone - in their natural concentrations.

1.1.2 The additional, anthropogenic greenhouse effect

The fact that concentrations of natural atmospheric components, as well as those of other greenhouse-relevant gases not present in the natural atmosphere, are increasing due to human activities, gives cause for concern (cf. Fig. 1.1). These increasing concentrations are causing an additional anthropogenic greenhouse effect, in addition to the natural greenhouse effect, that is causing global mean temperatures to increase. The fact that these changes are occurring rapidly, in comparison to geological time-scales, is particularly troubling. Not only temperatures are changing; precipitation relationships, climate zones and the frequency and intensity of unusual climatic events are changing as well. Changes in the climate balance could have significant effects, especially on natural or near-natural ecosystems, and on agriculture and forestry.

1.2 Climate-relevant trace gases

The most important gases responsible for the additional greenhouse effect are carbon dioxide (CO_2), chlorofluorocarbons (CFCs), as well as halons, methane (CH_4), nitrous oxide (N_2O) and ozone (O_3). Other climate-relevant gases include perfluorated fluorocarbons (PFCs, especially CF_4 and C_2F_6), sulphur hexafluoride (SF_6), partly halogenated CFCs (H-CFCs), hydrogenous chlorofluorocarbons (HCFCs) and water vapour from aircraft exhaust; sulphate aerosols tend to counteract the additional greenhouse effect. The additional greenhouse effect is reinforced in that the absolute amount of water vapour in the atmosphere grows as air and ocean temperatures increase; this causes a further temperature increase.

Some trace gases also have sources other than emissions. Such gases are produced from precursor substances produced by chemical reactions. For example, in the troposphere, ozone is formed only chemically, from NMVOCs, CH_4, CO and NO_x. In addition, ammonia emissions lead to formation of N_2O in soils; these emissions have an order of magnitude of a few percent of the amount of nitrogen discharged into the soil.

The so-called Global Warming Potential (GWP) is an important gas measure within the comprehensive approach taken by the Framework Convention on Climate Change - which covers all greenhouse gases not subject to the Montreal Protocol. The GWP for a particular greenhouse gas is a description of that gas' absorptive effect, in terms of relative magnitude, and in relation to the reference substance, CO_2, taking into account the gas' persistence in the atmosphere.

Table 1.1 shows the characteristics of the most significant greenhouse gases. The mass-based GWP figures indicate the direct radiation effects due to absorption of infrared radiation. The indirect chemical effects, such as formation of the greenhouse gases ozone, CO_2 and water vapour, as a result of methane oxidation or ozone depletion by CFCs and halons, are given in parentheses - quantitatively for methane and qualitatively for CFCs and halons. The GWP figures for the direct and indirect effects of methane are about the same. The stratospheric-ozone depletion caused by CFCs and halons works against the direct effects of radiation. Because of the strong chronological and spatial variations in ozone concentrations, however, no global GWP figure can be given for this effect.

Neither can any global GWP figures be determined for the indirect climate-relevance of NMVOCs, CO, CH_4, and NO_x (formation of ozone, a greenhouse gas), due to the large chronological and spatial variations in the concentrations of these substances. Because of these difficulties, it is currently also impossible to make reliable quantitative predictions concerning the effects on climate of chronological and spatial changes in ozone distributions, as a result of anthropogenic emissions.

Because the various greenhouse gases differ in their persistence within the atmosphere, a substance's relative climate-relevance depends on the time frame considered. The GWP figures in Table 1.1 apply only to time frames of 100 and 500 years. The relative contribution of substances with shorter persistence than CO_2, such as methane, decreases as the time frame is enlarged, and it grows as the time frame is reduced.

Tab. 1.1: Characteristics of the most important climate-relevant trace gases

	Carbon dioxide	Methane	Nitrous oxide	CFC 11	CFC 12	Halon 1301
Concentration	ppmv	ppmv	ppbv	pptv	pptv	pptv
Pre-industrial period (1750 to 1800)	280	0.6	265	0	0	0
1992	355	1.75	310	268	503	2
Increase per year (1992)	1.5 (0.4 %)	0.005 (0.4 %)	0.7 (0.26 %)	2.5 (0.9 %)	13 (2.6 %)	0.15 (7.5 %)
Persistence (years)	50-200 [1]	10	120	50	103	65
GWP[2], Time horizon 100 years	1	11 (10)[3]	270	3400 (-)[3]	7100 (-)[3]	5500 (-)[3]
500 years	1	4 (5)[3]	170	1400 (-)[3]	4100 (-)[3]	2100 (-)[3]

[1] The persistence of CO_2 in the atmosphere depends, in a complex manner, on the exchange processes that take place between the various CO_2 reservoirs. Exchange of CO_2 between the atmosphere and temporary reservoirs such as vegetation or surface waters takes only a few years. The actual removal of CO_2 from the atmosphere depends primarily on the rate of exchange between the oceans' thin mixing layer, which is near the surface, and their deep layers. These processes, which have been only incompletely quantified, take place over a time scale of about 100 years.

[2] GWP with respect to mass; direct radiation effects

[3] Indirect chemical effects: quantitative for methane, qualitative for CFCs and halons. A minus

sign means that the indirect chemical effect counteracts the direct radiation effect.

Source: IPCC Supplement 1992

The following section describes the most significant sources and sinks of the various greenhouse gases.

Carbon dioxide (CO_2)

The most significant sources for CO_2 are combustion of fossil fuels (coal, oil, natural gas) and the widespread destruction of forests (cf. Table 1.2). Since the beginning of the industrial age (about 1800), the CO_2 concentration in the atmosphere has risen from 280 to 355 ppm, i.e. by about one-fourth.

The most important CO_2 sink is the oceans. Forests are another sink. There is uncertainty, however, concerning the overall functioning of the sinks. In particular, there are indications that some sinks have not yet been identified.

Tab. 1.2: The most important global anthropogenic carbon and carbon dioxide influences*) for the period 1980 - 1990 [in billions of tonnes per year]

	Carbon	Carbon dioxide
Emissions from burning of fossil fuels	5.4 ± 0.5	19.8 ± 1.8
Net emissions from forest clearing and land use	1.6 ± 1.0	5.9 ± 3.7
Atmospheric accumulation	3.4 ± 0.2	12.5 ± 0.7
Absorption by the oceans	2.0 ± 0.8	7.3 ± 2.9
Net imbalance	1.6 ± 1.4	5.9 ± 5.1

*) Conversion factor 3.67
Source: IPCC Supplement 1992

In the biosphere, some 120 billion tonnes of carbon are absorbed annually from the atmosphere, and an equivalent amount is released into the atmosphere; these transfers are caused by life processes. If the total amount of vegetation remains unchanged, the amount absorbed is the same as the amount released, and there is no average change in the atmosphere's CO_2 concentration. The amount of CO_2 emitted annually, found in ca. 6 billion tonnes of carbon from fossil fuels, may seem small in comparison to the biologically transferred amounts; nonetheless, in conjunction with widespread forest destruction, it causes a change in the atmosphere's CO_2 concentration.

Methane (CH_4)

Methane is formed when organic material decays under anaerobic conditions (without oxygen). The largest natural sources for methane are wetlands (marsh gas). The most significant anthropogenic sources include rice cultivation, keeping of livestock, oil/natural-gas production and distribution, mining and landfills. Methane emissions indirectly cause greater water-vapour concentrations in the stratosphere.

Methane's most significant chemical breakdown reaction is its interaction with OH radicals formed photochemically in the atmosphere.

Halogenated hydrocarbons

Fully halogenated chlorofluorocarbons (CFCs) are exclusively anthropogenic in origin. Throughout the world, they have been emitted on a large scale, and to a certain extent are still being emitted, primarily in the following areas:

Propellants in aerosols (sprays), as well as foams and insulating material, refrigerants in refrigeration equipment, cold-storage facilities etc. and solvents and cleansers.

The only known sink for these substances is photolysis in the stratosphere, as a result of which chlorine atoms are formed, which deplete stratospheric ozone.

The partly halogenated chlorofluorocarbons (H-CFCs), which are used as substitutes for CFCs, also contribute to the anthropogenic greenhouse effect.

Other highly active greenhouse gases include halons, which contain bromine atoms, in addition to fluorine and chlorine. Halons are used almost exclusively in fire-extinguishing and explosion-suppression equipment.

Since the stop to production and use (in Germany, completed, for the most part, at the end of 1993/beginning of 1994) of these and other ozone-depleting substances is governed by the "Montreal Protocol on Ozone-Depleting Substances", they are not discussed further in this report.

Nitrous oxide (laughing gas; N_2O)

Globally, the most important source for N_2O is microbial transformation of nitrogen compounds in soils. Such transformation takes place both under natural conditions and as the result of nitrogen discharges from agriculture, industry and traffic and transport. The contributions of N_2O emissions from soils, as the result of microbially transformed surplus nitrogen originating in nitrogen fertilisation, have been insufficiently well researched. It is known, however, that in heavy soils with low seepage rates - that retain groundwater for long periods of time - most of the surplus nitrogen in the ground (80-95%) is emitted into the air, after transformation processes have occurred. Nitrification and denitrification of ammonia nitrogen, one source of which is agricultural ammonia emissions, and which is discharged from the atmosphere into the soil, can also contribute to the formation of N_2O.

In Germany and other industrial countries, chemical-industry processes (especially production of adipic acid) are another important source. N_2O is also produced in catalytic cleaning of motor vehicle emissions and, to a small extent, in combustion processes.

Photochemical processes in the stratosphere are the main means by which N_2O is broken down.

Ozone (O_3)

Since about the beginning of this century, ozone concentrations in the troposphere (to an altitude of about 10 km) have risen continually.

Ozone is not emitted; instead, it is formed in the atmosphere by photochemical reactions between nitrogen oxides (NO_x) on the one hand and volatile organic compounds (NMVOCs and CH_4) and carbon monoxide (CO) on the other. In areas with high emission density for these substances, these reactions, under intense solar radiation such as that occurring during high-pressure summer weather systems, result in relatively high ozone pollution (summer smog).

Other gases

Other greenhouse substances, of which there are a number, are insignificant, in view of the amounts in which they are currently being emitted. Some of these substances have very high atmospheric persistence and GWP values. For this reason, emissions trends for these substances should be closely monitored. Among these substances are perfluorated fluorocarbons (PFCs) and sulphur hexafluoride.

Of greatest relevance among the PFCs are CF_4 and C_2F_6, which are emitted during aluminium electrolysis in the dry way, during certain operational states (anode effect). PFCs have been proposed as substitutes for halons in fire retardants in those areas in which use of halons is still permitted as an exception. In Germany, PFCs have still not been permitted for such purposes, however.

Sulphur hexafluoride (SF_6) is used primarily in high-voltage portions of switching systems, in encapsulated form. The SF_6 is recycled. SF_6 is also used as a protective gas, and for removal of impurities, in production of aluminium and magnesium.

The hydrogenous fluorocarbons (HFCs) have considerably shorter atmospheric persistence than the PFCs. Since they are used as substitutes for CFCs (for example, R 134a), increases in their production can be expected. HFCs (like PFCs) have also been proposed as substitutes for halons in fire retardants in those areas in which halon use is still permitted by exceptions to regulations. In Germany, use of HFCs for such purposes has not yet been authorised. In 1990, production and usage volumes of HFCs were still insignificant in Germany.

Sulphate aerosols, which form from sulphur dioxide, also help modify the earth's radiation balance. In the troposphere, sulphate aerosols intensify cloud formation and increase cloud reflectivity. In the stratosphere, they increase scattering of incoming sunlight. Globally, increasing aerosol concentrations are likely to dampen the temperature increases caused by greenhouse gases. Because aerosols are unevenly distributed in the atmosphere, they are primarily expected to have regional effects. Precise predictions are still impossible, however.

The water vapour released by aircraft in the upper troposphere and the lower stratosphere also contributes to the anthropogenic greenhouse effect. These local emissions are likely to have a non-negligible effect in these regions, due to the low natural water-vapour concentrations and the long persistence involved.

1.3 Global climate change

Climate models can be used to make predictions of possible future climate change. Currently, global, coupled ocean-atmosphere climate models are being used to simulate climate development over time periods of up to 100 years. Such models are currently being developed and applied by the Max Planck Institute for Meteorology in Hamburg (MPI Hamburg) and by three other institutes in the US and the UK.

The climate-model predictions concerning the future extent and chronological progression of anthropogenic climate change still contain many uncertainties, since important climate-system processes are still incompletely understood. The models contain a multitude of approximations and uncertainties regarding physical and chemical processes within the climate system. The uncertainties occur especially in connection with circulation in the oceans and with hydrological-cycle processes - especially the effects of clouds, interactions with the biosphere and the effects of stratospheric sulphate aerosols and of stratospheric ozone depletion. The term "climate change" as used in this report should be understood in light of the above-mentioned uncertainties.

On the other hand, there is no question that massive anthropogenic interference in the atmosphere's trace-substance composition is exerting considerable influence on the earth's radiation balance. If only for the reason that a considerable time lag can occur between greenhouse-gas emissions and the effects of climate change, precaution demands that we act, in our own interest and in the interest of future generations, even if not all questions concerning the complex scientific interrelationships, the extent and, especially, the effects of climate change, have been answered. The Federal Government considers measures for reducing emissions of climate-relevant gases to have priority.

The combined effects of all greenhouse gases are currently being calculated with the aid of equivalent CO_2 concentrations.

Assuming that no measures to limit emissions of greenhouse gases are taken, the equivalent CO_2 concentration will increase annually by about 1 percent. Such an increase, which, in relation to pre-industrial CO_2 concentrations, would lead to a doubling of the equivalent CO_2 concentration by the year 2025, corresponds to the IPCC's emissions scenario A ("business as usual"). This scenario assumes 22 billion tonnes of CO_2 emissions in 1985, 28.3 billion tonnes in the year 2000 and 42.2 billion tonnes in 2025. With this assumption, the near-ground air temperature, as a global and seasonal mean, would increase by ca. 0.3°C ±0.15°C per decade. This would in turn result in an average air-temperature increase of 3.0°C ±1.5°C over 100 years. Such rapid warming is unusual in the earth's climate history.

In the IPCC's emissions scenario D, in which it is assumed that measures rapidly become effective, it is also assumed that 1985 CO_2 emissions amounted to 22 billion tonnes, that emissions in the year 2000 will amount to 20.6 billion tonnes and that emissions in 2025 will total 18.7 billion tonnes. In this case, the mean global international increase calculated with the MPI Hamburg's model is only 0.6°C after 100 years.

The models' regional predictions are uncertain, because of their coarse resolution. Nonetheless, the following can be derived from them:

- The low-altitude temperature increase is greater over land than over water. Because the Northern Hemisphere has larger land masses than the Southern Hemisphere, the warming will be more pronounced north of the equator than south of it.
- At first, warming in tropical latitudes will be stronger than in higher latitudes. As the CO_2 concentration in the atmosphere increases, the region of strongest warming will shift to the Northern Hemisphere's higher latitudes, however.
- Global warming will cause an increase in evaporation of surface water; as a result, precipitation will increase primarily in the higher latitudes of both hemispheres, in Asian monsoon areas and, in winter, in the Northern Hemisphere's middle latitudes.
- In summer, precipitation will decrease over non-tropical land areas; as a result, ground moisture will decrease.

The following observations could indicate that climate change is beginning:

- Charts of the global and seasonal means for near-ground air temperatures over the last 100 years show an increase between 0.3 and 0.6°C, with an accumulation of unusually warm years in the 1980s and the early 1990s.
- A decrease of about 8% in the annual snow cover in the Northern Hemisphere since the early 1970s,
- A decrease of about 50% in the masses of alpine glaciers since 1850,
- A decrease in precipitation in the Sahel Zone,

- Increasing warming of tropical oceans, and an increase of water-vapour concentrations in the lower tropical troposphere since the mid-1970s (in conjunction with increasing temperatures in the lower troposphere in the tropics and subtropics),
- Decreases in stratospheric temperatures in both hemispheres.

None of these indications, however, is proof in itself that these effects are indeed anthropogenic in origin, since the variations in the observed magnitudes still lie within the range of natural fluctuations. Yet the observed climate phenomena do agree with the climate predictions obtained with the climate-model calculations.

1.4 The global effects of climate change

Global climate change could have the considerable effects described below. These effects would not be the same in all regions, and their magnitude cannot yet be predicted with sufficient precision.

Climate-caused weather changes

The contrasts between humid and arid regions could increase. As a result, the frequency of extreme events, such as long periods of drought, alternating with strong precipitation, could increase, especially in the tropics and subtropics.

Rise in ocean levels

The rise in ocean levels of 30-50 cm, predicted by model calculations to occur by the year 2050 (with trends based on the IPCC's scenario A), could result in increased frequency and intensity of floods and in permanent flooding of fertile and, in part, densely settled, lowland coastal areas. In addition, some island countries could lose considerable portions of their areas; some could even become uninhabitable.

Forests/natural ecosystems

The ability of forests and other ecosystems to adapt to change could be overwhelmed by both the extent and the speed of climate changes. As a result, the species composition and structure of ecosystems could change to such an extent over the short term that ecosystems would no longer be able to fulfil their original functions for human society. The ecological and socio-economic consequences of such inability could be considerable.

Agriculture

Climate change could especially endanger agricultural production. Especially in semi-arid climates, soil desiccation and consequent degradation (such as excessive salt concentrations and erosion) would have to be expected.

In warmer climates, increased frequency of extreme climatic events, and stronger spreading of plant diseases and pests, could have negative effects on crop yields.

Global climate change, in conjunction with a rapidly growing world population, could have a drastic effect on the world-wide food situation. The accelerated microbial decay of organic material in warmer climates could lead to additional release of CO_2 into the atmosphere, thus intensifying the greenhouse effect. In addition, soil fertility could decrease, decreasing yields and production reliability of soils.

2. Outline data

A difficulty encountered in compiling outline data is that the two parts of Germany belonged to two different - in many respects - political blocs until unification on 3 October, 1990. Consequently, the living conditions, as well as the economic and social circumstances, etc. were extremely different in the two parts.

This also adds to the difficulty of preparing this report. For example, separate data must be given for the period during which the GDR existed. In many areas, the data cannot be compared; in some other areas, data is unavailable for the former GDR. 1990, an important year for the Framework Convention on Climate Change, is also the year in which German unification took place. Consequently, until 3 October, separate data was collected for each part of the country; after this date, joint data was collected. Apart from these formal considerations, it is clear that the profound and dynamic upheavals that took place, especially in the area of the former GDR, make collection of precise data more difficult, and require data to be listed separately even after 1990.

2.1 The political framework

2.1.1 Political structure

The Federal Republic of Germany is a federal state. Its Basic Law (constitution) distributes tasks and responsibilities between the Federal Government and the Länder. Fig. 2.1 shows how Germany's territory has been divided into a total of 16 Länder. The Länder, in turn, have transferred a range of tasks and responsibilities to government districts (*Regierungsbezirke*) and rural districts (*Landkreise*), consisting of communities and cities, and to non-district cities. In addition, communities have the right to regulate all local-community affairs under their own responsibility, within the legal framework.

2.1.2 Legislation

In the Federal Republic of Germany, legislative competencies are divided between the Federal authorities and the Länder. The Federal authorities have the right to pass laws in certain areas assigned exclusively to it by the Basic Law (for example, concerning foreign affairs, defence and currency), as well as the right to pass legislation, in certain areas, that competes with Länder laws (for example, concerning waste disposal, air quality and noise control), and the right to pass framework laws in certain areas (for example, concerning nature conservation, care for the landscape and water management). On the basis of this distribution of competencies, the Federal authorities are largely responsible for environmental legislation. In areas in which the Basic Law gives the Federal authorities no legislative authority, the Länder have the legislative competency.

Proposed legislation at the federal level can be introduced by the German Bundestag (Lower House of Parliament), by the Bundesrat (Länder assembly, Upper House of Parliament), or by the Federal Government itself (i.e. the executive branch; at the initiative of the responsible ministries).

After the Bundesrat (in connection with initiatives of the Government) or the Federal Government (the executive branch; in connection with Bundesrat initiatives) has responded officially, the proposed legislation is sent to the Bundestag for deliberation - a process subject to certain deadlines. Proposed legislation based on initiatives of parliamentary factions or groups of members of Parliament is placed directly on the plenary session's agenda.

Proposed legislation is treated in the Bundestag in three different "readings" (*Lesungen*). After a first general discussion concerning the necessity and the aims of the proposed legislation, the bill is sent to the responsible committees for specialised, technical discussion. On the basis of the reports of these committees, a second reading takes place (discussion concerning proposed amendments to the proposed legislation); in the third reading, a vote is then taken.

If the proposed legislation is rejected by the Bundestag, it is considered to have failed (with the possibility remaining that it be re-introduced at a later date).

If the Bundestag passes the proposed legislation, it must then also be passed by the Bundesrat, if it touches on Länder interests. If the Bundesrat rejects it, a complicated process begins known as a "resolution phase with mediation" (*Beschlußphase mit Vermittlung*).

If the legislation is passed, it is countersigned by the Chancellor and the appropriate federal ministers and then sent to the Federal President for approval. Once the Federal President has signed it, the legislation is considered "signed into law". After it has been announced in the Federal Law Gazette, the law then comes into force on the date specified within the law.

In order to safeguard the basic rights and freedoms guaranteed by the Basic Law, the Federal Constitutional Court (the highest court in the Federal Republic of Germany) examines laws, upon submission of a formal application, with regard to their constitutionality.

The Federal Government or federal ministers can be empowered by law to issue legal ordinances by which, within the framework of the relevant empowerment, the execution of a law is more closely regulated. In addition, the Federal Government can issue general administrative provisions. Both legal ordinances and administrative provisions, if they touch on Länder responsibilities - and this is normally the case in the environmental sector - must be approved by the Bundesrat.

2.1.3 Execution of laws

As a rule, federal laws, legal ordinances and administrative provisions are executed by the Länder, as their own affairs. This also applies to the environmental sector. In addition, there are areas in which federal administration applies and areas in which the Länder execute federal laws on behalf of the Federal Government (for example, safety of nuclear installations and radiation protection); in these areas, there is a federal supervisory authority.

Länder laws are carried out by the Länder.

2.2 Population

2.2.1 Population size

From 1970 to 1993, Germany's population grew by 3.5 million, with former West Germany exhibiting a slight increase and the area of the former GDR a slight decrease (cf. Table 2.1). The increase in former West Germany, especially since the end of the 1980s, is due primarily to migration from the area of the former GDR and from abroad.

Tab. 2.1: Population 1970 to 1993 [in millions]

	Former West Germany	Area of the former GDR	Germany
1970	60.7	17.1	77.8
1975	61.8	16.9	78.7
1980	61.6	16.7	78.3
1985	61.0	16.6	77.6
1987	61.2	16.7	77.9
1990	63.7	16.0	79.8
1991	64.5	15.8	80.3
1992	65.3	15.7	81.0
1993 1)	65.4	15.7	81.1

1) Table date: July 1994
Source: Federal Statistical Office: Statistisches Jahrbuch für die Bundesrepublik Deutschland, several editions

2.2.2 Predicted population growth

Predictions of Germany's future population growth vary (cf. Table 2.2). The main factors influencing population growth are the birth rate and immigration.

Tab. 2.2: Population trends in Germany [in millions]

Source	2000	2005	2010	2020
DIW 1990	80.8	-	78.9	-
IFEU 1992	81.7	81.7	-	-
Prognos 1992	80.1	79.7	78.6	-
8. Coordinated population forecast				
Variant I 1)	83.3	-	82.0	78.6
Variant III 2)	84.1	-	84.8	83.7

1) Net migration is 100,000 persons per year
2) Net migration is 300,000 persons per year
Sources: Prognos-Energiereport 2010, 1992
Motorisierter Verkehr in Deutschland - IFEU Study, 1992
Federal Statistical Office: Wirtschaft und Statistik, expected to appear in issue 7/94

2.2.3 Age structure

Figs. 2.2 and 2.3 illustrate the age structure of Germany's population. The demographically unfavourable structure (imbalance toward older age groups) results from increasing life expectancies and lower birthrates (which, in part, are continuing to decrease).

2.2.4 Population density

Table 2.3 shows population density in 1990. Fig. 2.4 shows how population density varies by region in Germany. In particular, it also shows that the area of the former GDR has a much lower population density than former West Germany.

Tab. 2.3: Population density in 1990 [in persons per km^2]

	Former West Germany	Area of the former GDR	Germany
Population density	256	148	224

2.2.5 Per-capita emissions of greenhouse gases

The following section lists per-capita emissions of CO_2, CH_4 and N_2O.

Energy-related per-capita CO_2 emissions in Germany, at 12.3 tonnes per person in 1990, are considerably higher than the global average of 4.2 tonnes/person (cf. Table 2.4 and Figs. 2.5 and 2.6); this is due primarily to Germany's high level of industrialisation and its standard of living. Climate also plays a significant role; heating is necessary during the cold season (October to April). From 1990 to 1993, per-capita CO_2 emissions decreased from 12.3 to 10.9 tonnes per person.

Tab. 2.4: Energy-related per-capita CO_2 emissions[1)] [in tonnes per person]

	1970	1980	1987	1990	1991 2)	1992 2)	1993 2)
Former West Germany	11.7	12.4	11.4	10.8	11.2	10.9	10.9
Area of the former GDR	16.6	18.4	20.5	18.5	13.7	12.0	11.2
Germany	12.8	13.7	13.4	12.3	11.7	11.1	10.9
World	4.4	4.4	-	4.2	4.1	4.1	-

1) Tentative figures
2) Figures pursuant to IPCC regulations, not including high-seas bunkering and international air transport

Sources: OECD: Energy Statistics and Balances, various editions;
Federal Environment Agency; World Population Prospects UN, 1992; Energie-Daten 92/93, Federal Ministry of Economics 1993

The large difference between former West Germany and the area of the former GDR with regard to per-capita emissions should be noted. The high figure for the former GDR, one of the world's highest, was due to that country's extremely inefficient use of fuels, as well as to the dominant role of lignite there. Since 1990, per-capita emissions in the area of the former GDR have moved rapidly toward figures in former West Germany.

In former West Germany, per-capita CH_4 emissions decreased steadily until 1992; the total decrease was 23%. The trend in the area of the former GDR ran counter to this development; per-capita CH_4 emissions increased (cf. Table 2.5). In 1990, per-capita CH_4 emissions in the Federal Republic of Germany were some 15% higher than the world-wide average.

Tab. 2.5: Per-capita CH_4 emissions [in kilogrammes per inhabitant]

	1970	1980	1990	1991*	1992*
Former West Germany	100	90	79	78	77
Area of the former GDR	58	71	75	70	74
Germany	91	86	78	76	77
World	n.a.	n.a.	68	n.a.	n.a.

* Emissions figures are partly based on comprehensive estimates

Sources: IPCC-Supplement Report 1992, Federal Environment Agency

Table 2.6 lists per-capita N_2O emissions in 1990. In Germany (including N_2O emissions from adipic-acid production), they are about three times the world-wide average. Because the data is incomplete, no trend can be reported.

Tab. 2.6: Per-capita N_2O emissions [in kilogrammes per inhabitant]

	1990
Former West Germany	2.9
Area of the former GDR	2.2
Germany	2.7
World	0.65

Sources: IPCC-Supplement Report 1992, Federal Environment Agency

2.3 Geography/land use

2.3.1 Area of the Federal Republic of Germany

The area of the Federal Republic of Germany is 356,950 km^2 = 35,695 million hectares. The area of former West Germany is 248,620 km^2 and that of the former GDR is 108,330 km^2.

2.3.2 Land use

Table 2.7 and Fig. 2.7 show land use in 1989. Trends in land use in former West Germany are characterised primarily by a continual increase of settled areas and areas set aside for traffic and transport, primarily at the expense of agricultural areas (landscape consumption). No reliable data is available for the area of the former GDR concerning land-use trends.

Tab. 2.7: Land use in Germany by main types of use in 1989 [in km^2]

	Agricultural areas[1)]	Areas used for settlement and traffic / transport	Forest areas	Water areas	Other areas	Total area
Germany	195 270	43 620	103 850	7 640	6 570	356 950
Former West Germany	133 550	32 880	74 010	4 500	3 680	248 620
Area of the former GDR	61 710	10 740	29 840	3 140	2 900	108 330

1) Arable land used for farming, as meadowland and pastureland, for horticulture and viticulture, excluding bogland and heaths. Because a different classification system is used, the figures given

here are not identical with those provided under "area used for agricultural purposes" in Tab. 2.8

Source: Federal Statistical Office: Statistisches Jahrbuch fhr die Bundesrepublik Deutschland 1993

2.3.3 Agriculture

2.3.3.1 Areas used for agricultural purposes

Table 2.8 shows the area used in Germany for agricultural purposes; Table 2.9 lists the cultivated area. Fig. 2.8 shows how the agriculturally used area is regionally distributed.

Ecologically oriented farming is practiced on a small, but increasing percentage of the overall area used for agriculture. According to the Federal Ministry of Food, Agriculture and Forestry, in 1993 this percentage was 0.75%.

Tab. 2.8: Areas used for agricultural purposes in 1991 [in km^2]

	Former West Germany	Area of the former GDR	Germany
Areas used for agricultural purposes	117 849	52 911	170 762
<u>of these:</u>			
Permanent grassland	42 672	9 971	52 650
Crop area	73 015	42 445	115 460

Source: Federal Statistical Office: Statistisches Jahrbuch fhr die Bundesrepublik Deutschland

Tab. 2.9: Use of crop areas (excluding domestic gardens and continuous crop farming) in 1991 and 1993 [in km²]

Crop	Former West Germany		Area of the former GDR		Germany	
	1991	1993	1991	1993	1991	1993
Grain	41 624	41 350	20 612	21 100	62 236	62 450
Pulse crops	361	360	503	500	864	860
Root crops	6 449	6 400	2 295	2 400	8 744	8 800
Rape/beets	4 399	4 270	5 668	5 720	10 067	9 900
Fodder crops	11 789	11 800	6 752	6 880	18 541	18 680

Source: Federal Statistical Office: Statistisches Jahrbuch fhr die Bundesrepublik Deutschland

2.3.3.2 Fertilizers and animal husbandry

In agriculture, fertilizer use (cf. Table 2.10) and livestock (cf. Table 2.11) are the most significant factors in emissions of climate-relevant gases.

Among fertilizers, it is primarily nitrogen fertilizers (ammonium, nitrate, urea, ammonia) which are significant, because small percentages of the nitrogen in these fertilizers (1-3%, depending on soil type and use) are released as nitrous oxide (laughing gas, N_2O). In former West Germany, use of nitrogen fertilizers increased from 1970 to fiscal year 1987/1988, with brief interruptions; since then, it has been decreasing steadily. In 1989/1990, the decrease in comparison to 1988 was 7%; in 1991/1992, it was 17%, in comparison to 1987/1988. In the area of the former GDR, an increase occurred until 1988/1989. The decrease in fertilizer use in fiscal year 1989/1990, as compared to 1988/1989, was 18%. The reason for this decrease is found in the uncertain economic framework that prevailed before German unification.

Livestock influences emissions of greenhouse gases in two ways. On the one hand, methane (CH_4) is emitted when ruminants' stomachs break down cellulose fibre. On the other hand, methane also is produced by microbial decay of animal excrement, a process that is influenced by excrement origin and by the conditions under which excrements are stored and spread on fields. Under certain conditions, N_2O can also form from animal excrements. Since 1990, the amount of livestock in Germany has decreased. For example, the number of beef cattle decreased from ca. 19.5 million in 1990 to 16.2 million in 1992.

Tab. 2.10: Domestic sales of fertilizers 1989/90 and 1992/93 [in 1000 t of nutrients]

		Nitrogen (N)	Phosphate (P_2O_5)	Potassic fertilizer (K_2O)	Lime (CaO)
Germany	89/90	2 167	884	1 313	3 076
	92/93[1]				
Former West Germany	89/90	1 487	594	792	1 641
	92/93	1 280	402	573	1 440
Area of the former GDR	89/90	680	290	521	1 435
	92/93[1]				

[1] These figures were not published until December 1992, since the group of companies required to provide data was still incomplete until then.

Source: Statistisches Jahrbuch fhr die Bundesrepublik Deutschland 1993

Tab. 2.11: Animal husbandry[1)] in 1990 and 1992 [in 1000]

	Former West - Germany		Area of the former GDR		Germany	
	1990	1992	1990	1992	1990	1992
Calves less than 1/2 year	2 275	2 083	737	398	3 012	2 481
Young beef cattle 1/2 to 1 year	2 868	2 566	833	425	3 701	2 991
Beef cattle older than 1 year	1 619	1 441	642	283	2 261	1 724
Cows[*]	7 780	7 286	2 733	1 724	10 513	9 010
Beef cattle overall	14 542	13 377	4 946	2 831	19 487	16 208
Pigs	22 036	22 115	8 783	4 399	30 819	26 514
Sheep	1 784	1 706	1 456	680	3 240	2 386
Horses	406	460	85	71	491	531
Poultry	81 055	80 751	32 824	23 263	113 879	104 014

[*] Dairy cows, heifers and all other cows
[1)] December census
Source: Federal Statistical Office: Statistisches Jahrbuch fhr die Bundesrepublik Deutschland 1993

2.3.4 Forestry

Germany's forests are temperate-zone mixed forests. Some 10.8 million hectares of Germany, or about 30% of the country's area, is covered by forest. Table 2.12 provides an overview of the main tree species found, along with area percentages for each. Fig. 2.8 shows the regional distribution of areas used for forestry.

Tab. 2.12: Overview of tree species distribution (as of October 1990)

Tree species group	Area	
	millions of ha	%
Oak	0.9	9
Beech, other deciduous trees	2.7	25
Deciduous trees total	3.6	34
Pine and European larch	3.4	31
Spruce and other conifers	3.8	35
Conifers total	7.2	66
Germany	10.8	100

Sources: Bundeswaldinventur 1986 - 1990 (for former West Germany); Mitteilungen der Landesforstverwaltungen (for the former GDR)

2.4 Climate

Germany's climate is influenced primarily by the country's location within the temperate zone, which has frequently changing weather. In each location within the country, the generally prevailing climate is modified by altitude and distance from the Atlantic. Overall, the climate features prevailing westerly winds and precipitation at all times of the year.

In the northern German plain, the annual precipitation varies from 500 to 700 mm; in the central mountains, it varies from 700 to over 1,500 mm. In the Alps, it reaches over 2,000 mm. The coast and the inland lowlands receive precipitation of over 10 mm on 10-20 days of the year. The corresponding figure for the central mountain regions is 20-30 days, and in the high mountains (Zugspitze) it is 50-70 days.

As one moves from the northwest to the east and southeast, a gradual transition from a more maritime to a more continental climate is apparent, i.e. the amounts of precipitation decrease and temperature amplitudes between summer and winter, and between night and day, gradually increase. The average temperatures in January, the coldest month of the year, are between +1.5°C and -1.5°C; in the mountains, they can fall to -6.0°C and lower, depending on altitude. In the northern German plain, mean July temperatures vary from +17°C to +18°C; in the upper Rhine rift valley, they range up to +20°C. The average annual temperature is +9°C. Strong winds (over 8 on the Beaufort scale) occur on only 1 to 6 days of the year in lower inland altitudes. On the coast and the offshore islands, and in the central mountains, they occur on 10 to 20 days; in the Alps, they occur on about 50 days of the year.

The degree-day number is an indicator that is widely used in the energy sector to determine heating requirements. It takes account only of days with a daytime mean temperature of less than +15°C. The long-term degree-day mean for Germany is 4,000. A figure of 3,000 is reached in the winter half of the year alone.

Currently, comprehensive, consistent data is still not available in Germany for background concentrations of climate-relevant gases and their trends. Establishment of a background station within the WMO's Global Atmospheric

Watch (GAW) is currently being prepared.

The Federal Environmental Agency's measurement network provides data on regional concentrations in more rural areas, although longer chronologies are available only for CO_2 (cf. Table 2.13 and Fig. 2.9). In 1992, regional concentrations at the Schauinsland measuring station were ca. 1.8 ppm for CH_4; for N_2O, they were about 320 ppb.

Tab. 2.13: Average annual levels for carbon dioxide concentrations [in ppm]

Measuring station	1975	1980	1985	1990	1993
Westerland	338	349	352	359	364
Deuselbach	340	347	351	362	365
Brotjacklriegel	336	341	352	357	359
Schauinsland	333	340	347	355	359

Source: Federal Environment Agency, measurement network

2.5 Economy

2.5.1 Gross national product, gross domestic product and gross value added

The gross domestic product (GDP) is the monetary result of the production process, i.e. the sum of all goods and services produced within a country's geographic boundaries, by both citizens and foreigners, minus the value of the pertinent goods consumed during the production process.

The economic size of various sectors is given as gross value added (GVA); it differs from the GDP by the amounts of the non-deductable turnover tax and import duties. These economic amounts are added to the total gross value added and cannot be separated out for the individual sectors.

If a relation to environmental pollution caused by economic processes is to be established, then the GDP is the more suitable reference figure, since it is a measure of an economy's overall economic activity - in contrast to gross national product (GNP), which is more an indicator of income, and to GVA, which is a measure for individual economic sectors (cf. Table 2.31).

Table 2.14 (cf. also Fig. 2.10) shows the development of GVA for individual economic sectors, in DM and in US$, for the relevant rates of exchange. For 1970-1987, the data is in 1985 prices; beginning in 1990, it is expressed in terms of 1991 prices. The 1990 GVA (non-adjusted) for former West Germany amounted to a total of 2,438.3 billion DM. This is equivalent to a per-capita figure of 38,280 DM/inhabitant. Because the area of the former GDR had a different economic system, no comparable data is available for years prior to 1990. Only for the second half of 1990 can the GVA (this also applies to GNP and GDP) for the area of the former GDR be calculated in a manner that permits comparison. It amounted to some 108 billion DM, or 67 billion US$. This figure, when converted to an entire-year figure, to permit comparison, would then amount to a GVA of about 215 billion DM, corresponding to 13,440 DM/inhabitant. The national income calculated for the GDR can be compared with GVA and GDP only to a limited extent; it is given in the last line of Table 2.14. No breakdown by sectors is available for this figure. The mean increase in national income from 1970 to 1987 was about 4.6% per year. The mean economic growth, in relation to GDP (cf. Table 2.31), was about 2.2% per year in former West Germany.

Tab. 2.14: Gross value added (GVA) by sectors from 1970 to 1993 [in billions]; from 1970 - 1987 in 1985 prices; beginning in 1990, in 1991 prices

	1970		1975		1980		1985		1987		1990[1)]		1993[2)]		Percentage share per sector for GVA 1990[1)]
	DM	US $[*)]	DM	US $[*)]	DM	US $[*)]	DM	US $[*)]	DM	US $[*)]	DM	US $[*)]	DM	US $	
Agriculture, forestry, fishing													39.2	24.2	
- former West Germany	25.8	-	28.7	11.7	29.3	16.3	31.9	10.9	32.1	17.8	36.5	22.5	35.0		1.5 %
- Area of the former GDR	-	-	-	-	-	-	-	-	-	-	4.9	3.0	4.2		4.5 %
Goods manufacturing													1 028.5	622.7	
- former West Germany	616.7	-	638.7	259.7	735.0	408.3	740.2	251.8	738.9	410.5	968.4	597.8	941.4		39.7 %
- Area of the former GDR	-	-	-	-	-	-	-	-	-	-	40.7	25.1	87.1		37.8 %
Trade and transport													402.1	243.7	
- former West Germany	182.6	-	200.8	81.6	247.0	137.2	261.5	88.9	271.8	151	355.7	219.6	372.2		14.6 %
- Area of the former GDR	-	-	-	-	-	-	-	-	-	-	18.3	11.3	29.9		17.0 %
Services													902.3	547.5	
- former West Germany	268.8	-	334.7	136.1	419.9	233.3	490.8	166.9	538.6	299.2	749.2	462.5	847.2		30.7 %
- Area of the former GDR	-	-	-	-	-	-	-	-	-	-	18.8	11.6	55.0		17.4 %
Government sector and private households													392.7	238.1	
- former West Germany	165.6	-	204.8	83.3	232.2	129	249.9	85	258.6	143.7	328.5	202.8	346.0		13.5 %

- Area of the former GDR	-	-	-	-	-	-	-	-	-	-	25.0	15.4	46.8		23.2 %
Total GVA													2 764.7	1 676.2	
- former West Germany unadjusted	12-59.6	-	1407.7	572.2	1663.5	924.2	1774.3	603.5	1840.1	1022.3	2 438.3	1 505.1	2 541.8		100 %
- Area of the former GDR	-	-	-	-	-	-	-	-	-	-	107.7	66.5	223.0		100 %
National income of the former GDR in GDR marks	121.6	-	158.2	-	193.6	-	241.9	-	260.6	-	-	-	-	-	

*) Dollar figures calculated in line with the exchange rate valid at the time (please note that the exchange rates vary considerably

1) Data for the area of the former GDR in 1990 related only to the second half of 1990

2) Tentative figures

Sources: Statistisches Jahrbuch fhr die Bundesrepublik Deutschland, Wiesbaden, various editions/Monatsberichte der Deutschen Bundesbank Frankfurt

2.5.2 Per-capita gross domestic product and gross national product

Table 2.15 shows the development of GDP per capita for Germany, and the area of the former GDR, from 1991 to 1993, as well as for former West Germany, from 1970-1993, all in 1991 prices.

To permit comparison with former West Germany, Fig. 2.11 lists GNP per capita in 1991, for various countries, in US$. This figure highlights the differences between the industrial countries and developing countries in this regard.

Tab. 2.15: Development of gross domestic product per inhabitant between 1970 - 1993, in 1991 prices [in DM]

	1970	1975	1980	1985	1987	1990	1991	1992	1993
Former West Germany	25 420	27 810	32 760	35 020	36 250	39 570	40 850	40 980	40 150
Area of the former GDR	-	-	-	-	-	-	11 450	12 640	13 540
Germany	-	-	-	-	-	-	35 070	35 490	35 000

Source: Federal Statistical Office

2.5.3 Energy-related CO_2 emissions in relation to GDP

Table 2.16 shows the decoupling of economic growth and CO_2 emissions. In former West Germany, the relation of energy-related CO_2 emissions to GDP decreased by some 41% between 1970 and 1993 (cf. Fig. 2.12).

Tab. 2.16: Energy-related CO_2 emissions in relation to real gross domestic product (GDP) (in 1991 prices)

Year	GDP in billions of DM	CO_2 emissions in millions of t[1)]	CO_2 emissions in relation to GDP in kg/1 000 DM (rounded off)
Former West Germany			
1970	1 543	711	461
1975	1 719	702	408
1980	2 018	766	380
1985	2 136	703	329
1987	2 218	699	315
1990	2 520	688	273
1991	2 635	723	274
1992	2 676	712[2)]	266
1993	2 626	710[2)]	270
Area of the former GDR			
1991	181	217	1 199
1992	198	189[2)]	955
1993	213	176[2)]	826
Germany			
1991	2 816	940	334
1992	2 874	901[2)]	314
1993	2 839	886[2)]	312

1) Figures in accordance with IPCC regulations, and excluding high-seas bunkering and international air transport
2) Tentative result
Sources: Federal Environment Agency, Federal Statistical Office

2.5.4 Employment, by sectors

Table 2.17 shows the development of employment in the various sectors, with the overall-workforce percentage employed in each sector, for the 1970-1993 period and for both former West Germany and the area of the former GDR. The two sectors of services companies and state and private budgets (combined for statistical reasons) exhibit a marked increase in numbers of people employed, whereas the corresponding figures in other areas only slightly increased or decreased - except for the areas of forestry and agriculture, in which employment figures dropped drastically, especially in the area of the former GDR.

Tab. 2.17: Employment per sector from 1970 to 1993 [in 1 000]

	1970	1975	1980	1985	1990	Percentage of employees in each sector in 1990	1991	1992[2]	1993[2]
Agriculture, forestry, fishing - Former West Germany - Area of the former GDR	3 259 2 262 997	2 668 1 749 895	2 281 1 403 878	2 118 1 196 922	1 745 995 784	4.7 % 3.4 % 8.8 %	1 364 964 401	 924 -	 880 -
Goods manufacturing - Former West Germany - Area of the former GDR	16 784 12 987 3 797	15 545 11 624 3 859	15 691 11 721 3 970	14 878 10 800 4 078	15 309 11 309 3 988	41.0 % 39.8 % 45.0 %	14 487 11 496 2 998	 11 354 -	 10 823 -
Trade and traffic - Former West Germany - Area of the former GDR	6 194 4 755 1 439	6 199 4 872 1 447	6 495 5 032 1 463	6 418 4 919 499	6 729 5 314 1 413	18.0 % 18.7 % 15.9 %	6 848 5 547 1 303	 5 646 -	 5 595 -
Services sector - Former West Germany - Area of the former GDR	4 469 2 933 1 536[1]	9 569 3 424[1] 1 748[1]	5 884 3 970 1 914[1]	6 432 4 391 2 041[1]	5 931 5 294 663	15.9 % 18.5 % 7.5 %	6 401 5 590 813	 5 843 -	 5 977 -
Government sector and private households - Former West Germany - Area of the former GDR	3 623 3 623 -	- 4 351 -	- 4 854 -	- 5 183 -	7 586 5 567 2 019	20.3 % 19.6 % 22.8 %	7 298 5 630 1 664	 5 720 -	 5 739 -
Total number of employees - Former West Germany - Area of the former GDR	34 329 26 560 7 769	33 759 26 020 7 949	35 205 26 980 8 225	35 029 26 489 8 540	37 300 28 479 8 867	100 % 100 % 100 %	36 446 29 227 7 219	35 831 29 487 6 344	35 142 29 014 6 128

1) The statistical figures for the former GDR and former West Germany for 1975 do not distinguish between a) employees in services companies and b) employees in the government sector and in private households
2) Data available only for Former West Germany
Source: Federal Statistical Office, Statistisches Jahrbuch, various years, as of 4/94

2.6 Energy

2.6.1 Reserves of fossil fuels

Table 2.18 lists Germany's proven recoverable reserves of coal, oil and natural gas, along with the amounts of time for which they are expected to last, for 1990 and 1993. Table 2.19 lists these reserves for selected parts of the earth.

Proven recoverable reserves are known reserves that can be extracted under current technological and economic conditions. The amount of time for which reserves are expected to last (continuity of supply) is obtained by dividing total amounts of reserves by current annual production amounts.

Table 2.20 contains an overview of fossil fuel production in Germany in 1990 and 1993. The figures for the corresponding world-wide reserves and production volumes have been included to show Germany's share of world-wide reserves and of the international energy market.

Tab. 2.18: Proven recoverable reserves of fossil fuels*

	Coal			Crude oil			Natural gas		
	Proven recoverable reserves[1)]		Continuity of supply[2)]	Proven recoverable reserves [1)]		Continuity of supply[2)]	Proven recoverable reserves[1)]		Continuity of supply[2)]
	billions of tonnes of hard coal units	%[3)]	in years	millions of tonnes	%[3)]	in years	billions of m^3	%[3)]	in years
Germany 1990	38	5.6	230	62.8	0.03	15	347.2	0.19	15
Germany 1993	41	5.5	327	50.4	0.04	16	297.7	0.21	17
Former West Germany 1990	32	4.1	335	61.9	0.03	15	300.4	0.19	19
Former West Germany 1993	35	4.7	386	49.8	0.04	17	285.0	0.20	18
Area of the former GDR 1990	6	0.9	80	0.9	-	-	46.8	-	7
Area of the former GDR 1993	6	0.8	173	0.6	-	-	12.7	-	10
World 1990	677	100	223	135 915	100	43	119 288	100	64
World 1993	739	100	238	135 734	100	43	142 038	100	65

* As of 31 December, 1993
1) Recoverable under current technical and economic conditions

2) Proven recoverable reserves divided by current annual production
3) Percentage of world reserves

Sources: Bundesanstalt fhr Geowissenschaften und Rohstoffe; Nieders@chisches Landesamt fhr Bodenforschung

Tab. 2.19: Proven recoverable reserves of fossil fuels world-wide*

1992/1993	Crude oil conventional reserves	Natural gas	Coal Hard coal	Coal Lignite
	billions of tonnes	billions of m^3	billions of tonnes of hard coal units	billions of tonnes of hard coal units
Western Europe	2.1	5 373	29.2	20.0
Eastern Europe incl. CIS	8.0	57 162	169.4	61.4
Middle East	89.1	44 773	0	0
Asia excl. CIS	4.9	7 148	120.2	9.2
North America	3.9	7 359	184.9	17.4
Latin America	4.3	7 602	8.8	0
Africa	8.3	9 729	60.4	0
Australia, Oceania	1.1	2 898	44.2	13.8
World	135.7	142 038	617.1	121.8

*) As of: 31 December, 1993
Sources: Bundesanstalt fhr Geowissenschaften und Rohstoffe; Nieders@chsisches Landesamt fhr Bodenforschung

Tab. 2.20: Fossil fuel extraction*

	Coal		Crude oil		Natural gas	
	millions of t of HCU	%	millions of t	%	billions of m^3	%
Germany 1990	165.1	5.2	4.0	0.1	22.8	1.1
1993	125.3	-	3.1	0.1	17.5	0.8
Former West Germany 1990	95.4	3.0	4.0	0.1	16.0	0.8
1993	90.6	-	3.0	0.1	16.2	0.7
Area of the former GDR 1990	69.7	2.2	-	-	6.8	0.3
1993	34.7	-	0.1	-	1.3	0.1
World 1990	3 152	100	3 005	100	2 064.0	100
1993	-	-	3 168.6	100	2 177.2	100

* As of 31 December, 1993

1) 1993 figures for coal not yet available

Sources: Bundesanstalt fhr Geowissenschaften und Rohstoffe, Hannover; Nieders@chisches Landesamt fhr Bodenforschung

Germany's own reserves - which amount to less than 1% of the world's reserves - and Germany's own oil and natural gas production - less than 1% of world-wide production - are virtually insignificant with respect to the country's own requirements, as these two fuels' roles in the country's overall energy structure show: oil meets a total of 41% of Germany's primary energy requirements, gas a total of 18% (1993 figures). Some 99% of Germany's oil requirements, and 96% of its gas requirements, are met through imports.

In 1990, Germany's solid-fuel production amounted to some 6% of world-wide production. Production of hard coal is decreasing.

In the area of the former GDR, lignite was the dominant fuel, meeting some 70% of the country's primary energy requirements. Lignite production there has been decreasing, due to economic restructuring, fuel substitutions and improvement of energy-use efficiency. From 1989 to 1993, lignite production decreased by some 62%.

In 1990, hard coal and lignite met some 37% of Germany's total primary energy requirements; by 1993, this figure dropped by 8%. In former West Germany, the ratio of hard-coal use to lignite use is about 70:30; in the area of the former GDR, it is 6:94.

2.6.2 Primary energy consumption

Table 2.21 and Fig. 2.14 give a summary of Germany's primary energy consumption for the period 1970-1991; Tables 2.22 and 2.23, and Figs. 2.15 and 2.16, show data broken down into consumption for former West Germany and for the area of the former GDR. Consumption figures are a sum of domestic production, imports and consumption from storage; from them are substracted figures for exports, bunkering and replenishment of storage. Fig. 2.17 shows development of primary energy consumption in Germany.

In former West Germany, primary energy consumption increased by 16% from 1970 to 1980. Subsequently, primary energy consumption remained nearly constant. From 1990 to 1993, primary energy consumption increased by 4.4%. While domestic fuel production decreased by 1.9% from 1990 to 1991, imports increased by 6.8%. In both exports and bunkering, volumes are decreasing.

In the area of the former GDR, there was a continual increase in primary energy consumption; from 1970-1987, the increase amounted to 29%. As a result of unification-related plant closures, improvements in energy-use efficiency and changes in overall energy structures, primary energy consumption decreased by 37% from 1987 to 1991. In the 1970s, marked increases occurred in both imports and exports. By 1985, fuel exports, as a result of energy policy, had increased 250% over the 1970 level.

Tab. 2.21: Primary energy throughput levels for Germany between 1970 and 1991 [in PJ]

		1970	1975	1980	1985	1987	1990	1991
Domestic extraction	+	7 507	7 100	7 291	7 488	7 153	6 319	5 444
Import	+	7 038	8 111	9 509	9 075	9 469	9 682	10 186
Consumption from stores	+	78	167	95	226	106	295	243
Export	-	1 375	1 192	1 440	1 432	1 155	1 324	1 231
Bunkering	-	174	142	142	147	147	105	89
Replenishment of stores	-	154	560	311	174	129	72	86
Primary energy consumption	=	12 920	13 484	15 002	15 036	15 297	14 785	14 467

Sources: Institut fhr Energetik (Leipzig),
DIW,
Institut fhr Wirtschaftswissenschaften der Akademie der Wissenschaften, Berlin,
Staatliche Vorratskommission fhr nutzbare Ressourcen der Erdkruste, Berlin
Arbeitsgemeinschaft Energiebilanzen, Essen
The "Arbeitsgemeinschaft Energiebilanzen" is a body in which all supraregional specialised energy producers' organisations in the Federal Republic of Germany work together with economic institutes that concentrate primarily on the energy sector.

Tab. 2.22: Primary energy throughput levels for former West Germany between 1970 and 1991 [in PJ]

Domestic extraction	+	5 089	4 748	4 733	4 425	4 145	3 934	3 861
		1970	1975	1980	1985	1987	1990	1991
Import	+	6 242	6 984	8 192	7 845	8 129	8 552	9 133
Consumption of stores	+	69	156	68	212	95	110	147
Export	-	1 242	1 032	1 148	966	752	965	1 009
Bunkering	-	156	118	122	122	122	87	84
Replenishment of stores	-	132	547	287	110	122	49	58
Primary energy consumption	=	9 870	10 191	11 436	11 284	11 373	11 - 495	11 990

Source: Arbeitsgemeinschaft Energiebilanzen, Essen

Tab. 2.23: Primary energy throughput levels in the area of the former GDR between 1970 and 1991 [in PJ]

		1970	1975	1980	1985	1987	1990	1991
Domestic extraction	+	2 418	2 352	2 558	3 063	3 008	2 385	1 583
Import	+	796	1 127	1 317	1 230	1 340	1 130	1 053
Consumption of stores	+	9	11	27	14	11	185	96
Export	-	133	160	292	466	403	359	222
Bunkering	-	18	24	20	25	25	18	5
Replenishment of stores	-	22	13	24	64	7	23	28
Primary - energy consumption	=	3 050	3 293	3 566	3 752	3 924	3 300	2 477

Sources: Institut fhr Energetik (Leipzig),
DIW,
Institut fhr Wirtschaftswissenschaften der Akademie der Wissenschaften, Berlin,
Staatliche Vorratskommission fhr nutzbare Ressourcen der Erdkruste, Berlin

2.6.3 Summary of primary energy utilisation

Table 2.24 provides a summary of Germany's primary energy utilisation in the period 1970-1993 (cf. Figs. 2.18 and 2.21). Tables 2.25 and 2.26 (cf. Figs. 2.19, 2.22 and 2.23) show data broken down by former West Germany and the area of the former GDR. The tables are divided into two sections:

- The upper section shows final energy consumption broken down by consumption sectors (industry, small consumers, households, traffic on roads, other traffic), in addition to non-energy-related consumption, the most important of which is raw-materials consumption in the chemical industry. The upper section also contains data for transformation input and output in power plants, in district-heating plants and in the remaining transformation sector.
- The lower table section shows primary energy consumption, broken down into consumption of each fuel.

The following are added to obtain total figures:

- Final energy consumption, by sectors,
- Non-energy consumption,
- Flare and pipeline losses,
- Transformation input,
- Consumption during transformation, by fuels.

The following are subtracted to obtain total figures:

- Transformation output,
- Statistical differences.

Tab. 2.24: Primary energy utilisation summary for Germany between 1970 and 1993 [in PJ]

		1970	1975	1980	1985	1987	1988	1990	1991	1992*)	1993*)
Energy consumption sectors:											
Industry[1]	+	3 599	3 526	3 608	3 313	3 200	3 230	2 977	2 694	2 585	2 421
Households	+	2 180	2 186	2 494	2 666	2 728	2 512	2 382	2 506	2 385	2 524
Small consumers[2]	+	1 526	1 669	1 505	1 837	1 917	1 831	1 703	1 688	1 621	1 665
Road traffic	+	1 063	1 313	1 614	1 657	1 828	1 899	2 067	2 117	2 503[8]	2 594[8]
Other traffic and transport	+	308	276	277	267	274	286	312	311		
Non-energy consumption[3]	+	834	860	970	888	864	944	958	890	914	894
Transformation area:											
Power stations, district heating facilities										4 148[9]	4 028[9]
- Transformation input[4]	+	3 772	4 451	5 326	5 919	6 039	6 159	6 002	5 961		
- Transformation output	-	1 337	1 671	2 044	2 327	2 394	2 420	2 428	2 372		
Other transformation areas[5]											
- Transformation input	+	10 152	8 988	9 325	8 416	7 972	8 162	7 715	6 816		
- Transformation output	-	9 177	8 114	8 366	7 600	7 131	7 365	6 893	6 144		
Primary energy consumption	=	12 920	13 484	15 002	15 036	15 297	15 238	14 795	14 467	14 156	14 126
Primary fuels											
Mineral oil	+	5 653	5 926	6 060	5 155	5 298	5 296	5 238	5 548	5 630	5 744
Hard coal	+	3 142	2 191	2 497	2 511	2 420	2 362	2 306	2 330	2 207	2 128
Lignite	+	3 190	3 178	3 388	3 865	3 566	3 536	3 201	2 507	2 163	1 972
Natural gas	+	563	1 656	2 190	2 086	2 287	2 218	2 316	2 432	2 409	2 535
Hydrodynamic power[6]	+	256	239	242	177	257	198	162	129	111	173
Nuclear energy	+	67	240	564	1 354	1 362	1 511	1 446	1 387	1498	1 439
Other fuels[7]	+	49	54	61	108	107	117	126	134	138	

											135

PJ = 1 Petajoule = 34,120 tonnes of hard coal units
1) Other mining and processing sectors
2) Including military agencies
3) For example, fuels used as raw materials in the chemical industry
4) Including consumption during transformation, by fuels, transmission losses, statististical differences
5) For example, refineries, coking plants, briquetting plants
6) Including foreign trade balance for electricity
7) Firewood and waste timber, fire turf, rubbish, sewage sludge, other gases and waste heat for electricity and district heating
8) Road traffic and other forms of transport
9) Transformation area as a whole
*) Provisional figures
Sources: Arbeitsgemeinschaft Energiebilanzen, Federal Statistical Office, Institut fhr Energetik (Leipzig), DIW, Federal Environmental Agency

Tab. 2.25: Primary energy utilisation summary for former West Germany between 1970 and 1993 [in PJ]

		1970	1975	1980	1985	1987	1988	1990	1991	1992[*]	1993[*]
Energy consumption sectors:											
Industry[1]	+	2 660	2 461	2 581	2 288	2 199	2 244	2 252	2 264	2 210	2 110
Households	+	1 808	1 815	2 016	2 141	2 161	1 987	1 860	2 117	2 063	2 172
Small consumers[2]	+	1 126	1 227	1 266	1 248	1 295	1 256	1 226	1 312	1 287	1 304
Road traffic	+	935	1 154	1 447	1 497	1 645	1 711	1 818	1 857		
Other traffic and transport	+	222	201	219	215	224	238	273	278	2 192[8]	2 263[8]
Non-energy consumption[3]	+	722	688	809	725	690	750	790	763	791	783
Transformation area:											
Power plants, district heating facilities										3 415[9]	3 370[9]
- Transformation input[4]	+	2 732	3 259	3 906	4 291	4 362	4 473	4 495	4 748		
- Transformation output	-	1 027	1 248	1 520	1 697	1 743	1 771	1 839	1 893		
Other transformation - areas[5]											
- Transformation input	+	7 648	6 487	6 767	5 798	5 325	5 567	5 592	5 501		
- Transformation output	-	6 956	5 853	6 048	5 222	4 785	5 030	4 972	4 957		
Primary energy consumption	=	9 870	10 191	11 436	11 284	11 373	11 425	11 495	11 990	11 958	12 002
Primary fuels											
Mineral oil	+	5 242	5 303	5 444	4 671	4 785	4 793	4 708	4 939	4 956	5 039
Hard coal	+	2 839	1 951	2 259	2 327	2 215	2 189	2 169	2 238	2 125	2 066
Lignite	+	896	1 009	1 148	1 057	914	925	940	963	976	920
Natural gas	+	543	1 443	1 887	1 747	1 913	1 855	2 034	2 187	2 154	2 233
Hydrodynamic power[6]	+	245	228	222	173	210	176	140	152	126	182
Nuclear energy	+	61	207	420	1 206	1 233	1 375	1 383	1 387	1 498	1 439
Other fuels[7]	+	44	50	56	103	103	112	121	124	123	123

PJ = 1 Petajoule = 34,120 tonnes of hard coal units
1) Other mining and processing sectors
2) Including military agencies
3) For example, fuels used as raw materials in the chemical industry
4) Including consumption during transformation, by fuels, transmission losses, statistical differences
5) For example, refineries, coking plants, briquetting plants
6) Including foreign trade balance for electricity
7) Firewood and waste timber, fire turf, rubbish, sewage sludge, other gases and waste heat for electricity and district heating

8) Road traffic and other forms of transport
9) Transformation area as a whole
*) Provisional figures
Sources: Arbeitsgemeinschaft Energiebilanzen, Federal Statistical Office, Federal Environmental Agency

Tab. 2.26: Primary energy utilisation summary for the area of the former GDR between 1970 and 1993 [in PJ]

		1970	1975	1980	1985	1987	1988	1990	1991	1992*)	1993*)
Energy consumption sectors:											
Industry[1)]	+	939	1 065	1 027	1 025	1 001	986	725	430	375	311
Households	+	372	371	478	525	567	525	522	389	322	352
Small consumers[2)]	+	400	442	539	589	622	575	477	376	334	361
Road traffic	+	128	159	167	160	183	188	249	260[8)]	311[8)]	331[8)]
Other traffic and transport	+	86	75	58	52	50	48	39	33		
Non-energy consumption[3)]	+	112	172	161	163	174	194	168	127	123	111
Transformation area:											
Power plants, district heating facilities											
- Transformation input[4)]	+	1 040	1 192	1 420	1 628	1 677	1 686	1 507	1 213	733[9)]	658[9)]
- Transformation output	-	310	423	524	630	651	649	589	479		
Other transformation areas[5)]											
- Transformation input	+	2 504	2 501	2 558	2 618	2 647	2 595	2 123	1 315		
- Transformation output	-	2 221	2 261	2 318	2 378	2 346	2 335	1 921	1 187		

Primary energy consumption	=	3 050	3 293	3 566	3 752	3 924	3 813	3 300	2 477	2 198	2 124
Primary											
fuels	+		623	616	444	513	503	530	609		706
Mineral oil	+	411	240	238	184	205	173	137	92	674	61
Hard coal	+		2 169	2 240	2 628	2 652	2 611	2 261	1 544		1 052
Lignite	+	303	213	303	339	374	363	282	245	82	302
Natural gas	+	2	11	20	4	47	22	22	-23	1	-9
Hydrodynamic	+	294	33	144	148	129	136	63	0	187	0
power[6]	+		4	5	5	4	5	5	10		12
Nuclear		20								255	
energy										-	
Other		11								15	
fuels[7]											
		6								--	
		5								15	

PJ = 1 Petajoule = 34,120 tonnes of hard coal units
1) Other mining and processing sectors
2) Including military agencies
3) For example, fuels used as raw materials in the chemical industry
4) Including consumption during transformation, by fuels, transmission losses, statistical differences
5) For example, refineries, coking plants, briquetting plants
6) Including foreign trade balance for electricity
7) Firewood and waste timber, fire turf, rubbish, sewage sludge, other gases and waste heat for electricity and district heating
8) Road traffic and other forms of transport
9) Transformation area as a whole
*) Provisional figures
Sources: Institut fhr Energetik (Leipzig), DIW, Federal Environmental Agency

Various tendencies were apparent during 1970-1993 in former West Germany's final-energy-consumption sectors. Whereas energy consumption for traffic and transport on roads nearly doubled between 1970 and 1991, energy use in industry declined overall (by 21%, from 1970 to 1993). On the other hand, overall electric power consumption has been increasing strongly.

The small-consumer and household sectors exhibited relatively small fluctuations. In the mid-1980s (1987) energy consumption by households was 20% higher than in 1970. Energy consumption decreased until 1990; by 1993, following a new increase, it returned to nearly the 1987 level.

Contrasting trends are apparent in the transformation sector. Whereas continual increases occurred in consumption by power plants and district-heating stations, the remaining transformation areas exhibited decreasing energy consumption (especially in the sectors of coke oven by-products and mineral-oil processing).

Marked increases took place from 1970-1993 in use of natural gas, nuclear energy and other fuels. Consumption of lignite and oil increased until 1980 and then decreased in the following decade. After 1990, a marked increase (7%) in mineral-oil use took place (this figure includes adjustment for economic factors). Over the same period, consumption of hard coal decreased by a total of 27%.

In 1990 in the area of the former GDR, primary energy consumption was about one-third of that in former West Germany. The overall energy structure shows a dominance of lignite over this period, although lignite's share of overall consumption decreased from about 70% in 1990 to 50% in 1993. In 1970, hard coal met about 10% of primary energy requirements; by 1993, it was meeting only 3% of these requirements.

Until 1980, consumption of mineral oils increased. Subsequently, under the influence of the oil crisis and trade-policy considerations, it decreased until the mid-1980s. In 1993, it began increasing again; the total increase over the 1970 level was 72%.

Tendencies in the final energy consumption sectors in the area of the former GDR differ from those in former West Germany. Whereas energy consumption in the road transport sector also about doubled from 1970 to 1991, it increased by only 9% in the industrial sector by 1985. Since then, it has decreased, with a particularly large decrease taking place in 1990 and 1991, as a result of the restructuring process. In 1993, primary energy consumption in industry was some 67% less than in 1970. In the household sector, energy consumption remained nearly constant during the 1970s. It increased by some 40% until 1990; from 1990 to 1993, it decreased by 33%. The small-consumers sector showed a clearly increasing trend until 1987, by which point it had increased by about 56%. Subsequently, this sector's energy consumption decreased drastically; in 1992, it was 16% less than the 1970 level. In 1993, it increased again.

2.6.4 Final energy consumption by types of application

The primary energy utilisation summaries (cf. Tables 2.24 through 2.26) show, among other information, final energy consumption volumes by sector. To identify final energy consumption areas in which energy can be saved, it is necessary first of all to break down this energy consumption by energy services. It must be remembered, however, that only very limited statistical data exists for energy input in some application areas. In the household and small-consumer sectors in particular, the poor quality of the available data strongly limits reliability of analyses. Within the IKARUS research programme, an effort is being made to improve the data. Table 2.27, and Figs. 2.24 and 2.25, show a breakdown only for former West Germany. The table shows that about three-fourths of households' final energy consumption goes to provide indoor heat. About half of small consumers' final energy consumption goes toward the same purpose, whereas in industry process heat is the major factor, accounting for about 70% of consumption. In the transport sector, almost 100% of energy consumed is transformed into mechanical energy.

Useable energy is the energy form available to the consumer, after the final transformation, for the required energy service - for example, light, heat, mechanical energy. Table 2.27 also shows the useable energy required in former West Germany to meet various energy services requirements.

A standard way of characterising energy consumption for given useable energy requirements is to figure final energy consumption per unit of useable energy. This figure is a measure of the technical efficiency of energy transformation in heating systems, household appliances, machines, heat generators and transport vehicles. The energy supply must be structured in such a manner that required energy services are met in a manner that conserves resources and produces low emissions, while taking economic considerations into account. Energy-transformation efficiency is an important means of attaining this aim.

The development during the period covered by Tab. 2.27, for example, shows that a marked increase in efficiency was achieved in provision of indoor heat. This was achieved through replacement of obsolete, oversized heating systems with modern systems tailored to the heating requirements of the buildings in which they are installed, and with efficiencies over 85%. The efficiency achieved thus far also reveals the potential that still remains for saving energy and reducing emissions, if all existing buildings are equipped with modern heating technology.

Even greater savings potential can be tapped if thermal insulation in existing buildings is improved in conjunction with modernisation of heating systems. Improved insulation further improves the efficiency of indoor heating.

Of all the final energy consumed in former West Germany, about half is available as useable energy, while the remainder is lost to the environment as waste heat.

Although efficiency has been increased in some sectors, overall energy use has hardly improved. The reason for this is that there has been a disproportionately large increase in final energy consumption in the low-efficiency transport sector; this increase has nearly "consumed" improvements in other sectors.

Increasing efficiency in energy use not only reduces losses; it also decreases environmental pollution and energy losses throughout the chain of useable-energy provision - including energy production, fuel transport, transformation into secondary energy sources, and final energy consumption. Fig. 2.26 shows how large the losses are in the preliminary links of this chain. The figure shows both losses in final consumption sectors and in energy transformation and provision. The graph also shows a different way of viewing primary energy consumption, in addition to considering useable energy and non-energy-related consumption. Overall, the energy losses from energy provision and energy use in former West Germany's final energy consumption sectors amount to some 63% of primary energy consumption. In former West Germany, therefore, the ratio of primary energy to final energy to useable energy is 3:2:1.

Tab. 2.27: Final energy consumption, according to sectors and energy-use efficiency, in relation to final energy consumption, in former West Germany

	1987				1990			
	Final energy consumption		Provision of useable energy		Final energy consumption		Provision of useable energy	
	Final energy PJ	%	Useable energy PJ	Efficiency %	Final energy PJ	%	Useable energy PJ	Efficiency %
Total traffic and transport	1 869	100.0	339	18.1	2 091	100.0	378	18.1
- Indoor heating	4	0.2	3	65.0	2	0.1	2	70.0
- Mechanical energy, light	1 865	99.8	336	18.0	2 089	99.9	376	18.0
Total households	2 161	100.0	1 310	60.6	1 860	100.0	1 212	65.2
- Process heat	322	14.9	129	40.0	314	16.9	138	46.0
- Indoor heat	1 692	78.3	1 134	67.0	1 397	75.1	1 020	73.0
- Mechanical energy, light	147	6.8	47	32.0	149	8.0	54	36.0
Total small consumers	1 295	100.0	660	51.0	1 226	100.0	652	53.2
- Process heat	290	22.4	102	35.0	289	23.6	113	39.0
- Indoor heat	683	52.7	458	67.0	580	47.3	418	72.0
- Mechanical energy, light	322	24.9	100	31.0	357	29.1	121	34.0
Total industry	2 199	100.0	1 227	55.8	2 252	100.0	1 275	56.6
- Process heat	1 526	69.4	870	57.0	1 576	70.0	914	58.0
- Indoor heat	251	11.4	163	65.0	207	9.2	145	70.0
- Mechanical energy, light	422	19.2	194	46.0	469	20.8	216	

								70.0 46.0
Total of all sectors - Process heat - Indoor heat - Mechanical energy, light	7 524 2 198 2 630 2 756	100.0 28.4 35.0 36.6	3 536 1 101 1 758 677	47.0 51.5 66.8 24.6	7 429 2 179 2 186 3 064	100.0 29.3 29.4 41.3	3 517 1 165 1 585 767	47.3 53.5 72.5 25.0

Sources: Arbeitsgemeinschaft Energiebilanzen, RWE-Anwendungstechnik

2.6.5 Per-capita energy consumption

Table 2.28 shows development of per-capita energy consumption in Germany - both for the entire country and broken down by former West Germany and the area of the former GDR - for the period 1970-1993 (cf. Fig. 2.27).

For comparison, Tables 2.29 and 2.30 show development of world-wide primary energy consumption and per-capita energy consumption for the world population and for selected countries and groups of countries (cf. Fig. 2.28).

The per-capita energy consumption in Germany is about three times that of the world population's per-capita energy consumption.

While the world population's per-capita energy consumption remained nearly constant for two decades at a level of about 60 gigajoules per person, per-capita energy consumption increased by about 18% in Germany from 1970 to 1987. Subsequently, a decrease took place (of 11% by 1993).

Marked differences are apparent between former West Germany and the area of the former GDR in terms of development of per-capita energy consumption. While per-capita energy consumption in former West Germany stagnated during the 1980s, in the area of the former GDR it increased continually until 1987. On the average, consumption there was some 20% greater than in former West Germany. Subsequently, a strong decrease took place until 1993; by this year, per-capita energy consumption had dropped to about half the 1987 level.

Tab. 2.28: Per-capita energy consumption in Germany between 1970 and 1993

	1970	1980	1985	1987	1990	1991	1992*	1993*
Total population (in millions)	77.8	78.3	77.6	77.9	79.7	80.3	81.0	81.1
- of these, no. in former West Germany	60.7	61.6	61.0	61.2	63.7	64.5	65.3	65.4
- of these, no. in area of the former GDR	17.1	16.7	16.6	16.7	16.0	15.8	15.7	15.7
Total primary energy consumption (PJ)	12 920	15 002	15 036	13 843	14 795	14 467	14 156	14 126
- of this, amount in former West Germany	9 870	11 436	11 284	10 023	11 495	11 990	11 958	12 002
- of this, amount in the area of the former GDR	3 050	3 566	3 752	3 820	3 300	2 477	2 198	2 124
Total per-capita energy consumption (GJ/person)	166	192	194	196	186	180	175	174
- of this, in former West Germany	163	186	185	186	180	186	183	184
- of this, in the area of the former GDR	178	214	226	235	206	157	140	135

*Tentative figures

Sources: Federal Statistical Office
UN, Energy Statistics Yearbook, N.Y. 1992,
Arbeitsgemeinschaft Energiebilanzen,
DIW,
Institut fhr Energetik

Tab. 2.29: Development of the primary energy consumption and per-capita energy consumption of the world population between 1970 and 1991

	1970	1980	1985	1987	1990	1991
World consumption in primary energy (PJ)*	212 636	268 432	288 776	303 085	341 673	344 618
World population (millions)	3 697 918	4 450 210	4 854 547	5 027 302	5 295 300	5 386 733
Per-capita energy consumption of the world population (GJ/person)*	58	60	60	60	65	64

* Not including biomass

Sources: Statistisches Jahrbuch 1992
UN, Energy Statistics Yearbook, Nr. 4. 1992,
World Energy Statistics and Balances
UN, World Population Prospects, 1993
Energiedaten 92/93, BMWi, 1993

Tab. 2.30: Primary energy consumption[1] and per-capita energy consumption, by groups of countries and selected countries, in 1990

	Primary energy consumption (PJ)	Per-capita energy consumption (GJ/person)
OECD	166 809	199
USA	79 790	317
EC, total	47 601	145
Japan	17 928	145
Germany[2]	15 372	193
Former West Germany[2]	11 647	181
Area of the former GDR[2]	3 725	229
France	9 243	164
Great Britain	8 793	153
Italy	6 479	113
Australia	3 707	217
Spain	3 684	95
Netherlands	2 780	186
Belgium	2 006	201
Sweden	1 990	232
Greece	927	91
Denmark	767	149
Portugal	687	70
Ireland	440	125
Luxembourg	149	393
Eastern Europe	74 481	175
USSR (former)	56 833	197
Poland	4 122	109
Czechoslovakia (former)	2 933	187
Romania	2 550	110
OPEC	16 999	37
Indonesia	3 403	19
Saudi Arabia	3 052	205
Venezuela	1 670	85
Nigeria	1 665	14
Other countries	83 713	23
PR China	28 438	25
India	10 224	12
Brasil	5 580	37
Egypt	1 334	26

1) Incl. biomass
2) Due to the use of differing statistics, the figures differ from those in Table 2.28

Sources: Energy Balances (various editions); OECD/IEA; Federal Environment Agency, Berlin

2.6.6 Development of GDP, primary energy consumption and specific energy consumption

Table 2.31 shows the development of gross domestic product and primary energy consumption (in 1985 prices) in former West Germany for the period 1970 to 1993 (cf. Fig. 2.29). It also shows this development for Germany and for the area of the former GDR for the period 1991 to 1993.

Since 1970, the gross domestic product in former West Germany increased by nearly two-thirds. On the other hand, primary energy consumption, after increasing by 16% in the 1970s, remained largely constant from 1980 to 1990. As a result, specific energy consumption decreased by 29% from 1970 to 1990.

Tab. 2.31: Development of real gross domestic product (in 1991 prices), of primary energy consumption and of specific energy consumption in Germany

Year	Gross domestic product		Primary energy consumption		Specific energy consumption
	Billions of DM	Index 1970 = 100	PJ	Index 1970 = 100	PJ/billion DM
Former West Germany					
1970	1 543	100	9 870	100	6.40
1975	1 719	111	10 191	103	5.93
1980	2 018	131	11 436	116	5.67
1985	2 136	138	11 284	114	5.28
1987	2 218	144	11 373	115	5.13
1990	2 520	163	11 495	116	4.56
1991	2 635	171	11 990	121	4.55
1992	2 676	173	11 958	121	4.47
1993	2 626	170	12 002	122	4.57
Area of former GDR					
1991	181		2 477		13.68
1992	198		2 198		11.10
1993	213		2 124		9.97
Germany					
1991	2 816		14 467		5.14
1992	2 874		14 156		4.92
1993	2 839		14 126		4.97

Source: Federal Statistical Office

2.6.7 Development of energy prices

Table 2.32 shows the development of selected energy prices for the period 1970 to 1992 in former West Germany (cf. Figs. 2.30 and 2.31). The table shows both import and consumer prices, and breaks down the latter into prices for the household, industry and transport sectors.

Tab. 2.32: Development of energy prices (nominal) in former West Germany

	Unit	1970	1980	1985	1987	1990	1992*
Crude oil	$/GJ	0.22	6.17	4.73	3.14	4.05	3.36
Import prices:							
- Crude oil	DM/GJ	1.41	10.69	14.59	5.88	6.54	5.31
- Natural gas	DM/GJ	1.49	6.18	11.46	4.45	4.58	4.27
- Hard coal	DM/GJ	2.05	3.82	4.97	3.00	3.16	2.87
Consumer prices:							
Households (incl. VAT)							
- Heating oil, light	DM/GJ	3.15	12.10	15.60	7.42	9.60	9.36
- Natural gas [2]	DM/GJ	8.87	16.14	23.37	15.27	16.42	18.98
- Broken coke [3]	DM/GJ	7.47	18.05	21.75	21.78	21.29	21.92
- Electricity [2]	DM/GJ	37.33	57.12	76.00	79.72	81.56	82.53
Industry: (excl. VAT)							
- Hard coal [3]	DM/GJ	2.55	6.69	8.70	8.80	9.20	9.77
- Heating oil, heavy [4]	DM/GJ	2.15	8.65	12.99	5.78	5.75	4.92
- Natural gas [2]	DM/GJ	2.01	7.55	14.42	7.28	8.51	8.29
- Electricity [2]	DM/GJ	17.80	27.81	36.89	38.44	37.61	37.44
Traffic/transport:							
- Normal petrol [5) 6)]	DM/GJ	17.22	35.60	41.57	29.7	34.91	41.11
- Diesel fuel [5]	DM/GJ	15.99	32.53	37.36	25.63	28.61	29.69

*) Tentative figures
1 GJ = 27.9 l heating oil, light; 31.5 m^3 natural gas; 34.9 kg broken coke; 277.8 kWh electric power; 23.4 kg heating oil, heavy; 33.6 kg hard coal; 28.0 l diesel fuel; 0.17 barrel crude oil[1]
1) b = barrel = ca. 159 l; until 1983 Arabian light; from 1984 Brent; since July 1987 Brent dated
2) Average proceeds
3) Fine coal (fat coal), Ruhr district

4) Average prices if 2001 t and more are sold per month
5) Brand-name product with self-service
6) Unleaded regular grade petrol as from 1986
Source: Federal Statistical Office

The general tendency in the development of import and consumer prices was a strong increase, until 1985, over 1970 levels; subsequently, prices decreased, more or less markedly, until 1992. The exceptions were electricity prices for households and prices for electricity and hard coal for industry; these prices increased continually throughout the entire period under consideration.

Developments in gross national product and in cost of living were similar. On the other hand, import prices, based on a price index (1985 = 100), had decreased by 1990 nearly to the 1980 level.

Table 2.33 shows the development of the tax component in energy prices, for selected fuels and sectors.

Table 2.34 contains a price comparison for 1990 between former West Germany and the OECD countries of Europe.

Tab. 2.33: Percentage of taxes in energy prices in former West Germany [%]

	1980	1990
Diesel fuel	41.4	50.1
Petrol	48.7	63.1
Light heating oil:		
- Industry	3.0	13.8
- Households	14.3	24.4
Heavy heating oil for electricity production	4.2	23.3
Electricity:		
- Industry	4.3	7.6
- Households	15.3	19.0

Source: IEA

Tab. 2.34: Relative prices: former West Germany/European OECD countries*) [in %]

	1990
Diesel fuel Petrol	93.4 88.2
Light heating oil: - Industry - Households	 86.6 71.9
Heavy heating oil for electricity production	-
Electricity: - Industry - Households	 113.8 130.4

*) German prices were given in relation to unweighted average prices of the European OECD countries, expressed in US dollars at the exchange rate of the day

Source: Energy Balances, OECD/IEA, 1991

Table 2.35 compares 1990 energy prices in the household and industry sectors in selected countries (cf. Figs. 2.32 and 2.33).

Tab. 2.35: International energy prices of selected countries in 1990 for households and industry, by fuels

Price comparison for households

	Petrol US dollars per GJ	Heating oil (light) US dollars per GJ	Electricity US dollars per GJ	Gas US dollars per GJ
France	24.83	9.47	33.89	9.50
Germany	18.86	6.45	35.28	7.47
Italy	32.02	18.39	36.94	13.18
Japan	19.57	6.59	37.78	16.97
Great Britain	22.51	6.63	26.94	7.37
USA	9.40	8.00	21.94	5.67

Price comparison for industry

	Coal US dollars per GJ	Heating oil (heavy) US dollars per GJ	Electricity US dollars per GJ	Gas US dollars per GJ
France	3.48	3.19	15.83	3.76
Germany	6.22	3.48	25.28	4.53
Italy	-	4.57	26.94	3.80
Japan	2.33	4.55	34.72	9.94
Great Britain	2.63	3.26	18.06	3.79
USA	1.24	2.67	13.33	2.70

Source: IEA Statistics 1992, 4th quarter 1991; calculated on the basis of purchase-power parity and/or exchange rates

2.7 Transport and housing

2.7.1 Transport volume

Tables 2.36 and 2.37 show how transport volumes have developed in the passenger and goods transport sectors (cf. Figs. 2.34 through 2.39).

In former West Germany, total transport volumes increased by over 60% in the period 1970 to 1992. In passenger transport, the "modal split" has shifted more and more in favour of air transport and individual motor-vehicle transport, and away from railways and local public passenger transport (LPPT). A similar development has taken place in transport of goods, as more and more transports have been shifted from railways to roads.

Until 1990, most transports in the area of the former GDR were accomplished by rail and LPPT; after 1990, individual motor-vehicle transport and transport of goods by road increased rapidly.

2.7.2 Numbers of motor vehicles

Table 2.38 shows how numbers of motor vehicles (MV) developed in former West Germany (1970-1993), in Germany and in the area of the former GDR (1980-1993). The different outset situation in East and West is particularly clear (former West Germany in 1990: 480 MV/1,000 inhabitants; area of the former GDR in 1990: 250 MV/1,000 inhabitants). The development of the overall number of motor vehicles in the area of the former GDR since 1990 has to do with the strong growth in road traffic that has occurred there.

Tab. 2.36: Traffic volume in passenger transport [in billions of passenger-kilometers]

Year	Air transport		Public transport: Railways		Public transport: Local transport		Personal-motor-vehicle traffic		Taxis and hired cars		Total volume
	billions of pass.-km	in %	billions of pass.-km	in %	billions of pass.-km	in %	billions of pass.-km	in %	billions of pass.-km	in %	billions of pass.-km
Former West Germany											
1970	6.6	1.4	39.2	8.6	58.4	12.8	350.6	76.8	1.7	0.4	456.5
1975	8.4	1.6	39.2	7.5	67.7	13.0	405.4	77.6	1.8	0.3	522.5
1980	11.0	1.8	41.0	6.8	74.1	12.4	470.3	78.6	2.2	0.4	598.6
1985	12.7	2.1	43.5	7.2	62.3	10.3	481.6	80.0	2.0	0.3	602.1
1987	14.7	2.3	40.0	6.2	61.3	9.4	531.3	81.8	2.1	0.3	649.4
1990	18.4	2.5	44.6	6.2	65.1	9.0	593.8	82.0	2.5	0.3	724.4
1991	17.6	2.4	45.2	6.2	67.2	9.2	601.0	81.9	2.5	0.3	733.5
1992	19.5	2.6	47.5	6.3	68.7	9.2	610.0	81.6	2.6	0.3	748.3
Area of the former GDR											
1980	0.2	0.2	22.0	20.4	29.7	27.5	55.7	51.6	0.3	0.3	107.9
1985	0.3	0.2	22.5	18.4	29.3	24.0	69.7	57.1	0.3	0.2	122.1
1987	0.3	0.2	22.6	17.5	30.0	23.3	75.7	58.7	0.3	0.2	128.9
1990	0.3	0.2	18.0	13.5	24.8	18.6	90.0	67.5	0.3	0.2	133.4
1991	0.4	0.3	10.2	7.9	16.3	12.6	102.6	79.0	0.3	0.2	129.8
1992	0.6	0.5	9.8	7.6	14.5	11.2	104.3	80.5	0.3	0.2	129.5

Tab. 2.36 (con'd):

Year	Air transport		Public transport: Railways		Public transport: Local transport		Personal-motor-vehicle traffic		Taxis and hired cars		Total volume
	billions of pass.-km	in %	billions of pass.-km	in %	billions of pass.-km	in %	billions of pass.-km	in %	billions of pass.-km	in %	billions of pass.-km
Germany											
1980	11.2	1.6	63.0	8.9	103.8	14.7	526.0	74.5	2.5	0.4	706.5
1985	13.0	1.8	66.0	9.1	91.6	12.6	551.3	76.1	2.3	0.3	724.3
1987	15.0	1.9	62.6	8.0	91.3	11.7	607.0	78.0	2.4	0.3	778.3
1990	18.2	2.2	62.6	7.3	89.9	10.5	683.8	79.7	2.8	0.3	857.8
1991	18.0	2.1	55.4	6.4	83.5	9.7	703.6	81.5	2.8	0.3	869.3
1992	20.1	2.3	57.3	6.5	83.2	9.5	714.3	81.4	2.9	0.3	877.8
1993 *	21.7	2.4	56.0	6.3	79.5	9.0	730.8	82.3	-	-	888.0

* Figures for 1993 available only for Germany

Sources: Verkehr in Zahlen 1991/1993, ed.: Federal Ministry of Traffic, IFO-Wirtschaftskonjunktur 1994

Tab. 2.37: Traffic volume in goods transport [in billions of tonne-kilometers]

Year	Air transport		Railways		Road transport local		Road transport long-distance		Inland waterways		Long-distance pipelines		Total volume
	billions of tonne-km	in %	billions of tonne-km	in %	billions of tonne-km	in %	billions of tonne-km	in %	billions of tonne-km	in %	billions of tonne-km	in %	billions of tonne-km
Former West Germany													
1970	0.14	0.07	71.5	33.2	36.1	16.8	41.9	19.4	48.8	22.7	16.9	7.8	215.3
1975	0.18	0.08	55.3	25.9	36.7	17.2	59.3	27.2	47.6	22.3	14.6	6.8	213.7
1980	0.25	0.10	64.9	25.4	44.4	17.4	80.0	31.3	51.4	20.1	14.3	5.6	255.3
1985	0.31	0.12	64.0	25.1	40.6	15.9	91.6	35.9	48.2	18.9	10.5	4.1	255.2
1987	0.37	0.14	59.1	22.6	42.8	16.3	99.9	38.1	49.7	19.0	10.1	3.9	262.0
1990	0.44	0.15	61.8	20.6	49.4	16.5	120.4	40.1	54.8	18.3	13.3	4.4	300.1
1991	0.42	0.13	62.9	19.7	51.4	16.1	136.3	42.7	55.0	17.3	13.5	4.2	319.5
1992	0.43	0.13	56.8	17.8	52.9	16.5	140.0	44.0	55.5	17.5	13.3	4.2	318.9
Area of the former GDR													
1980	n.a.	-	56.4	66.7	12.4	14.	8.6	10.	2.2	2.6	5.0	5.9	84.6

						7		2					
1985	n.a.	-	58.7	72.7	9.3	11. 5	5.8	7.2	2.4	3.0	4.5	5.6	80.7
1987	n.a.	-	58.8	72.5	9.2	11. 3	6.3	7.8	2.4	3.0	4.4	5.4	81.1
1990	n.a.	-	40.9	69.2	6.8	11. 5	6.2	10. 5	1.9	3.2	3.3	5.6	59.1
1991	n.a.	-	17.8	48.4	7.0	19. 0	8.0	21. 7	1.0	2.7	3.0	8.1	36.8
1992	0.4	-	13.9	31.9	10.0	23. 0	16.1	37. 0	1.2	2.8	2.3	5.3	43.5

Tab. 2.37 (con'):

Year	Air transport		Railways		Road transport				Inland waterways		Long-distance pipelines		Total volume
					local		long-distance						
	billions of tonne-km	in %	billions of tonne-km	in %	billions of tonne-km	in %	billions of tonne-km	in %	billions of tonne-km	in %	billions of tonne-km	in %	billions of tonne-km
Germany													
1980	-	-	121.3	35.7	56.8	16.7	88.6	26.1	53.6	15.8	19.3	5.7	339.6
1985	-	-	122.7	36.6	49.9	14.9	97.4	29.0	50.6	15.1	15	4.5	335.6
1987	-	-	117.9	34.4	52.0	15.2	106.2	31.0	52.1	15.2	14.5	4.2	342.7
1990	-	-	102.7	28.6	56.2	15.7	126.6	35.3	56.7	15.8	16.6	4.6	358.8
1991	-	-	80.7	22.7	58.4	16.4	144.3	40.5	56.0	15.7	16.5	4.6	355.9
1992	0.8	0.22	70.7	19.5	62.9	17.4	156.1	43.1	56.7	15.7	15.6	4.3	362.0
1993	0.6	0.17	62.6	17.7	65.2	18.4	155.8	44.1	55.5	15.7	13.9	3.9	353.5

* Figures for 1993 available only for Germany

Sources: Verkehr in Zahlen 1991/1993, ed. Federal Ministry of Traffic, IFO-Wirtschaftskonjunktur 1994

Tab. 2.38: Development of numbers of vehicles, including low-pollution cars and newly registered vehicles, by various technical groupings

	Year (1 July)	Total cars			Trucks and towing vehicles	Motorcycles	Other vehicles
		Total in millions	of these, low-pollution cars *)				
			%	Number in millions	in millions	in millions	in millions
Former West Germany	1970	13.9	-	-	1.1	0.2	-
	1975	17.9	-	-	1.2	0.3	-
	1980	23.2	-	-	1.3	0.6	1.8
	1985	25.8	1.9	0.5	1.3	1.0	2.0
	1987	27.9	10.0	2.8	1.4	1.1	2.0
	1990	30.7	30.9	9.5	1.5	1.2	2.1
	1991	31.3	41.5	13.0	1.5	1.3	2.2
	1992	32.0	49.9	16.0	1.6	1.4	2.3
	1993	32.7	67.0	21.9	1.6	1.7	2.9
Area of the former GDR	1970	-	-	-	-	-	-
	1975	-	-	-	-	-	-
	1980	2.7	-	-	0.2	1.3	0.4
	1985	3.3	-	-	0.2	1.3	0.5
	1987	3.6	-	-	0.2	1.3	0.5
	1990	4.8	-	-	0.3	1.3	0.6
	1991	5.6	-	-	0.2	1.2	0.4
	1992	5.9	30.5	1.8**)	0.3	1.1	0.4
	1993	6.1	55.3	3.4	0.7	0.2	0.6
Germany	1980	25.9	-	-	1.5	1.9	2.2
	1985	29.1	-	-	1.5	2.3	2.5
	1987	31.5	-	-	1.6	2.4	2.5
	1990	35.5	-	-	1.8	2.5	2.7
	1991	36.9	-	-	1.7	2.5	2.6
	1992	37.9	80.4	17.8	1.9	2.5	2.7
	1993	38.8	65.2	25.3	2.3	1.9	3.5

*) Vehicles conforming to Annex XXIII (US norm) + XXV (EC norm), diesel + spark-ignition engine; source: statistics of the Kraftfahrtbundesamt

**) Calculated using figures of the Kraftfahrtbundesamt: difference between Germany as a whole and former West Germany

Source: Verkehr in Zahlen, publ. by : Federal Ministry of Traffic; Kraftfahrtbundesamt

2.7.3 Forecast development of transport volume

As a result of the EC Single Market, German unification and the opening-up of eastern European markets, transport volume will continually to grow strongly. Tables 2.39 through 2.42 contain forecasts concerning the further development of transport volumes until the year 2010, for both passenger and goods transports (cf. Figs. 2.40 through 2.43). These forecasts are based on premises of the Federal Traffic Infrastructure Plan (*Bundesverkehrswegeplan - BVWP*), as well as on estimates of the German Institute for Economic Research (DIW).

It is clear that both under trend conditions (scenario F of the BVWP and DIW), and under the assumption that certain stresses are added to road traffic (for example, travel-time delays and increases in travel costs; scenario H), large further increases in personal-motor-vehicle traffic and in long-distance transports by road must be expected. This fact makes it necessary for further efforts to be made to limit emissions in this sector, by means of technical and planning measures.

Tab. 2.39: Development and anticipated development,through the year 2010, of goods transports [in billions of tonne-kilometers]

	Long-distance road transport			Railway transport			Inland waterways		
	Former West Germany	Area of the former GDR	Germany	Former West Germany	Area of the former GDR	Germany	Former West Germany	Area of the former GDR	Germany
1988[1)]	106.2	6.7	112.9	60.0	60.4	120.4	52.9	2.5	55.4
1992[1)]	140.0	16.1	156.1	56.8	13.9	70.7	55.5	1.2	56.7
2010 DIW[2)]	196	61	257	94	41	135	79	24	103

1) Source: Verkehr in Zahlen, publ. by Federal Ministry of Traffic; Kraftfahrtbundesamt

2) from : R&D project "Verminderung der Luft- und L@rmbelastung durch den Ghterverkehr 2010" of the Federal Environment Agency; Publication planned soon

Tab. 2.40: Forecast total goods-transport volume in 2000, 2005 und 2010 according to the Federal Traffic-infrastructure plan (*Bundesverkehrswegeplan*) [in billions of tonne-kilometers]

	Long-distance road transport			Railway transport			Inland waterways		
	Former West Germany	Area of the former GDR	Germany	Former West Germany	Area of the former GDR	Germany	Former West Germany	Area of the former GDR	Germany
2000 Scen. H Scen. F	154.9 160.5	26.5 39.3	181.4 188.8	101.6 96.6	65.9 65.2	167.5 160.6	79.0 78.4	11.8 11.8	90.8 90.1
2005 Scen. H Scen. F	169.7 178.5	28.3 42.9	209.0 221.4	117.9 110.1	63.9 61.4	183.1 171.6	86.0 84.9	17.1 16.9	103.1 101.9
2010 Scen. H Scen. F	182.2 194.6	56.2 62.6	238.4 257.2	133.9 122.9	60.2 54.4	194.1 177.3	90.9 89.5	25.4 24.6	116.3 114.1

Source: "prognos" 1992 "Entwicklung der Emissionen von Luftschadstoffen und CO_2 durch den Verkehr in Ost- und Westdeutschland bis 2010; BMV-FuE Nr. 90344/91

Tab. 2.41: Development of passenger transport [in billions of passenger-kilometers]

	Personal-motor-vehicle traffic			Public transport on roads			Railways			Air transport		
	Former West Ger-many	Area of the former GDR	Germany	Former West Ger-many	Area of the former GDR	Germany	Former West Ger-many	Area of the former GDR	Germany	Former West Ger-many	Area of the former GDR	Germany
19-88	555.6	79.2	634.8	63.7	30.8	94.5	41.8	22.8	64.6	15.7	0.6	16.3
19-92	611.0	104.3	714.3	68.7	14.5	83.2	47.5	9.8	57.3	19.5	0.6	20.1

Quelle: Verkehr in Zahlen, publ. by: Federal Ministry of Traffic; Kraftfahrtbundesamt

Tab. 2.42: Forecast passenger-transport volume in 2000, 2005 und 2010, according to the Federal Traffic Infrastructure Plan [in billions of passenger-kilometers]

	Personal-motor-vehicle traffic			Public transport on roads			Railways			Air transport		
	Former West Ger-many	Area of the former GDR	Germany	Former West Ger-many	Area of the former GDR	Germany	Former West Ger-many	Area of the former GDR	Germany	Former West Ger-many	Area of the former GDR	Germany
2000 Scenario H Scenario F	634.2 653.9	129.0 134.6	763.2 788.5	80.0 75.0	24.5 22.6	104.5 97.6	58.6 52.7	28.4 25.1	87.0 77.8	20.7 19.7	3.0 2.9	23.7 22.6
2005 Scenario H Scenario F	651.0 679.8	151.7 160.2	802.7 839.9	82.6 74.7	25.3 22.4	107.9 97.2	64.7 56.5	27.0 22.5	91.6 79.0	23.3 21.9	5.6 5.4	29.0 27.4
2010 Scenario H Scenario F	659.0 679.8	176.6 189.0	835.6 885.4	84.1 74.7	26.2 22.3	110.3 95.7	69.8 56.5	17.4 13.8	87.2 73.6	25.6 21.9	9.6 9.2	35.2 33.0

Source: "prognos" 1992 "Entwicklung der Emissionen von Luftschadstoffen und CO_2 durch den Verkehr in Ost- und Westdeutschland bis 2010; BMV-FuE Nr. 90344/91

2.7.4 Residential structures and existing housing

In 1990, the average size of residences in Germany was 81.9 m^2; each resident had an average of 34.8 m^2 (cf. Table 2.43). In the area of the former GDR, the corresponding figures, at 64.4 m^2 per residence and 28.2 m^2 of living space per person, were smaller than those in former West Germany: 86.5 m^2 per residence and 36.4 m^2 of living space per person.

Tab. 2.43: Housing

	Former West Germany		Area of the former GDR		Germany	
	1990	1992	1990	1992	1990	1992
Living space in m^2						
- per residence	86.5	86.7	64.4	64.5	81.9	82.2
- per resident	36.4	36.5	28.2	29.0	34.8	35.1
Number of rooms						
- per residence	4.4	4.4	3.8	3.8	4.3	4.3
- per resident	1.9	1.9	1.7	1.7	1.8	1.8
Residences with						
- 1 room	2.3	2.3	1.7	1.8	2.2	2.2
- 2 rooms	5.8	5.8	8.8	8.9	6.5	6.5
- 3 rooms	21.0	21.0	27.4	27.4	22.3	22.3
- 4 rooms	29.2	29.1	37.8	37.7	30.9	30.8
- 5 rooms	19.6	19.6	16.6	16.5	18.9	19.0
- 6 and more rooms, in %	22.1	22.2	7.7	7.7	19.2	19.2

Source: Federal Statistical Office

There is a trend toward smaller residences. Among the causes for this are: the number of one-person households is increasing; the number of three-generation households is decreasing; there are fewer children per household; the numbers of divorces are increasing; children are tending to move out of their parents' home earlier; the difference in the life expectancies of men and women has increased. This trend is considerably stronger in former West Germany than in the area of the former GDR. Consequently, the percentage of three- and four-person households in former West Germany is considerably smaller than in the area of the former GDR (cf. Table 2.44).

As a result of the continuing strong demand for living space, and of the favourable supply conditions, the total number of residences will continue to increase in coming years. The reasons for the strong demand include changes in sizes of households, "catch-up" effects and immigration.

Tab. 2.44: Private households by size

Private households with	Household-size class as a ratio of all households, in %			
	Former West Germany		Area of the former GDR	
	1990	1992	1990	1992
1 Person	35.0	35.0	28.5	28.1
2 Persons	30.2	31.0	29.8	32.5
3 Persons	16.7	16.2	20.9	19.6
4 Persons	12.8	12.6	16.3	16.0
5 and more persons	5.3	5.2	4.5	3.8
Total	100.0	100.0	100.0	100.0

Source: Federal Statistical Office, Mikrozensus

3. Inventories of anthropogenic emissions and binding in reservoirs and by sinks

The following section provides an overview of emissions of the most important greenhouse gases. Ozone, one of them, is formed in the atmosphere by photochemical reactions of the precursor compounds NO_x (nitrogen oxides), NMVOC (methane-free volatile organic compounds) and CO (carbon monoxide). These substances have thus been included here as indirectly acting greenhouse gases. On the other hand, figures for CFCs and halons, pursuant to the provisions of the Framework Convention on Climate Change, are not the subject of the present report; that substance class is governed by the Montreal Protocol.

3.1 Inventory of greenhouse-gas emissions

3.1.1 Methods/basis for the inventories

3.1.1.1 Description and determination

The emissions tables begin with Table 3.1, which provides a strongly compressed summary, by type of emission-causing process. Emissions amounts are calculated on the basis of statistics for the wide range of emissions-relevant socio-economic activities - for example, energy consumption, size of livestock inventories - using special indexes for emissions intensity. These indexes are normally referred to as emissions factors, and given in the form, for example, of kg of methane per dairy cow and year. The basis for the figures for energy-related emissions are the fuel and propellant consumption figures provided by the Working Group on Energy Balance Statements (for former West Germany) and by the *Institut fhr Energetik (IfE)* (for the area of the former GDR).

The degree of detail in the calculations depends on the complexity of the relevant circumstances and on data availability. Rough estimates of emissions are possible even for incomplete sets of relevant data.

3.1.1.2 Classification of emission sources

For the present report, the emission-source classification provided by the "IPCC Draft Guidelines for National Greenhouse Gas Inventories" has been used. The total-emissions figures do not take account of emissions caused by international activities (for example, maritime commerce (bunkering), international air transports). These emissions are listed separately, however, to illustrate the relevant emissions percentages.

3.1.2 Emissions of greenhouse gases

3.1.2.1 Overview

In keeping with Article 4 of the Framework Convention on Climate Change, only anthropogenic emissions have been included. As to CO_2, only those emissions have included that have significance in the resulting balance-sheet summary of emissions and biomass binding; i.e. combustion of wood and plant waste, and biological decay of organic waste, are not included. On the other hand, all emissions from waste incineration have been included.

Table 3.1 shows emissions of greenhouse gases for Germany in 1990. The most significant greenhouse gas, by volume, is CO_2; ca. 1 billion tonnes of it are emitted per year (cf. Fig. 3.1).

The energy-related percentages of emissions of the various greenhouse gases differ widely. Emissions of CO_2,

NO_x and CO are almost completely energy-related. About half of NMVOC emissions are energy-related. In Germany, emissions of the greenhouse gases CH_4 (cf. Fig. 3.2) and N_2O (cf. Fig. 3.3) are predominantly not energy-related.

Tab. 3.1: Summary of emissions of greenhouse gases in Germany in 1990

Sources and sinks of greenhouse gases	CO_2 Mt/a		CH_4 kt/a		N_2O kt/a		NO_x as NO_2 kt/a		CO kt/a		NMVOC not including CFCs/CCs kt/a	
Total emissions	1 012		6 218		223		2 944		10 768		2 978	
	709	303	5 015	1 203	183	40	2 377	566	7 131	3 637	2 234	744
1. Energy-related	983		1 767		33		2 923		10 104		1 679	
	687	296	1 574	193	24	9	2 361	561	6 526	3 578	1 093	586
2. Industrial processes	29		11		100		21		664		129	
	22	7	9	2	95	5	16	5	605	59	111	18
3. Use of solvents and products					6						1 170	
					5	1					1 030	140
4. Agriculture			2 043		80		n.a.		n.a.		n.a.	
			1 497	546	55	25	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
5. Land use changes and forestry[1]	(- 20)											
	(- 14)	(- 6)										
6. Waste management	n.a.		2 397		4		n.a.		n.a.		n.a.	
	n.a.	n.a.	1 935	462	4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

High-seas bunkering[1]	8		0		n.a.		155		37		16	
	7	1	0	0	n.a.	n.a.	128	27	31	7	13	3
International air transport[1]	11		0		n.a.		50		58		9	
	11	1	0	0	n.a.	n.a.	49	2	54	4	9	1

n.a. Not available

[1] Not included in total emissions

Source: Federal Environment Agency

Germany	
Former West Germany	Area of the former GDR

3.1.2.2 Emissions-data structure

Emissions data is presented in both combined form for Germany and in separate form for former West Germany and the area of the former GDR. The IPCC's structural scheme has been used as a basis for this presentation.

Tables 3.2 through 3.4 provide overviews of total emissions by emission-source groups.

Annex 1 contains a detailed listing of emissions (including subgroups and individual activities), as well as reference data for selected emissions-causing activities (production and distribution of fossil fuels, agriculture, waste management and use of solvents). This selection has been made with the aim of shedding light on emissions processes that play a significant role in emissions of the directly acting greenhouse-gas components CH_4 and N_2O.

Whereas the "Agriculture" section includes biological processes (among others), if they are regularly repetitive (while remaining largely unchanged with regard to type and extent), the emissions-source group "Land Use Change" is reserved for transition processes occurring on a time-scale that can extend far beyond the individual reference year in question.

Forest use is the central focus of "Land Use Change". The reason for this is that more carbon per unit area is stored in forest land than in land used for other purposes. Changes in forests, especially in their area, influence the size of above-ground and below-ground carbon reservoirs. Clearing of forests releases CO_2. New afforestation, as well as maintenance of wood-removal rates that are smaller than growth rates, results in CO_2-

binding in biomass.

Land use changes also affect emissions of other greenhouse gases. For example, drainage of wetlands changes CH_4 emissions. Conversion of grassland to cultivated farmland mainly affects N_2O emissions, in addition to CO_2 emissions.

In Germany, land use changes are expected primarily as a result of set-asides of agricultural land. Such set-asides provide opportunities for new afforestation. Because of the long-term nature of transition processes, standardised calculation methods for emissions data are required, in the interest of international comparability. Such methods remain to be prepared and agreed upon. Chapter 3.2 of the present report (Inventory of CO_2-binding in reservoirs/by sinks - forests) describes the carbon volumes bound through afforestation.

Tab. 3.2: Emissions of greenhouse gases, by sectors, in Germany in 1990

Sources and sinks of greenhouse gases	CO_2 Mt/a	CH_4 kt/a	N_2O kt/a	NO_x as NO_2 kt/a	CO kt/a	NMVOC excl. CFCs/CCs kt/a
Total emissions	1 012	6 218	223	2 944	10 768	2 978
1. Energy-related emissions	983	1 767	33	2 923	10 104	1 679
A Combustion-related	983	228	33	2 921	10 078	1 474
1 Energy generation and transformation	436	12	15	672	921	11
2 Industry	169	16	4	217	899	15
3 Traffic and transport	159	69	9	1 732	5 990	1 252
4 Small consumers	65	5	2	35	183	10
5 Households	129	91	3	73	1 483	96
6 Agriculture and forestry[1)]	5	1	0	2	35	2
7 Other[2)]	21	3	0	183	224	60
8 Burning of biomass[3)]	-	31	0	7	234	28
B Non-combustion-related	1	1 539	0	2	26	205
1 Extraction and distribution of oil and gas	1	317	0	2	26	205
2 Coal mining	-	1 222	-	-	-	-
2. Industrial processes	29	11	100	21	664	129
A Iron and steel industry	-	6	-	3	549	9
B Non-ferrous metal production	1	-	-	-	113	-
C Chemical industry (inorganic)	3	-	14	13	2	-
D Chemical industry (organic)	-	-	86	-	-	59
E Nonmetallic minerals	25	2	-	5	-	-
F Other	-	3	-	-	-	61
3. Use of solvents and products	-	-	6	-	-	1 170

Sources and sinks of greenhouse gases	CO_2 Mt/a	CH_4 kt/a	N_2O kt/a	NO_x as NO_2 kt/a	CO kt/a	NMVOC excl. CFCs/CCs kt/a
A Painting	-	-	-	-	-	480
B Degreasing and dry cleaning	-	-	-	-	-	110
C Production and use of chemical products	-	-	-	-	-	200
D Other[4)]	-	-	6	-	-	380
4. Agriculture	-	2 043	80	n.a.	n.a.	n.a.
A Fermentation	-	1 420	-	-	-	-
B Animal waste	-	623	11	-	-	-
D Agricultural soils	-	-	69	-	-	-
E Burning of agricultural waste	-	n.a.	n.a.	n.a.	n.a.	n.a.
5. Land-use changes and forestry	(- 20)[5)]	-	-	-	-	-
A Conversion of forest land to arable or pasture land	-					
B Conversion of grassland to arable land	n.a.					
C Set-aside of agricultural land	n.a.					
D Managed forests	(- 20)[5)]					
6. Waste management	n.a.	2 397	4	n.a.	n.a.	n.a.
A Dumpsites	-	2 318	-	-	-	-
B Wastewater treatment	-	79	-	-	-	-
C Other	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
High-seas bunkering[5)]	8	0	n.a.	155	37	16
International air transport[5)]	11	0	n.a.	50	58	9

1) Not including traffic and transport emissions
2) Including traffic and transport emissions from agriculture and forestry
3) Data is incomplete; includes only wood burned by households and small consumers, charcoal (including manufacture) and agricultural waste
4) Laughing gas; solvents in households, printing inks, glues
5) Not included in total emissions

\- No emissions
n.a. No figures available

Source: Federal Environment Agency

Tab. 3.3: Emissions of greenhouse gases, by sectors, in former West Germany in 1990

Sources and sinks of greenhouse gases	CO_2 Mt/a	CH_4 kt/a	N_2O kt/a	NO_x as NO_2 kt/a	CO kt/a	NMVOC excl. CFCs/CCs kt/a
Total emissions	709	5 015	182	2 379	7 131	2 234
1. Energy-related emissions	687	1 574	23	2 363	6 526	1 093
A Combustion-related	687	111	23	2 361	6 526	921
1 Energy generation and transformation	275	9	10	364	96	9
2 Industry	121	10	3	177	624	9
3 Traffic and transport	139	47	7	1 570	4 984	827
4 Small consumers	45	2	1	31	24	1
5 Households	94	16	2	67	350	11
6 Agriculture and forestry[1)]	1	0	0	1	1	0
7 Other[2)]	13	2	-	145	155	41
8 Burning of biomass[3)]	-	25	0	6	192	23
B Non-combustion-related	1	1 463	0	2	0	172
1 Extraction and distribution of oil and gas	1	261	0	2	0	172
2 Coal mining	-	1 202	-	-	-	-
2. Industrial processes	22	9	95	16	605	111
A Iron and steel industry	-	6	-	3	495	8
B Non-ferrous metal production	1	-	-	-	108	-
C Chemical industry (inorganic)	2	-	10	9	2	-
D Chemical industry (organic)	-	-	85	-	-	52
E Nonmetallic minerals	19	-	-	4	-	-
F Other	-	3	-	-	-	51
3. Use of solvents and products	-	-	5	-	-	1 030

Sources and sinks of greenhouse gases	CO_2 Mt/a	CH_4 kt/a	N_2O kt/a	NO_x as NO_2 kt/a	CO kt/a	NMVOC excl. CFCs/CCs kt/a
A Painting	-	-	-	-	-	380
B Degreasing and dry cleaning	-	-	-	-	-	110
C Production and use of chemical products	-	-	-	-	-	160
D Other [4)]	-	-	5	-	-	380
4. Agriculture	-	1 497	55	n.a.	n.a.	n.a.
A Fermentation	-	1 045	-	-	-	-
B Animal waste	-	452	8	-	-	-
D Agricultural soils	-	-	47	-	-	-
E Burning of agricultural waste	-	n.a.	n.a.	n.a.	n.a.	n.a.
5. Land-use changes and forestry	(- 14)[5)]	-	-	-	-	-
A Conversion of forest land to arable or pasture land	-					
B Conversion of grassland to arable land	n.a.					
C Set-aside of agricultural land	n.a.					
D Managed forests	(- 14)[5)]					
6. Waste management	-	1 935	4	n.a.	n.a.	n.a.
A Dumpsites	-	1 914	-	-	-	-
B Wastewater treatment	-	21	4	-	-	-
C Other	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
High-seas bunkering[5)]	7	0	n.a.	128	31	13
International air transport[5)]	11	0	n.a.	49	54	9

1) Not including traffic and transport emissions
2) Including traffic and transport emissions from agriculture and forestry
3) Data is incomplete; includes only wood burned by households and small consumers, charcoal (including manufacture) and agricultural waste
4) Laughing gas; solvents in households, printing inks, glues
5) Not included in total emissions

\- No emissions
n.a. No figures available

Source: Federal Environment Agency

Tab. 3.4: Emissions of greenhouse gases, by sectors, in the area of the former GDR in 1990

Sources and sinks of greenhouse gases	CO_2 Mt/a	CH_4 kt/a	N_2O kt/a	NO_x as NO_2 kt/a	CO kt/a	NMVOC excl. CFCs/CCs kt/a
Total emissions	303	1 203	40	566	3 637	744
1. Energy-related emissions	296	193	9	561	3 578	586
A Combustion-related	296	117	9	561	3 552	553
1 Energy generation and transformation	161	3	5	308	825	2
2 Industry	48	6	1	40	275	6
3 Traffic and transport	20	22	1	163	1 006	425
4 Small consumers	20	3	1	4	159	9
5 Households	35	75	1	6	1 133	85
6 Agriculture and forestry[1)]	4	1	0	1	34	2
7 Other [2)]	8	1	0	38	69	19
8 Burning of biomass[3)]	-	6	0	1	51	5
B Non-combustion-related	0	76	0	0	26	33
1 Extraction and distribution of oil and gas	0	56	0	0	26	33
2 Coal mining	-	20	-	-	-	-
2. Industrial processes	7	2	5	5	59	18
A Iron and steel industry	-	0	-	0	54	1
B Non-ferrous metal production	0	-	-	-	5	-
C Chemical industry (inorganic)	1	-	4	4	0	-
D Chemical industry (organic)	-	-	1	-	-	7
E Nonmetallic minerals	6	2	-	1	-	-
F Other	-	-	-	-	-	10
3. Use of solvents and products	-	-	1	-	-	140

Sources and sinks of greenhouse gases	CO_2 Mt/a	CH_4 kt/a	N_2O kt/a	NO_x as NO_2 kt/a	CO kt/a	NMVOC excl. CFCs/CCs kt/a
A Painting	-	-	-	-	-	100
B Degreasing and dry cleaning	-	-	-	-	-	n.a.
C Production and use of chemical products	-	-	-	-	-	40
D Other[4]	-	-	1	-	-	n.a.
4. Agriculture	-	546	25	n.a.	n.a.	n.a.
A Fermentation	-	375	-	-	-	-
B Animal waste	-	171	3	-	-	-
D Agricultural soils	-	-	22	-	-	-
E Burning of agricultural waste	-	n.a.	n.a.	n.a.	n.a.	n.a.
5. Land-use changes and forestry	(- 6)[5]	-	-	-	-	-
A Conversion of forest land to arable or pasture land	-					
B Conversion of grassland to arable land	n.a.					
C Set-aside of agricultural land	n.a.					
D Managed forests	(- 6)[5]					
6. Waste management	n.a.	462	n.a.	n.a.	n.a.	n.a.
A Dumpsites	-	404	-	-	-	-
B Wastewater treatment	-	58	-	-	-	-
C Other	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
High-seas bunkering[5]	1	0	n.a.	27	7	1
International air transport[5]	1	0	n.a.	2	4	1

1) Not including traffic and transport emissions
2) Including traffic and transport emissions from agriculture and forestry
3) Data is incomplete; includes only wood burned by households and small consumers, charcoal (including manufacture) and agricultural waste
4) Laughing gas; solvents in households, printing inks, glues
5) Not included in total emissions

\- No emissions
n.a. No figures available

Source: Federal Environment Agency

3.1.2.3 Accuracy of emissions data

Table 3.5 contains a qualitative evaluation of emissions-data reliability for directly acting greenhouse gases. In part, the emissions data is subject to considerable uncertainty. This is due, first of all, to a simple lack of data for certain emissions-producing processes. But a much more important reason is that the ways in which various emissions-relevant activities contribute to the data are poorly understood. Both the socio-economic reference data and the listed emissions factors are subject to this type of uncertainty. Where detailed, well-founded statistics are available - for example, for energy consumption, industrial production or livestock inventories - the quality of the overall emissions picture hinges on the degree to which emissions factors are understood. But where statistics are less well-detailed - for example, for waste management - they themselves can be the cause of uncertainty.

With the exception of CO_2, emissions factors have been identified primarily on the basis of measurements carried out under controlled conditions. In many cases, the number of such measurements must be considered insufficient, however - especially in the area of non-energy-related emissions. Further research is being carried out in this area.

In the present report, systematic determination of emissions includes, for the first time, the components CH_4 and N_2O. In contrast to assessments of CO_2, a component for which well-founded emissions data is available, study of the greenhouse gases CH_4 and N_2O (especially the latter) is still subject, in general, to considerable uncertainty.

It should also be noted, with regard to emissions-data reliability, that figures for the area of the former GDR are usually subject to greater uncertainty than are the corresponding figures for former West Germany. This is due partly to the fact that fewer emissions studies have been carried out there, and partly to the major transitions that took place in this area in 1990.

In general, reliability of combustion-related emissions data continues to be considerably greater than data for emissions from other types of processes, in which pollutant formation can be extremely complex. Such complexity is found in the emissions-source groups selected as subgroups. But it should also be remembered that relevant circumstances within these groups are by no means homogeneous. For example, CH_4 emissions resulting from enteric fermentation in ruminants are relatively well understood, while there is considerable uncertainty regarding residual substances of animal origin - concerning the amounts produced, the ways in which they are stored and the relevant emissions factors involved.

Tab. 3.5: Estimates of the accuracy of the 1990 emissions data for Germany*

Sources and sinks of greenhouse gases	CO_2	CH_4	N_2O
1. Energy-related emissions	E	F	F
A Combustion-related	E	F	F
1 Energy generation and transformation	E	E	F
2 Industry	E	F	F
3 Traffic and transport	E	F	F
4 Small consumers	E	F	F
5 Households	E	F	F
6 Agriculture and forestry	E	F	F
7 Other	E	F	P
8 Burning of biomass	-	P	P
B Non-combustion-related	E	P	F
1 Extraction and distribution of oil and gas	E	F	F
2 Coal mining	-	P	-
2. Industrial processes	F	F	F
A Iron and steel industry	-	F	-
B Non-ferrous metal production	F	-	-
C Chemical industry (inorganic)	F	F	F
D Chemical industry (organic)	-	-	E
E Nonmetallic minerals	F	-	-
F Other	-	F	-
3. Use of solvents and products	-	-	F
A Painting	-	-	-
B Degreasing and dry cleaning	-	-	-
C Production and use of chemical products	-	-	-
D Other	-	-	F
4. Agriculture	-	F	P
A Fermentation	-	F	-
B Animal waste	-	P	P
D Agricultural soils	-	-	P
E Burning of agricultural waste	-	-	-
5. Land-use changes and forestry	F	-	-
A Conversion of forest land to arable or pasture land	-	-	-
B Conversion of grassland to arable land	-	-	-
C Set-aside of agricultural land	-	-	-
D Managed forests	F	-	-
6. Waste management	-	P	P
A Dumpsites	-	P	-
B Wastewater treatment	-	P	P
C Other	-	-	-

*) Qualitative evaluation of data accuracy
E Excellent
F Fair
P Poor
Source: Federal Environment Agency

3.1.3 Development of carbon dioxide emissions

Table 3.6 shows the development of CO_2 emissions. As the table indicates, CO_2 emissions increased from 1970 to 1980. Since then, they have been decreasing.

Due to a lack of complete energy data for 1992 and 1993, only tentative figures can be provided here. Any discrepancies between these figures and published figures are due to this report's strict adherence to the territorial principle. In keeping with the IPCC's instructions, high-seas shipping (bunkering) emissions and international air-transport emissions have not been included in overall considerations. These emissions are listed separately, but have not been added to total national emissions.

CO_2 emissions in Germany (not including high-seas bunkering and international air transport) decreased from 1,068 million tonnes in 1987 to 911 million tonnes in 1993. This decrease corresponds to a reduction of 14.7%. In the area of the former GDR, CO_2 emissions decreased by nearly 50% during this period. The main causes of this decrease were the economic-restructuring process; an approx. 6% decrease in population size; a partial shift of production into former West Germany; improvements in energy efficiency; and decreases in consumption of lignite, a CO_2-intensive fuel. On the other hand, CO_2 emissions in former West Germany were about 2% higher in 1993 than they were in 1987 (cf. Fig. 3.4). This increase must be seen in light of the fact that the population of former West Germany grew in size by some 7% from 1987 to 1993.

Tab. 3.6: Emissions*) of carbon dioxide in Germany between 1970 and 1993 [in millions of t/a]
***) Only balance-relevant emissions from fossil fuels and production processes**

	Energy-related emissions		Non-energy-related emissions		Total emissions		High-seas bunkering[1]		International air transport[1]	
1970	995		37		1 032		13		4	
	711	284	30	7	741	291	12	1	4	0
1975	996		33		1 029		11		5	
	702	294	26	7	728	301	9	2	5	0
1980	1 074		34		1 108		11		7	
	766	308	26	8	792	316	9	1	6	0
1985	1 040		28		1 068		11		8	
	703	337	20	8	723	345	9	2	7	1
1987	1 041		27		1 068		11		9	
	699	342	19	8	718	350	9	2	8	1
1990	983		29		1 012		8		11	
	687	296	22	7	709	303	7	1	11	1
1991	940		25		965		8		10	
	723	217	22	3	745	220	6	1	10	0
1992[2]	901		25		926		7		10	
	712	189	22	3	734	192	6	1	10	0
1993[2]	886		25		911		7		10	
	710	176	22	3	732	179	6	1	10	0

[1] Not included in total emissions

[2] Tentative figures

Source: Federal Environment Agency

Germany	
Former West Germany	Area of the former GDR

3.1.4 Development of methane emissions

Unlike carbon dioxide emissions, methane emissions are caused only to an insignificant extent by energy-related processes. The main sources of methane are keeping of livestock in agriculture, the waste-management industry (gas release from dumpsites and wastewater treatment) and fuel production, storage and distribution.

Table 3.7 summarises the development of methane emissions in Germany (cf. Fig. 3.5). It shows that total emissions in Germany decreased by about 12% from 1970 to 1992. In contrast with the decrease in former West Germany, annual emissions in the area of the former GDR increased slightly, but continuously, until 1989. In 1990, this trend reversed, however, as a result of a drastic reduction of livestock inventories.

The nearly continuous reduction in total emissions is due to decreases in livestock inventories (especially since 1990) and to decreases in annual hard-coal production. This trend has been partly countered by increasing dumpsite emissions, caused by increases in waste. The greatest uncertainties in this context are encountered in assessing these dumpsite emissions. In the first place, the amount of waste produced in Germany is precisely analysed only every three years (the last time was in 1990; the area of the former GDR was also analysed, with the results subject to major uncertainties). The causes of emissions produced after 1990 can only be conjectured. In the second place, these emissions are influenced by a wide spectrum of factors, such as the precise composition of waste, dumpsite type, degree to which dumpsite material is compacted for deposition, etc. In conjecturing the causes of these emissions, it was only possible to consider such influences in sum.

Tab. 3.7: Methane emissions in Germany, by sectors, between 1970 and 1992* [in kt/a; figures rounded off]

	Animal husbandry - fermentation		Animal husbandry - animal waste		Fuel extraction, production, distribution		Wastewater treatment sewage sludge recycling		Dumpsites		Other sources[1]		Total emis-sions	
1970	1450		620		2150		85		2450		320		7050	
	1050	390	440	180	2100	50	12	70	2250	200	230	90	6050	990
1975	1500		640		1850		100		2500		250		6850	
	1050	420	440	200	1800	50	14	85	2300	240	150	95	5750	1100
1980	1550		680		1700		110		2500		250		6750	
	1100	440	470	210	1650	50	15	90	2200	280	140	120	5550	1200

1985	1600		700		1700		110		2300		240		6650	
	1150	450	490	220	1600	70	15	95	1950	350	120	120	5350	1300
1987	1500		680		1600		110		2300		240		6450	
	1100	440	470	210	1550	80	17	90	1950	340	120	130	5150	1300
1990	1400		620		1550		80		2300		230		6200	
	1050	380	450	170	1450	75	20	60	1900	400	110	120	5000	1200
1991	1250		540		1500		75		2500		220		6100	
	1000	250	430	110	1400	110	20	55	2000	470	110	110	5000	1100
1992	1200		520		1550		75		2650		220		6200	
	980	220	420	95	1400	130	20	55	2100	550	110	110	5050	1150

[*] Not including high-seas bunkering; figures for 1991 and 1992 are based partly on comprehensive estimates (statistics for these years available only for animal husbandry).

[1)] Emissions from production processes, stationary and mobile combustion processes

Source: Federal Environment Agency

Germany	
Former West Germany	Area of the former GDR

3.1.5 Development of nitrous oxide emissions

In 1990, the main sources of N_2O emissions were industrial production processes (especially adipic acid production) and agriculture (cf. Fig. 3.3). Data on the chronological development of N_2O is available only for certain sectors; for this reason, such data has not been included here.

In this context, it is noteworthy that, according to the best possible estimates, 1-3% of nitrogen fertilizers spread on fields are emitted as N_2O, although this range is quite uncertain. There is a dependency on soil type and soil use (among other dependencies). The literature gives figures between 0.3 and 9% for this.

According to the most recent findings, use of animal waste produces higher N_2O emissions levels than had previously been thought. These studies have not yet been completed, however.

A very large range of emissions densities has been measured in agriculture. It does not suffice to determine amounts of N_2O directly emitted from agricultural land. There are at least two means by which nitrogen from agriculture can be emitted indirectly as N_2O:

a) Nitrate nitrogen transported by leachage water, and ammonium nitrogen transported through the atmosphere, can be denitrified or nitrified at locations other than their original locations. When this happens, N_2O is formed.

b) N_2O dissolved in leachage water is transported and released at a new location.

3.1.6 Development of nitrogen oxide emissions

Nitrogen oxides are produced almost exclusively by combustion processes in plants and engines, through oxidation of the nitrogen contained in fuels and combusted air. A relatively small process-related percentage of emissions occurs predominantly in the chemicals sector (nitric acid production). The amount figures are calculated as NO_2.

Table 3.8 summarises the development of nitrogen oxide emissions in Germany. The table shows that total emissions in Germany decreased by about 4% from 1975 to 1991. Emissions increased until 1986; since then, they have been decreasing. The causes for this reduction in emissions, in former West Germany, are conversion to low-emissions firing systems, as well as flue-gas denoxification in large combustion plants. As a result of the introduction of emissions-reduction technologies, emissions have also decreased in the transport sector, in spite of increasing traffic volumes.

In the area of the former GDR, total emissions have decreased since 1989; this is due to the economic restructuring processes there. This trend is countered only by increasing emissions in the road-transport sector (increasing numbers of automobiles, increasing overall mileage).

Tab. 3.8: Nitrogen oxide emissions (given as NO_2) in Germany, by sectors, between 1975 and 1991* [in kt/a; figures rounded off]

	Power stations and district-heating facilities		Industry[1)]		Small consumers		Households		Road traffic		Other traffic		Total emissions	
1975	890		500		60		85		1 150		320		3 000	
	660	230	430	70	55	7	80	3	1 050	100	330	95	2 500	510
1980	1 050		470		65		90		1 450		310		3 450	
	800	240	400	75	55	7	85	3	1 350	100	220	90	2 950	520
1985	1 050		390		55		90		1 550		310		3 500	
	760	290	300	90	50	8	90	4	1 500	90	230	80	2 900	560
1986	1 050		380		60		95		1 650		320		3 500	
	730	300	290	90	50	8	90	4	1 550	90	240	80	2 950	570
1987	950		370		50		95		1 650		310		3 450	
	660	300	280	95	45	6	90	5	1 550	110	230	80	2 850	590
1988	890		370		50		85		1 650		310		3 350	
	590	300	270	100	40	7	80	4	1 550	110	230	80	2 750	600
1989	780		350		45		75		1 650		320		3 200	
	480	300	260	95	35	6	70	4	1 550	120	240	80	2 600	610
1990	610		320		40		75		1 650		320		3 000	
	340	270	250	70	35	6	75	4	1 500	140	250	70	2 450	560
1991	570		280		45		90		1 650		300		2 900	
	350	220	240	35	40	4	85	3	1 500	150	240	60	2 450	470

Germany	
Former West Germany	Area of the former GDR

* Not including high-seas bunkering; figures do not correspond to the IPCC structure; discrepancies with Tab. 3.1 through 3.4 are possible as a result of different differentiations of air traffic

1) Includes emissions from production processes and industrial combustion

Source: Federal Environment Agency

3.1.7 Development of carbon monoxide emissions

Carbon monoxide is formed primarily through incomplete combustion in engines and smaller combustion plants. Process-related emissions occur primarily in the areas of iron and steel, non-metallic minerals and aluminium. Table 3.9 summarises the development of carbon monoxide emissions in Germany. As the table shows, total emissions in Germany decreased by about 45% from 1975 to 1991. The disproportionately large emissions decrease in former West Germany is due mainly to legally mandated exhaust regulations for road traffic and to conversion to liquid and gaseous fuels, with considerably more favourable emissions trends, along with legal regulations, in the areas of households, small consumers and industrial combustion plants. In the area of the former GDR, the emissions decrease has been due to the structural changes there, which began at the end of the 1980s, and also to conversions to other fuels in households and smaller combustion plants.

Tab. 3.9: Carbon monoxide emissions in Germany, by sectors, between 1975 and 1991* [in kt/a; figures rounded off]

	Power plants and district-heating facilities		Industry[1)]		Small consumers		Households		Road traffic		Other traffic		Total emissions	
1975	660		2 800		440		2 150		10 400		600		17 000	
	35	620	2 350	440	210	230	1 250	900	9 700	630	440	170	14 000	3 000
1980	770		2 550		430		2 000		9 250		480		15 500	
	45	730	2 050	520	160	270	960	1 050	8 500	740	320	160	12 000	3 450
1985	840		2 100		420		2 050		6 800		430		12 600	
	45	800	1 550	570	140	280	880	1 150	6 050	780	280	150	8 900	3 750
1986	820		2000		400		2 050		6 850		410		12 500	
	45	780	1 450	570	140	260	810	1 250	6 050	820	270	140	8 750	3 800
1987	850		1 850		500		2 050		6 750		400		12 400	
	45	810	1 300	570	130	370	770	1 300	5 900	870	260	140	8 400	4 050
1988	850		1 950		430		1 800		6 600		380		12 000	
	45	810	1 400	580	120	310	650	1 150	5 650	920	250	130	8 100	3 900
1989	840		2 000		370		1 650		6 250		380		11 500	
	45	800	1 400	570	110	260	590	1 050	5 250	970	250	140	7 650	3 800
1990	780		1 750		340		1 750		6 000		300		10 800	
	45	730	1 300	430	110	230	580	1 150	4 850	1 000	240	55	7 200	3 650
1991	650		1 500		250		1 300		5 450		260		9 400	
	50	600	1 300	210	120	130	640	650	4 450	1 000	220	45	6 750	2 650

* Not including high-seas bunkering; figures do not correspond to the IPCC structure; discrepancies with Tab. 3.1 through 3.4 are possible as a result of different differentiations of air traffic

1) Includes emissions from production processes and industrial combustion

Source: Federal Environment Agency

Germany	
Former West Germany	Area of the former GDR

3.1.8 Development of emissions of methane-free volatile organic compounds

About half of the emissions of methane-free volatile organic compounds (NMVOCs) are produced by incomplete combustion processes, especially in motor vehicles. Larger plants, such as power plants and industrial combustion plants, are thus of less importance in this context. The traffic sector, in addition to emissions in exhaust, produces additional NMVOC emissions through evaporation from vehicles - through tank ventilation and leaks (especially in carburettors) - and in distribution of light petrol (storage, transfer and filling).

Other processes of considerable emissions relevance include solvent use and production processes, especially in the areas of mineral oils, chemicals and the food and luxury food industries.

Table 3.10 summarises the development of NMVOC emissions in Germany. As the table shows, total emissions in Germany decreased by about 11% from 1975 to 1991. The emissions decrease in former West Germany is due to exhaust regulations for motor vehicles, as well as to corresponding legal regulations for industrial processes. In addition, reduced solvent use helped decrease emissions. In the area of the former GDR, emissions increased until the late 1980s; since 1990, they have been decreasing gradually.

Tab. 3.10: Emissions of methane-free volatile organic compounds, by sectors, in Germany between 1975 and 1991* [in kt/a; data rounded off]

	Stationary sources [1)]		Fuel extraction and distribution		Road traffic		Other traffic		Solvent use		Total emissions	
1975	440		160		1 200		140		1 250		3 200	
	350	95	150	14	950	260	75	65	1 150	120	2 650	560
1980	330		180		1 350		130		1 250		3 250	
	220	110	160	17	1 050	310	65	65	1 150	140	2 600	650
1985	290		190		1 300		130		1 250		3 200	
	170	130	170	19	990	330	65	60	1 100	150	2 500	690
1986	290		200		1 350		120		1 250		3 200	
	160	120	180	20	1 000	340	65	55	1 100	150	2 500	700
1987	290		210		1 350		120		1 250		3 200	
	160	130	190	20	970	360	60	55	1 100	160	2 450	720
1988	260		210		1 350		110		1 200		3 150	

	160	120	190	20	940	390	60	50	1 050	160	2 400	740
1989	260		200		1 300		120		1 200		3 050	
	150	110	180	25	870	410	60	55	1 050	160	2 300	750
1990	270		210		1 250		100		1 150		3 000	
	160	110	170	35	840	420	60	40	1 050	140 000	2 250	740
1991	240		190		1 200		80		1 150		2 850	
	160	80	160	35	740	440	55	25	1 000	140 000	2 150	720

[*] Not including deep-sea bunkerings; figures do not correspond to the IPCC structure; discrepancies with Tab. 3.1 through 3.4 are possible as a result of different differentiations of air traffic

[1)] Includes emissions from production processes and industrial combustion

Source: Federal Environment Agency

Germany	
Former West Germany	Area of the former GDR

3.1.9 Perfluorated compounds

Emissions in 1990 of the perfluorated compounds CF_4 and C_2F_6 are estimated at about 1,000 tonnes and about 150 tonnes, respectively. These emissions occur primarily in connection with aluminium production. The maximum for emissions of sulphur hexafluoride (SF_6) in 1990 was about 500 tonnes.

3.2 Inventory of CO_2-binding in reservoirs/by sinks - forests

Where not indicated otherwise, figures are based on condition of forests in Germany in 1992.

3.2.1 Forest area

Table 3.11 shows the area of forest land in Germany; Table 2.12 shows the distribution of species.

Tab 3.11: Forest land in Germany

Area of forest land in 1990:	10.8 million ha
Percentage of land covered by forest:	30 %
Development over the last decade:	Increase of 5,000 ha/a
Prediction for the next decade:	Increase of 10,000 ha/a

Source: Federal Ministry of Food, Agriculture and Forestr

3.2.2 Carbon reserves in forest ecosystems

3.2.2.1 Conversion of theoretical cubic metres of supply into tonnes of carbon

To estimate carbon reserves, the wood supply is converted in the following manner:

With the existing distribution of species, one theoretical cubic metre (TCM) corresponds to about 0.5 tonnes of wood in absolutely dry condition (adry). One tonne of wood adry corresponds to 0.5 tonnes of carbon (C). Consequently, one TCM corresponds to about 0.25 tonnes of carbon.

3.2.2.2 Carbon storage in forests

It is estimated that about 1.5 to 2.0 billion tonnes of carbon (C) are stored in Germany's forests. These figures are based on the following assumptions:

- Rough timber: According to the results of the Federal Forest Inventory, the average rough timber reserves (logs over 7 cm in diameter) in production forests of former West Germany amounts to approx. 300 cubic metres of supply per hectare; for the area of the former GDR, this figure is estimated at about 190 cubic metres per hectare. This results in a weighted area-based average of 270 cubic metres of supply per hectare. This in turn corresponds to approx. 67.5 tonnes of carbon per hectare.

- The remaining timber mass above ground (mainly timber below 7 cm in diameter) is estimated as about 30% of the rough timber mass; this corresponds to about 20 tonnes C/ha.

- Hardly any information is currently available about the carbon reserves in the remaining above-ground biomass (for example, ground vegetation, dead wood); it is assumed that these reserves can be neglected in this context.

- The amount of carbon contained in biomass below ground (roots and humus) is currently estimated at 50 to 100 tonnes C/ha.

3.2.2.3 Annual carbon binding in forests

At present, the annual growth of timber stocks in Germany amounts to about 6 m^3/ha. These figures are based on experience. An average of approx. 4 m^3/ha are removed each year by felling and other uses, so that annual net growth amounts to about 2 m^3/ha. This means that existing forests currently store an additional 0.5 tonnes C/ha, or a total of 5.4 million tonnes C, per year; this is equivalent to about 20 million tonnes of CO_2 (cf. Tables 3.1 through 3.4 and A 42). But the storage capacity of this reservoir stops increasing when forests reach a maturity stage (climax stage), and thus their maximum biomass levels. It is not possible to predict when this occurs; when it does occur, forests cannot bind any additional CO_2. The volumes of bound carbon and released carbon then balance each other. Later, the bound carbon can be released in a decomposition phase, to be re-bound in turn during the subsequent build-up phase. These phases follow a variable course within a mosaic of small-scale space frames and time frames.

The timber harvested is converted into products of varying "life spans". Carbon stored in this timber remains bound for a considerable period.

4. Effects of climate change and adaptation measures

Climate changes can affect "natural systems" (geo- and biosystems), the "material basis" of human civilisation (economy, agriculture and forestry, infrastructure) and social aspects of quality of life that are primarily non-material, such as individual and social lifestyles, culture and policy (cf. Chapter 1.4)

These areas are interrelated in complex ways. By modelling interconnections and interactions between climate and the areas it influences, it is possible to obtain insights into the sensitivity or stability of these areas in the face of climate changes.

4.1 Climate scenario

The statements made in this report concerning the future development of European climate are based mainly on findings of climate forecasts prepared at the MPI Hamburg and the Hadley Centre in Bracknell, England. These forecasts employ coupled ocean-atmosphere circulation models (cf. Chapter 1.3). The Hadley Centre's scenario calculations are based on the assumption that CO_2 equivalency concentrations increase by 1% annually; the MPI Hamburg uses an annual-increase figure of 1.3% (IPCC emissions scenario A).

Temperature

A mean temperature increase of approx. 0.25"C per decade is forecast for Western Europe. The natural variability in the mean surface temperature, about 1"C, could mask the forecast warming in Western Europe for about 30-50 years, however.

Precipitation

Climate-model calculations indicate an increase of winter precipitation in northern and central Europe. It has not yet been possible to derive a clear trend for the summer months. An increase in the frequency of regional strong rains seems possible. Due to the very large variability of precipitation, by quantity, area and time, climate-related changes are not likely to become apparent for at least 100 years.

Soil moisture

No substantial change in soil moisture during the cold half of the year is expected for Western Europe. During summer months, increased temperatures would be expected to decrease soil moisture, if precipitation patterns remained unchanged.

Storms

No reliable predictions concerning changes in the frequency and intensity of storms can be made, since the models yield partly contradictory results concerning this point.

Sea level rise

Over the next hundred years, the seas are expected to rise between 15 and 20 cm as a result of thermal expansion of sea water. The expected melting of mountain glaciers and smaller inland ice sheets could entail a further increase of the same order. All in all, the mean rate of sea level increase is expected to be between 3-4 mm per year. These figures are considerably lower than those obtained with simpler IPCC models in 1990. Regional variations in projected mean global rise are possible.

4.2 Aquatic ecosystems

4.2.1 Marine and coastal ecosystems

The potential effects of changed climatic conditions on coastal ecosystems (dunes, tidal flats, bodden areas, salt marshes, estuaries) have been little studied, in comparison with potential effects on biosphere and geosphere systems. It must be assumed, however, that the tidal-flat and bodden ecosystems so typical of German coastal areas could be seriously affected by climate change. Shifts in the physical, chemical, biological and hydrodynamic parameters of these ecosystems would have to be expected, along with effects on their biocenotic structures. Species and habitats threatened or overstrained by human interference could suffer serious additional effects. Measures of coastal protection could partly limit the abilities of tidal-flat and bodden ecosystems to respond dynamically to changes.

A rise in sea levels would increase the frequency of critical water levels and exacerbate the risk of flooding. Increased action of erosive forces could cause coastlines to recede. Other possible consequences could include a rise of the near-shore groundwater level and a progressive salinisation of coastal-region aquifers.

As regards tidal flats, landward displacement of the surf zone would result in a local loss of elevation and in deepening of tidal channels. Apart from a progressive inundation of tidal flats, this could involve heightened erosion, which could denude these areas and destroy existing tidal areas and their ecosystems.

Typical of the bodden areas are frequent changes in the flow direction of water currents and in salinity. This does not necessarily mean that they are less resistant to climate change, however. In particular, changes in precipitation patterns could become a stress factor for bodden areas.

In addition, brackish water could penetrate more deeply into estuaries, especially into the developed estuaries of the Weser and Elbe rivers; this would have serious ecological consequences.

Changed wind conditions, resulting in new predominant wind directions, could affect rates of longitudinal sediment transport and influence the material balance of adjacent coastal zones. This could involve the displacement of zones prone to erosion and accumulation, as well as shifting of dune-forming zones. An increase in mean wind velocities would result in rougher seas and increased hydrodynamic energy acting on individual coastal sections.

A shift in seasonal distribution of precipitation could result in changes in substance and sediment input from land.

4.2.2 Limnic and fluvial ecosystems

In all likelihood, climate changes will affect hydrological cycles in central European regions, influencing limnic and fluvial ecosystems in the process. Warming of near-ground air would also raise water and ground temperatures, which would probably influence water quality and the composition of aquatic communities. Changes in flow regimes could also affect many areas of the German water resources management industry.

Warming could be expected to bring higher stream flow in the winter season and lower flow in summer. The present flow regime of rivers such as the Rhine and the Danube is characterised by the balancing function of snowfall in the Alps. Increased air temperatures would shift snow and glacial lines of alpine and central mountain regions in such a manner that less water would be stored as snow during the winter months. This trend, in conjunction with the forecast slight increases in amounts of winter precipitation, would increase run-off during winter months, thus exacerbating the risk of flooding, especially during strong rains. As a consequence, the danger posed by identified river flooding areas to settlements could increase, and limitations might be placed on use of unsettled river flooding areas. Possibly, flood spillways of existing reservoirs and retention basins would no longer be able to safely carry off increased flood run-off.

In summer months, the amount of water contained in increased winter run-off would be lacking (due to lack of storage); this would decrease run-off volume, leading in turn to higher nutrient and pollutant concentrations in the water bodies concerned.

Sedimentation in free-flowing waters will increase as a result of higher solids and bed-load transportation. This could impair both the function and the service life of reservoirs. Moreover, siltation of lakes would be accelerated in regions prone to heightened erosion.

Increased frequency of strong rains would intensify soil erosion, especially in regions with little plant growth (in certain periods) and on cultivated land in areas particularly subject to erosion during periods of little or no vegetation. In addition, existing urban drainage systems and stormwater outlets of wastewater treatment plants might be overburdened. And during extended periods of low water flow in receiving bodies, during summer months, the ratio of discharged drainage water to receiving water could change for the worse.

A change in amounts of precipitation, and in seasonal distribution of precipitation, would also affect new collection of groundwater. Intensified groundwater collection would have to be expected during winter months in regions with highly permeable soils. In summer months, warming would reduce new groundwater collection, especially in less permeable soils, as a result of greater evaporation in conjunction with normal precipitation. Initial model calculations using these assumptions have indicated that a reduction of the useable groundwater supply in northern and western German regions would occur. If agricultural water requirements increased, supply of water from groundwater could be affected in regions with reduced groundwater collection.

Run-of-river hydroelectric power stations would generate less power in the summer due to reduced stream flow. The efficiency of thermal power stations using either flow cooling or closed cooling systems would decrease with higher water temperatures, due to a decrease of the useful warming-up margin.

In sections of navigable waterways without barrage weirs with lock, reduced stream flow in summer months would result in diminished loading depths and, consequently, a limitation or even suspension of navigation. Shipping traffic would also be hampered in winter months, due to increased flood frequency. A further obstruction of navigation is expected to arise from accelerated sedimentation in waterways, especially within reaches and harbour inlets.

4.3 Terrestrial ecosystems

4.3.1 Agriculture

In addition to the effects of changed physical climate parameters (temperature, precipitation, radiation), the direct effects of a changed composition of substances in the atmosphere will decisively influence the consequences of climate change for vegetation.

Climate changes could lead to selection pressure. The results of such pressure, functioning within the framework of adaptation processes, cannot be predicted, due to the manifold interactions involved. One thing is certain, however: during these adaptation processes, the stability of the ecosystem's structure can be adversely affected (for example, by the appearance of new competing species, new pests or increased pest abundance; by new pathogens; and by increased fire risk and soil erosion). As temperatures rise, the natural range of tropical-disease pathogens could spread northwards.

Of outstanding importance among the direct effects of a change in atmospheric substance composition are the effects caused by the change in CO_2 content. CO_2 has particular significance in this context due to its key role in plant photosynthesis.

It is assumed that an increase of CO_2 concentrations would reduce in intensified plant growth - at least in C_3 plants. But scientists disagree over whether increased CO_2 concentrations would indeed have this "fertilization effect".

There are first indications, however, that high CO_2 levels could cause considerable changes in the chemical composition of plants (for example, changed C/N ratios). Little is still known today about what effects this would have, for example, on crop harvest quality, on infestations with destructive insects and on soil nutrient reactions in general. Almost nothing is known about how perennial crops would react to high CO_2 concentrations in the atmosphere.

Current knowledge does not permit quantitative assessment of the impact of global climate change on dry matter production in agricultural crops and in wild plant stock, and hence on the dynamics of natural vegetation.

The magnitude and speed of climate change could impair the adaptability of agricultural ecosystems.

4.3.2 Forests and unmanaged terrestrial ecosystems

Forests are extremely complex ecosystems. They would be particularly affected by climate change because trees have long life-spans and - compared to climate change - long generation times. Endangering forests would mean endangering their multiple functions. As the climate models and climate forecasts still lack regional resolution, it is hardly possible to forecast the impact of climate change on Germany's forest ecosystems (cf. Chapter 4.5). The extent to which climate change could overwhelm the forestry sector's means of adapting forests is also still unclear.

Similar statements can be made about unmanaged terrestrial ecosystems, of which only a small number are left in Germany. These ecosystems are indispensable as part of an integrated global concept for stabilising and conserving nature's balance and biodiversity, and they provide greater latitude within which evolutionary processes can adapt to climate change. That is why they have been placed under protection and turned into national parks, nature reserves and forest reserves.

A progressive increase of atmospheric CO_2 concentrations, and a shift in climatic zones, would disturb the interactions between natural communities and site conditions. This would create additional risks for threatened species and habitats.

4.4 Socio-economic effects

Considerable uncertainty prevails with regard to the economic and social effects of climate change. Changes in quality of life and in living conditions could result both directly from climate itself (changes in temperature and weather) and from the consequences of climate change for economic activities. Such consequences, for example, could take the form of material losses for the inhabitants of affected regions. Even though there is still considerable uncertainty concerning regional climate changes, it seems necessary (and a dictate of precaution) to analyse socio-economic systems' sensitivity and stability in the face of climate change and to develop possible adaptation strategies.

4.4.1 Economic sectors and infrastructures

Not only can global climate changes affect different regions in different ways; their effects on the various areas of human activity can also vary. It is likely that economic sectors that are particularly dependent on certain environmental conditions, or on environmental resources that depend on certain conditions (for example, vegetation, landscapes), or on climate-sensitive infrastructure systems (for example, navigable rivers), would be particularly affected by changes.

Climate changes would primarily affect forestry, but they would also influence agriculture, fisheries and tourism. Attention should also be given to the sensitivity and stability of infrastructures in the face of climate change; for example, consideration should be given in this context to the water supply, to wastewater treatment, to the energy supply and to coastal and flood protection.

4.4.2 Migratory movements

The existing disparities in prosperity among the different parts of the world, and variation in levels of national development, are a major driving force behind migratory movements. Increasingly, environmental degradation (for example, the loss of agricultural land through erosion and drought) is also the cause of migratory movements.

There is a likelihood that global climate changes would cause additional migratory movements. Increases in migratory movements would exacerbate the potential for conflict in regions affected by migration. Conflicts would also affect the economic and social situations of the countries from which, and into which, migrations were taking place.

4.4.3 Health

Human health and well-being can be influenced by climate changes. As epidemiological studies of the effects of unusual weather conditions on health reveal, such influence would especially be possible if climate change occurred too rapidly to permit adaptation.

Human health can also be indirectly affected by climate change, when pathogens spread to new regions as a result of changed environmental conditions. It is assumed that, depending on the regional effects of global warming, pathogens of tropical diseases could spread to Europe's temperate zones.

Cultivation of crop species adapted to new climates, and installation of irrigation systems in arid regions, could cause pathogens, pests and, possibly, epidemics, to spread, and to multiply/intensify or occur in previously unaffected regions. It must be remembered that such newly affected regions would have had no chance to develop resistance against new pathogens.

4.5 Adaptation measures

The Federal Government considers measures for combatting the anthropogenic greenhouse effect to have priority. For this reason, and because the magnitude of climate change cannot yet be sufficiently well forecast, no measures for adapting to climate change are yet planned.

Because the regional effects of climate change cannot be forecast, forests with a high degree of ecological resilience have particular significance. The formation of such forest types can be promoted by applying the following management principles:

- Increase use of forestry methods that promote near-natural forest ecologies;
- Protect and build-up ecologically stable, high-yield multi-species stands,
- Avoid large-scale clear-cutting,
- Plant appropriate (e.g. for the site) tree species,
- Give preference to natural forest rejuvenation,
- Use integrated plant protection,
- Use non-damaging stand care and soil husbandry practices,
- Keep wildlife density at an ecologically compatible level.

Such measures must not be viewed as substitutes for climate protection; they are supporting measures.

In order to identify and prepare measures to adapt to climate change, the Federal Government is emphasising research into the consequences of climate change (cf. Chapter 7.1.3.2).

5. Programme of measures to reduce emissions of climate-relevant gases and to bind them in reservoirs and by sinks

5.1 General description of the Federal Government's programme of measures

By resolution of 13 June, 1990 the Federal Government established the "CO_2 -reduction" Interministerial Working Group (IWG), placing it under the management of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The IWG's task was to prepare proposals for protecting the earth's atmosphere, on the basis of a 25% reduction of CO_2 emissions in former West Germany by the year 2005 - in relation to 1987 emissions levels. This reduction is to be an important element of a global concept. The IWG was also tasked with studying possibilities for reduction of other energy-related greenhouse gases.

On 7 November, 1990 the Federal Cabinet passed a second resolution for reduction of energy-related CO_2 emissions. According to this resolution, "The IWG should orient further proposals to a 25% reduction of energy-related CO_2 emissions in former West Germany, and, in view of the greater potential for CO_2 reduction in the new Federal L@nder, as expected through current findings, should orient proposals for that area to a considerably higher percentage reduction by 2005 - in relation to 1987 emissions levels."

On 11 December 1991, the Federal Cabinet took note of the "CO_2 -reduction" IWG's second intermediate report. The Cabinet upheld its previous resolutions in this context - those of 13 June and 7 November 1990 - and resolved to strive for a 25-30% reduction of CO_2 emissions in Germany by the year 2005, in relation to 1987 levels. The Federal Government is aware of the difficulties of achieving this; this awareness also arises from consideration of the changed world-wide framework.

The Federal Government bases its policy for reducing emissions of CO_2 and other greenhouse gases on the need for precautionary measures to protect the climate, on requirements for further reduction of "traditional" environmental pollution and the necessity of conserving limited resources over the medium-to-long term. Energy-related measures not only contribute to climate protection, they also ease the burden on the environment, across a wide spectrum (reduction of air, water and ground pollution). Reducing non-energy-related climate gases has a similar effect. Consequently, a number of different aims are being simultaneously accomplished within the Federal Government's global concept, along the lines of a "take precautions and avoid regret policy".

Since downstream facilities for reducing CO_2 emissions are still neither technically nor economically feasible, the only approach to solving this problem is efficient and thrifty energy use, on all levels of energy supply and use, along with fuel substitution, in order to reduce emissions of CO_2 and of other greenhouse gases. In the view of the Federal Government, progress in efficient and thrifty energy use is a requirement for lasting reductions in greenhouse gases.

Overall, the Federal Government maintains that its climate-protection policy is beginning to have an effect. It calls attention in this context to the measures it has been implementing, step by step, since 1990. This package, consisting of some 100 measures that have already been implemented or that are in the implementation phase, clearly highlights the Federal Government's intent to integrate economic instruments, regulatory approaches and supporting measures, within the framework of a global concept. The Federal Government is determined to continue with this step-by-step implementation of its climate-protection strategy, including the CO_2 -reduction programme.

5.2 Contents of the Federal Government's programme of measures

5.2.1 Measures for reducing emissions of climate-relevant gases

Table 5.1 (Part A) lists those of the Federal Government's measures for reducing emissions of CO_2 and other greenhouse gases that have already been approved and are being/have been implemented. The measures are grouped into the sectors energy supply, traffic and transport, buildings and structures, new technologies, agriculture and forestry, waste management and overarching measures.

Table 5.1 (Part B) lists those of the Federal Government's measures for reducing emissions of CO_2 and other greenhouse gases that are currently being approved by the relevant decision-making bodies, or whose approval is being prepared or planned. The measures are grouped into the areas of energy supply, traffic and transport, buildings and structures and overarching measures.

Some of these measures are new instruments that have been added since 1990. The great majority, however, are existing instruments that, since 1990, have been amended with a view to reducing emissions of CO_2 and other greenhouse gases: whose requirements have been tightened, whose terms (i.e. deadlines) have been extended with regard to the CO_2-reduction programme, or whose areas of application have been broadened with regard to this programme.

The measures are aimed at reducing emissions of CO_2 and, in parallel, those of other greenhouse gases as well, although these aims are not explicitly stated in every case.

Measures for research are described in Chapter 7; measures for providing environmental information, education and training are described in Chapter 8.

Chapter 5.3 lists measures of other involved parties (including the Lander); measures being carried out in the European Union framework are listed in Chapter 9.3.3.

Tab. 5.1: Federal measures to help reduce emissions of CO_2 and other greenhouse gases)

Part A. Measures that have been approved and are being/have been implemented

Energy supply:

Measure	Remarks
(1)Federal table of charges for electricity (Bundestarifordnung Elektrizit@t)	The new federal table of charges for electricity provides greater fairness in electricity rates for private households, commerce and agriculture, and strengthens incentives for saving electricity. To achieve these goals, the dependency of electricity rates on consumption was increased (took effect in 1990).
(2) Support for local and regional energy-supply and climate-protection concepts	Building on experience in former West Germany, the Federal Government is supporting various model projects for energy-supply concepts focused on reducing CO_2 emissions in the area of the former GDR. The energy agencies that, increasingly, are being funded by the L@nder can help to support development of energy-supply concepts. Detailed evaluation of the relevant programme of joint work by the Federal Ministry for Research and Technology and the Federal Ministry for Regional Planning, Building and Urban Development was completed in 1991.
(3) Act on the Sale of Electricity to the Grid	The Act on the Sale of Electricity to the Grid took effect on 1 January, 1991. In it, the Federal Government sets forth minimum payment levels for electricity generated from renewable energies, thus considerably enhancing the framework for renewable energies. An amendment of this act, which was passed in mid-1994, explicitly extends the act to cover electricity generated from organic residue and waste produced in commercial use and processing of wood (limited to plants of up to 5 MW). At the same time, payment levels for electricity generated by hydroelectric plants and combustion of organic residues and waste, and fed into the grid, were improved. Even higher payment levels continue to be in force for electricity from wind and solar power. The Federal Ministry of Economics intends to discuss the act's area of application, especially the issue of including heat/power cogeneration, as part of its progress report to the German Parliament, which it (the ministry) has announced for the end of 1994/beginning of 1995, when the law is to be passed. The preliminary

Measure	Remarks
	work for this report has begun.
(4) Elimination of the excise duty on lamps	The excise duty on lamps was eliminated as of 1 Jan 1993. As a result, new energy-saving lamps will no longer be taxed differently than conventional lamps.
(5) Federal Government/L@nder district-heating modernisation programme for the area of the former GDR	In 1992, a joint Federal Government/L@nder support programme was begun to increase use of heat/power cogeneration and to modernise the district-heating network in the area of the former GDR. The programme has annual funding of 300 million DM, of which the Federal Government and the L@nder each provide half. To date, a total of 433 measures, representing an investment volume of ca. 1.15 billion DM, have been funded. The majority of the funding has been concentrated on energy-generating plants, with the aim of increasing use of heat/power cogeneration. The programme is scheduled to continue until 1995. Operators of district-heating facilities (generation, distribution, transfer facilities) are eligible to apply for the programme. In each case, up to 35% of costs eligible for subsidy can be subsidised. In exceptions, a Land may grant a higher subsidy. Applications can be submitted to the relevant economic ministries in the area of the former GDR. This jointly funded district-heating modernisation programme is expected to enable district heating, provided primarily by through heat/power cogeneration, to maintain its comparatively large share (23%) of the indoor-heat market. Use of small heat/power cogenerators can help meet this aim.
(6) Funding for renewable energies	The 1994 federal budget includes a total of 10 million DM for funding individual measures involving use of renewable energies. This is not a general market-introduction programme. The Federal Government plans to continue this support, at a level of 30 million DM/year in 1995 and 1996, and at a level of 20 million DM/year in 1997 and 1998.
(7) Energy-saving programme of the European Recovery Programme (ERP)	This programme supports the installation, expansion and modernisation of plants and machines that a) Save energy and use it efficiently; b) Use renewable energies. Small and medium-sized industrial companies are eligible to apply. Low-interest loans of up to 1 million DM are provided, covering up to 50% of eligible costs. Loans may be larger in exceptional cases of particular environmental policy significance. Ap-

Measure	Remarks
	plications may be submitted to any bank. ERP loans are disbursed through the Deutsche Ausgleichsbank, Bonn.
(8) Support for advising of small and medium-sized companies concerning energy-saving	The primary focus of this support is advising concerning economic, organisational and technical questions related to thrifty, efficient energy use (advising on energy-saving). Those eligible to apply include legally independent industrial companies, if their turnover in the fiscal year prior to their application did not exceed 30 million DM; as well as agricultural-sector companies whose turnover in the fiscal year prior to their application did not exceed 2 million DM. Subsidies are granted up to 40% of the relevant invoiced advising costs, up to a maximum of 3,000 DM. In each case, total subsidies of up to 6,000 DM may be applied for. Industrial companies submit applications, after completion of advising, to the Association of German Chambres of Industry and Commerce, to the Federation of German Industries or to the business-promotion association of the Federation of the Self-employed (Gewerbef`rderungsgesellschaft des Bundesverbandes der Selbst@ndigen). Crafts companies apply to the German Crafts Federation (Zentralverband des Deutschen Handwerks); agricultural companies apply to the Federal Office of Food and Forestry (Bundesamt fhr Ern@hrung und Forstwirtschaft). Subsidies are paid only when applicants have themselves paid the invoiced advising fees in full. Recipients of advising subsidies from other public funds are ineligible for the programme.
(9) Support of the Forum fhr Zukunfts-energien	The Federal Ministry of Economics has funded the Forum fhr Zukunftsenergien (Future Energy Forum) since it was founded in 1989. The main emphases of the Forum's work are efficient energy use and renewable energies. Support will continue, and be gradually reduced, until 1996. As of 1997, no further public funding will be provided.
(10) Information on use of renewable energies	In 1993, the Federal Ministry of Economics published a brochure entitled "Increasing Use of Renewable Energies" (Erneuerbare Energien - verst@rkt nutzen). The brochure contains information about use of renewable energies in Germany, as well as information about available support and institutions that can provide further information and consultation.

Measure	Remarks
	The Federal Ministry for Research and Technology also published a brochure; it is entitled "Renewable Energies" (Erneuerbare Energien). It describes current applications and the most recent research and development progress regarding renewable energies.
(11) Information on saving energy and on efficient energy use	The Federal Ministry of Economics has published a series of brochures on the topic of "thrifty and efficient energy use" (sparsame und rationelle Energieverwendung). These publications describe, in clear language, the range of possibilities available to concerned citizens for saving energy. The Federal Ministry for Regional Planning, Building and Urban Development has a brochure with a similar aim: "Guide to Saving Energy in Your Home" (Energiespa-rbuch fhr das Eigenheim). Still another brochure is available that describes the Federal Ministry of Economics' support programme entitled "On-site advice on saving energy" (Energiesparberatung vor Ort).
(12) 4th Ordinance on the Execution of the Federal Immission Control Act (4. BImSchV)	As part of its effort on behalf of immissions protection, the Federal Government has removed wind-power systems from the area of application of the 4th Ordinance on Execution of the Federal Immission Control Act (4. BImSchV). This has considerably simplified administrative procedures for such systems, since wind-power systems no longer require authorisation under legal immissions-protection criteria.
(13) Tax breaks for heat/power cogeneration	As part of the amendments to the Mineral-Oil Tax Act made by the 1992 Tax-amendment Act, dated 28 February, 1992, the spectrum of tax breaks provided for use of heating oils and gases in engines was expanded. The tax breaks are provided for qualified heat/power cogeneration, regardless of the purpose for which the mechanical energy yielded and the decoupled heat are used - under the condition that on an annual average 60% of the generated heat and power are used, in relation to the amount of oil consumed.

Traffic and transport:

Measure	Remarks
(14)Increase of the mineral-oil tax	a) In 1991, the mineral-oil tax was increased. b) On 22 October 1993, the German Parliament, acting within the framework of the 1st Savings, Consolidation and Growth Programme, approved a further increase of the mineral-oil tax on carburettor and diesel fuels, scheduled to take effect on 1 January 1994: from by to Petrol leaded 0.92 DM/l 0.16 DM/l 1.08 DM/l Petrol unleaded 0.82 DM/l 0.16 DM/l 0.98 DM/l Diesel fuel 0.55 DM/l 0.07 DM/l 0,62 DM/l To compensate for the smaller tax increase on diesel fuel, the motor-vehicle tax on automobiles with diesel engines was increased by 7.50 DM/100 cc. The added tax revenue resulting from the increase of the mineral-oil tax, approx. 8.5 billion DM per year, is to be used to reduce the debt of the German Railway and to finance urgent tasks in the transport sector. The government's assumption of the Railway's debt is a prerequisite for the planned reform of the German Railway. This action makes a vital contribution to strengthening the railway, an environmentally friendly mode of transport.
(15) Emissions-oriented motor-vehicle tax (1st phase)	The governing political parties have approved conversion of the existing motor-vehicle tax, which is oriented to engine displacement, into an emissions-oriented tax. The Act on Combatting Abuse and on Tax Adjustment (Mi8brauchsbek@mpfungs- and Steuerbereinigungsgesetz - StMBG), of 21 December, 1993, introduces, as a first step toward the creation of an emissions-oriented motor-vehicle tax, certain elements into taxation of utility vehicles with an approved total weight over 3.5 t. The new regulation came into force on 1 April, 1994.
(16) 1992 Federal Traffic Infrastructure Plan	The 1992 Federal Traffic Infrastructure Plan calls for greater investments for the railway infrastructure than for national long-distance motorways. This is the first such plan to do this. The planned total volume of investments for the railway infrastructure is

Measure	Remarks
	213.6 billion DM, as compared to 209.6 billion DM for national long-distance motorways. A total investment volume of approx. 243 billion DM is planned for new construction and expansion of the national transport infrastructure between 1991 and 2012. Of this amount, approx. 118 billion DM is to go toward the railway network, while some 109 billion DM is planned for national long-distance motorways and about 16 billion DM is planned for national waterways.
(17) Increasing the attractiveness of local public transportation	Pursuant to Germany's Basic Law, responsibility for local public transportation lies predominantly with the L@nder. The Federal Government's influence (Federal Ministry of Transport) is found primarily in its jurisdiction over the Passenger-Transportation Act (Personenbef`rderungsgesetz), the Regionalisation Act (Regionalisierungsgesetz) and over the funding regulations contained in the Act on Financing of Community Transport (Gemeindeverkehrsfinanzie-rungsgesetz - GVFG). Determination of funding for the last of these acts, as well as determination of federal programmes for local transportation, are subject to approval by the L@nder. Part of the investments provided for by the Act on Expansion of the German Railway Network (Bundesschie-nenwegeausbaugesetz) are to be used for local public rail transportation. One aim is providing this financial assistance has always been to enhance the attractiveness, and thus increase use, of local public transportation, thus shifting the "modal split" in favour of local public transportation. The emissions reduction resulting from a large shift of passengers away from private motor vehicles and to local public transportation, especially in metropolitan areas with heavy traffic, is obvious. CO_2 emissions can be posi-tively influenced through increased use of local public transportation. Since 1967, the Federal Government has provided some 35 billion DM worth of financial assistance for measures on behalf of local public transportation. Since 1971, this assistance has been provided pursuant to the GVFG. The assistance has made possible total investments in this sector of (considerably) over 50 billion DM. The measures that have received assistance have included construction and expansion of subways and city trams, of central bus stations and maintenance facilities, of traffic-control systems for community roads, "park + ride" facilities and procurement of

Measure	Remarks
	new, low-emissions busses. Since 1992, procurement of other vehicles for local public transportation, as well as the construction of attractive bus and tram stops, and construction of facilities to speed up local transportation, have also been eligible for support.
(18) Gas-balance System Ordinance	Since 1993, when the Gas-balance System Ordinance came into force, NMVOC emissions from refuelling have been significantly reduced.
(19) Programme of research into urban traffic (Forschungs-programm Stadt-verkehr - FOPS)	The research carried out within the framework of the FOPS urban-traffic research programme has been of particular significance in enhancing local public transportation. The programme's research is concentrated on increased use of clean modes of transportation. FOPS has been established on an annual basis.
(20) Improving continuity of traffic flow	Traffic-control measures help increase traffic safety and continuity of traffic flow - for example, through more efficient use of the road network. These measures also help reduce environmental pollution from road traffic, especially by combining traffic-flow control systems with speed limits. Currently, some 70 traffic-control systems are in operation on national motorways (autobahns). In 1993, the Federal Ministry of Transport spent over 90 million DM on traffic-control measures for autobahns. The traffic-control programme for autobahns is scheduled to last from 1993 to 1997, during which it will provide over 60 new systems. Funding requirements, including those for systems under construction during the 1993-1997 programme phase, amount to 650 million DM.
(21) Information on energy-saving and environmentally oriented driving habits	In 1993, as part of a comprehensive information and awareness campaign, the Federal Ministry of Transport published a brochure entitled "Less CO_2 in traffic - do your part" (Weniger CO_2 im Verkehr - machen Sie mit), and the Federal Ministry of Economics published "More kilometres with less petrol" (Mehr Kilometer mit weni-ger Benzin). The aim of these brochures is to make drivers, in particular, more aware of fuel-saving driving habits, to encourage them to use public transportation and, in general, to foster greater environmental awareness on the part of automobile users. In 1994, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety launched

Measure	Remarks
	another "All about your car" (Rund ums Auto) poster-and-flyer information campaign to promote environmentally aware behaviour. In addition, the Federal Minister for the Environment assumed the honorary chairmanship of a relevant international youth competition. The aim of the competition is to teach environmentally aware driving in the schools, using behaviourally oriented teaching methods. In addition, a publication of the Federal Environmental Agency that appeared in spring 1994 contained a comprehensive chapter on environmentally oriented driving habits. Finally, an informative Federal Ministry of Transport publication on bicycles should help make local decision-makers more aware of this mode of transportation.
(22) Research projects and information concerning urban traffic planning and decreasing traffic pollution in cities	In March 1992, the research project "wide-area traffic abatement" (fl@chenhafte Verkehrsberuhigung), a joint effort of the Federal Ministry for Regional Planning, Building and Urban Development, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Ministry of Transport, was completed. During its 10 years of existence, this model project provided important impetuses to communities and the L@nder for reorientation in urban-traffic planning. The pedestrian-zone and traffic-abatement-area systems comprise a wide range of instruments with which communities can reduce environmental pollution of urban traffic. In July 1993, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety presented its comprehensive brochure "Environmentally cleaner urban traffic" (Umweltschonender Stadtverkehr). Its purpose is to give local-level policymakers and administrators practical information and ideas for implementing findings from research to make traffic in cities and communities environmentally cleaner.
(23) Railway structural reform	On 1 January 1994, laws reforming federal railway structures came into force. The central element of these laws is to privatise Deutsche Bundesbahn (German Federal Railway) and Deutsche Reichsbahn (the railway system in the area of the former GDR), which are structured as state agencies, and transform them into a stock corporation.

Measure	Remarks
	One of the main aims of the structural reform is to create a framework that will improve the railways' performance and competitiveness and enable them to increase their shares of the transport market. On 1 January 1996, local rail passenger transport will be regionalised; this will significantly improve the possibilities for integrating railway traffic into local and regional traffic concepts. The purpose of these efforts is to make rail transport a more flexible mode of transportation, especially in order to cause shifts of transports to the railway system, and away from other modes of transport.
(24) Freight centres	The Federal authorities are providing financial assistance, pursuant to the Act on Financing of Community Transport (GVFG), for the construction and expansion of public traffic areas of freight centres. Freight centres (Ghterverkehrzentren - GVZ) are an important element in promoting cooperation in the goods-transport sector. GVZs, by bringing together companies that provide transport services and related supplementary services, bundle and distribute flows of goods. Their function will be optimised when several freight centres, distributed throughout Europe if possible, are networked. Within local-transport systems, GVZs provide the basis for cooperative, efficient organisation of distribution traffic (urban logistics).
(25) Combined transport using waterways	On the basis of a study commissioned in September 1991 by the Federal Ministry of Transport, entitled "Combined transport using waterways" (Kombi-Verkehre hber Wasserstra8en), a waterway combined-transport project company (Wasserstra8enkombi-Projektgesell-schaft) was founded by the Federal Association of Shipping and Storage companies (Bundesverband fhr Spe-dition und Lagerei). This project, in conjunction with regulatory support measures, will provide a good basis for increased shifting of transports to inland waterways.
(26) Research programme on "Pollution in Aviation"	In order to support efforts to reduce emissions, the German Aerospace Research Establishment (DLR), in cooperation with industry, has designed a research programme entitled "Pollution in Aviation" (Schad-stoffe in der Luftfahrt). The programme, a proposed integrated national programme, has sections on atmosphere research and engine technology, on analysis of effects of pollution and on measures to reduce

Measure	Remarks
	emissions.
(27) Traffic research	The Federal Ministry for Research and Technology; Federal Ministry of Transport; Federal Ministry of Economics; Federal Ministry for the Environment, Nature Conservation and Nuclear Safety; and Federal Ministry of Defence are supporting numerous R&D measures in the areas of air traffic and ground-based transport and traffic systems.
(28) Tariffs-elimination Act (Tarifauf-hebungsgesetz)	The 1993 Tariffs-elimination Act continued ongoing deregulation of goods transports on roads. This deregulation harmonises the financial, technical and social framework for trucking companies, thus enabling them to operate more flexibly. The ongoing gradual harmonisation of national market regulations has intensified competition, forcing trucking companies to exploit all available means for increasing efficiency. The companies are now able to do so. As a result, they can reduce no-load trips and improve capacity use of their vehicles.

Buildings and structures:

Measure	Remarks
(29)Amendment of the	On 5 July 1994, Federal Cabinet approved the amended version of the Thermal Insulation Ordinance; on 1 January, 1995, it will come into force. The amended ordinance is expected to reduce heating requirements for new buildings, as of 1995, by an average of approx. 30 %, thus reducing CO_2 emissions by a similar amount. The amended ordinance also tightens thermal insulation requirements for existing buildings, when extent of renovation and modernisation measures exceeds certain levels. Further review of the ordinance, and possible further tightening of thermal insulation requirements, are planned for the late 1990s.
(30) Amendment of the Heating-systems Ordinance (HeizAnlV)	The amended version of the Heating-systems Ordinance came into force on 1 June, 1994. The new ordinance implements a significant part of the EC heating boiler directive and tightens requirements for heating systems and hot-water systems.
(31) Advising concerning energy-saving, and efficient energy use in housing structures - on-site advising	This programme subsidises on-site advising by engineers concerning structural thermal insulation, heating system technology and use of renewable energies. Subsidies are provided only for advising in buildings used predominantly as residences and whose construction was approved before 1 Jan., 1984. Those eligible for the programme include engineers from the areas of architecture, civil engineering, structural physics, electro-technology, mechanical engineering and building equipment. Advisors who work for power companies are ineligible. The programme provides subsidies of up to 1,600 DM, depending on the size of the building in question. Applications should be directed to the Rationalisierungskuratorium der Deutschen Wirtschaft e.V. (RKW), Eschborn.
(32) Tax breaks through the Support-area Act (F`rder-gebietsgesetz), pursuant to the 1991 Tax-Amendment Act of 24 June,	The Support-area Act (F`rdergebietsgesetz), introduced by the Tax-Amendment Act of 24 June, 1991, and amended by the Act on Securing the Futures of Sites (Standort sicherungsgesetz) of 13 September, 1993, provides tax breaks for modernisation and repair measures, and for the use of renewable energies (cf. notice of the revised version of 23 September, 1993, Federal Law Gazette I S. 1654). Up to 50 percent of expenses for modernisation of

Measure	Remarks
1991 and the Act on Securing the Futures of Sites (Stand-ortsicherungs-gesetz) of 13 September, 1993	buildings that generate revenue - such as commercially used buildings and buildings rented as residences - may be written-off. Up to 10 percent of modernisation expenses, to a maximum of 40,000 DM, are tax-deductible as extraordinary expenses for buildings used for (own) residential purposes. With both measures, the deductions may be taken for a ten-year period.
(33) Housing modernisation programme of the Kreditanstalt fhr Wiederaufbau (KfW) reconstruction bank	The housing modernisation programme of the Kreditanstalt fhr Wiederaufbau (KfW) reconstruction bank provides low-interest loans for modernisation and repair of housing in the area of the former GDR. This programme, which was established in October 1990, and for which 10 billion DM in loan funding was provided - has been increased to a loan-funding level of 60 billion DM, of which 10 billion DM is reserved for industrially prefabricated housing (slab housing). The low interest rates, which are provided for a ten-year period, are 2-3 percent lower than market rates. They are funded exclusively from the federal budget. Overall, the programme will cost the Federal authorities approx. 14 billion DM. By the end of June 1994, applications for loans totalling over 40.5 billion DM had been submitted, and over 27.5 billion DM of subsidised loans had been committed. The committed loans will support modernisation/repair measures in 1.6 million residences, or over 23 percent of all existing residences in the area of the former GDR. Nearly 11.3 billion DM are being invested in measures to save energy. To date, the great majority (17.6 billion DM) of the assistance provided through the KfW housing-modernisation programme has been claimed by private building owners, meaning it has gone primarily toward renovation of one and two-family houses.
(34) The joint programme "Economic Recovery in eastern Germany" (Auf-schwung Ost)	The special programme "Economic Recovery in eastern Germany", which terminated at the end of 1992, provided subsidies of up to 20% of expenditures in the area of the former GDR for modernisation of heating systems, thermal insulation and other housing-related, energy-saving measures. In 1991 and 1992, the Federal authorities provided a total of 1.5 billion DM for the programme. With the funding, modernisation/repair measures for approx. 882,000 residences were subsidised.
(35) Subsidies for construction of	In the area of the former GDR, modernisation/repair measures can be subsidised through the financial

Measure	Remarks
ɔublic (low-rent) ıousing	assistance provided to the L@nder by the Federal authorities in public-housing construction programmes (as of 1991, 1 billion DM annually). Once again in 1994, a commitment framework of 1 billion DM has been provided in the area of the former GDR. Pursuant to the Housing-construction Promotion Act (Wohn- ungsbauf`rderungsgesetz), which comes into force on 1 October 1994, support of modernisation/energy-saving measures with federal funding for public-housing construction will also be possible in former West Germany.
(36) Programme of research into experimental city and housing planning: "Redu- cing pollution in city planning" (Schadstoff- minderung im St@dtebau)	In 1993, the Federal Ministry for Regional Planning, Building and Urban Development, acting within the framework of its intradepartment research programme Experimental Housing Construction and City Planning (Experimenteller Wohnungs- und St@dtebau), established a research programme entitled "Reducing pollution in city planning". The programme's purpose is to identify the possibilities, which are considerable, for saving energy and reducing CO_2 emissions through appropriate housing construction and city planning. The programme is to cover both new structures and existing ones. The funded model projects will seek to identify appropriate planning measures and concepts for reducing CO_2 emissions as part of new construction and of renovation of housing developments.
(37) Acceleration of authorisation procedures by means of the Investment- facilitation and Housing-con- struction-site Act (Inve- stitionserleichter ungs- und Wohnbauland- gesetz)	In order to accelerate authorisation and approval procedures, the amended version of Art. 8 a of the Federal Nature Conservation Act, approved in conjunction with the Investment-facilitation and Housing-construction-site Act of 1 May, 1993, made the issue of compensations under nature conservation law subject to preliminary considerations of zoning. This means that the question of whether a construction project can be approved under planning law must also be resolved with regard to nature-conservation law - as part of the main zoning. After such resolution, intervention regulations under nature-conservation law remain applicable to outdoor measures, however. The L@nder are now called on to act appropriately - they can set forth, in their directives concerning application of nature-conservation law, that use of renewable energy sources normally, in and of itself, is a contribution to environmental protection that must be taken into account in review of the necessity and the extent of compensatory measures. This does not mean that individual-case reviews, using the relevant legal criteria, can be done away with, however.

Measure	Remarks
(38) Reduction of barriers to in-vestment in housing con-struction in the area of the former GDR, for cases in which ownership questions have not been settled	In recent years, housing companies (cooperatives and com-munity companies) have often been hesitant to claim support funding. This hesitation has been primarily due to unsettled questions of ownership, along with the resulting difficulties in securing loans, and to other difficulties, such as the refusal of community supervisory authorities to approve borrowing, the limitations placed on loan amounts as a result of the danger of long-term community overindebtedness and questions of cost-effectiveness. The 1st and 2nd Ordinance on Basic Rents (Grundmietenverordnung), and the Act on Assistance for Old Debts (Altschuldenhilfegesetz), which provides for interest assistance and limitation of old debts to 150 DM/m^2 living space, have decisively strengthened the liquidity of housing companies, however. Improved profits, in conjunction with the removal of burdens on loans resulting from old debts, are clearing the way for financ-ing of modernisation and repairs. In addition, barriers to investment have been removed by the Act on Assets (Verm`-gensgesetz), as well as the 1st and 2nd Act for the Amendment of Assets law (Verm`gensrechts@nderungsgesetz) and the Act on Assets of Housing Associations (Wohnungsge-nossenschafts-Verm`gensgesetz).
(39) Information fhr building owners, archi-tects, planners, engineers, craftsmen	The Federal Ministry for Regional Planning, Building and Urban Development has published a brochure, "Guide to Saving Energy in Your Home" (Energiesparbuch fhr das Eigenheim), that provides guidance to building owners and interested parties for selecting and executing modernisation and energy-saving measures. In 1993, this brochure was completely revised, and a large printing run was made available to the public. Another new edition is planned for 1994. In the area of the former GDR, the brochure's tips and recommendations are a particularly useful means of finding solutions that are both cost-effective and reasonable in terms of energy policy. The Federal Ministry for Regional Planning, Building and Urban Development arranged for experts to prepare a series of modernisation guideline brochures for the industrially prefabricated housing ("slab housing") in the area of the former GDR. These handbooks are available to the interested public, and should help decrease uncertainty in planning modernisation measures for these structures. The following brochures have appeared to date: 1. "0.8 t block construction" (Blockbau 0,8 t) 2. "P 25.0 t slab construction" (Plattenbauweise P 25,0 t)

Measure	Remarks
	3. "Apartment series 78" (Wohnungsbauserie 78) 4. "1.1 t strip construction" (Streifenbau 1,1 t) 5. "2.0 t high-rise apartments" (Wohnhochh@user 2,0t) In addition, as part of housing-damage research, the following brochures have been made available to interestec experts: Ë "Prefabricated residential buildings in the new Federal L@nder - types and design features" (Wohnbauten ir Fertigteilbauweise in den neuen Bundesl@ndern - Bauformen und Konstruktionsmerkmale) Ë "Prefabricated residential buildings in the new Federal L@nder - extent and main types of damage" (Wohnbauten in Fertigteilbauweise in den neuen Bundesl@n-dern - Ausma8 und Schwerpunkte der Bausch@den). Currently, the Institute for Preservation and Modernisation of Structures (Institut fhr Erhaltung and Modernisierung von Bauwerken) is preparing component-oriented modernisation catalogues. And in addition to the guideline brochures and catalogues, the Federal Ministry for Regional Planning, Building and Urban Development is preparing standard work descriptions that are similar to those in its book of standard modernisation and repair work for prefabricated parts. These texts are intended to support public construction administrations and hous

New technologies:

Measure	Remarks
(40)Specialised pro	This programme supports investments in development of environmental technologies: - for identifying links between causes and effects, - for development of technologies for avoiding, reducing and recycling pollutants and - for the development of cleaner modernisation technolo-gies. As a rule, up to 50% of investments are subsidised. Those eligible to apply include businesses, municipal authorities and private persons.
(41) Research into, and technical refinement of, power-plant and firing-plant	Main results: - Atmospherically circulating fluidised-bed combustion technology for small and medium-sized heating and power plants has been successfully introduced on the market, both within Germany and abroad.

Measure	Remarks
technology, especially cleaner coal-firing technology	- As part of implementation of the Ordinance on Large Combustion Plants, flue-gas desulphurisation and denitrification techniques are being applied on a large scale in power plants. - A number of coal-gasification processes have reached a sufficient level of maturity that they can now be employed in gas and steam-turbine power plants. Planning for such power plants is at an advanced stage. - Within the "high-temperature gas turbine" and "Tecflam" integrated research projects, painstaking background research has made it possible to increase the output and efficiency of turbines and to reduce generation of pollutants in combustion. As a next step, findings from concept projects for new power plants with improved efficiencies and lower emissions must be implemented in planning for actual demonstration plants. The added efficiency of these plants will help reduce production of the greenhouse gas CO_2.
(42) Research and development concerning gas and steam turbine power plants	Although power-plant technology has made substantial progress in recent decades, environmental protection requirements necessitate further research. One promise of gas and steam-turbine power plants, due to their higher efficiency, is that they will have lower emissions and fuel consumption for the same electricity and heat output. But before such results can be realised, new high-temperature gas turbines must be developed (in addition to other equipment) that can withstand the required high input temperatures and that will have optimised internal flows and coolant-gas conditions. As part of an integrated project involving industry, the German Aerospace Research Establishment (DLR) and institutes of higher education, work is proceeding on the development of the necessary technological basis for such turbines. In addition, a range of concepts for combined steam/gas turbine power plants are being studied, focusing on modern technologies such as charged fluidised-bed combustion, integrated coal gasification and pressurised coal-dust combustion. Planning is also being carried out for a combined-technology lignite-fired power plant, employing a pressurised fluidised bed, that is to be built in the area of the former GDR.
(43) Research and development concerning use of	Long-term support is being provided for research and development, including required pure research, in this area. The following topics are primary focuses of support:

Measure	Remarks
renewable energies	- Bringing electrical and combustion-engine heat pumps to market maturity, - Solar water-heating systems, - Increased use of passive solar systems, - Bringing mono- and polycrystalline silicon cells to production maturity, - Obtaining wide-ranging relevant experience through demonstration and operation of on-the-line and off-the-line photovoltaic power supply systems - including systems in agricultural operations, - Bringing small and medium-sized wind-power systems to market maturity, and obtaining initial operational experience with such systems, now that experience has been gained in the construction and operation of large systems, - Development of system components for generating and storing hydrogen, and for applying hydrogen technology - including high-performance electrolysis ("Hot Elly"), - Use of biomass energy.
(44) Programme for promotion of photovoltaic systems	Demonstration of the feasibility of using photovoltaic systems in Germany. This has included the "Federal Government/L@nder 1000-roof photovoltaic programme" (Bund-L@nder-1000-D@cher-Photovoltaik-Programm), involving 2,250 systems and an accompanying measurement and evaluation programme. The application period lasted until December 1993.
(45) Support for testing wind-power systems: "250 MW Wind"	Support is being provided for the installation and operation of wind-power systems at suitable sites in Germany. Those eligible to apply for the programme include private persons, private-law partnerships and legal entities, authorities and public-law institutions. Support is provided in the form of subsidies for operating expenses, in the amount of 6 to 8 pfennig per kWh of generated power, up to a fixed maximum. In exceptional cases, investment subsidies of up to 60 % (to a max. of 90,000 DM) are provided. Applications must be submitted by the end of 1994 to Forschungszentrum Jhlich GmbH Projekttr@ger Biologie, Energie, _kologie
(46) "Solarthermie 2000" solar-energy promotion programme	The "Solarthermie 2000" programme has been set up as a field test for demonstration and testing of solar heat systems in public buildings in the area of the former GDR. Findings from the field test, and results of analysis of the long-term behaviour of existing systems, are to enter

Measure	Remarks
	into design of solar (local) district heating test systems.
(47) Research and development concerning use of solar energy	The following additional research and development concerning use of solar energy is being carried out: " Refinement of technologies for solar thermal and solar photovoltaic systems, with the aim of making such systems economically competitive; continuation of component development, " Expansion of applied research in solar technology in major research establishments (within the framework of a joint solar energy research effort), " Refinement of technologies for manufacturing cost-effective, high-efficiency crystalline silicon cells, " Study of materials and manufacturing processes for thin-film solar cells constructed of amorphous silicon and connecting semi-conductors.
(48) Research and development concerning secondary energy systems integrated with renewable-energy systems	The following R&D work is being carried out on secondary energy systems integrated with renewable-energy systems: - Intensive research into, and development of, high-energy batteries (energy storage units), which are expected to play an important role in further development of electric cars (among other applications). One emphasis of this work is to improve ceramic-oxide materials in order to enhance their durability and availability. - Development and testing of high-temperature fuel cells (energy converters) for use in power plants. This work is focused on the melted carbonate fuel cell (MCFC), which will soon be ready for demonstration, and on the ceramic-oxide fuel cell (COFC), for which materials are still being developed. The permeable membrane fuel cell (PEMFC) appears suitable for mobile applications. A decision concerning support for this programme is expected soon.In general, these fuel cells, because of their potentially high efficiency, are considered to have considerable promise as electro-chemical energy converters. - Development of hydrological, geological and physical-chemical thermal storage systems that will use renewable energies within integrated systems.
(49) Research and development concerning efficient energy use	Under the heading "efficient energy use", funding is concentrated solely on energy research focusing on technologies oriented to final-energy consumption in the sectors of "households and small consumers" and "industry and traffic/transport". The aim of these efforts is to

Measure	Remarks
	reduce energy losses and to exploit potential for saving energy. Typical for this area of support is the large number of development projects, many of them quite small, and the need to subsidise some individual companies, taking into account the subsidiarity principle. The main results of these efforts include: - Pure research and experiments in the area of translucent thermal insulation have shown that new materials applied to solid outer walls of buildings or within skylights can improve the energy yield in both passive and active solar systems (such as flat collectors). As part of a broad integrated project, the basis is being created for a range of applied system developments and testing. - Increased combination of ventilation and heating systems, in conjunction with heat reclamation, has become highly significant as a result of intensified energy-saving measures. Questions of room-air quality and room-air flows have also acquired greater significance in this context. Sophisticated and calculation-intensive computer programmes now permit simulation of room-air flows and their evaluation in terms of comfort levels in interiors.
(50) Nuclear energy research/ reactor-safety research	In future, the main R&D support in this area will be aimed at reactor safety and issues of disposal of radioactive waste, along with various aspects of refinement of innovative reactor concepts with inherent passive safety components. The primary aim of reactor-safety research is to create, within the framework of the state's obligation to take precautions, the scientific and technological basis for evaluating the safety of nuclear facilities and to provide impetuses for improvement and further development of safety technology. In addition, R&D measures are supporting the Federal authorities' legal obligation to plan, construct and operate final storage sites. State support for development of advanced generations of reactors, i.e. the high-temperature reactor and the fast breeder reactor, has been stopped. The most significant results: - Test-oriented confirmation and expansion of the material-mechanics database for components subject to dynamic stresses and aging.

Measure	Remarks
	- From evaluation of completed studies on the earlier hot-steam reactor project: verification of the safety reserves for pipeline stresses in a nuclear power plant resulting from thermal shocks, aircraft crashes or earthquakes. - The effectiveness of the German emergency cooling concept, employing combined feed-in, has been confirmed by 1:1 scale tests at the Upper Plenum Test Facility (UPTF) in Mannheim. The suitability and effectiveness of system procedures was studied in the primary cycle (Prim@rkreislauf - PKL) integrated test stand. - On the basis of probabilistic safety analyses, the risk-reduction possibilities provided by activation of internal (i.e. within the facility) emergency protection measures for light-water reactors were identified. - Results to date of studies concerning the direct final storage of spent fuel elements have shown that this technology is feasible, even with strict safety requirements. All planned demonstration tests are in their final phases. These tests have been able to show, among other results, that long-term sealing-off of pollutants from the biosphere is technically feasible and proven; that final storage of radioactive waste in granite is fundamentally possible; and, finally, that enough basic knowledge concerning safe storage of chemical and toxic waste in deep geological formations is available to permit establishment, among other information, of precise specifications for
	the necessary conveying and filling techniques and for the cavern technology required for salt, the final storage medium. Additional measures, some of which are currently being prepared: - Further development of methods/procedures for evaluating remaining lifetimes of reactor components, - Experimental and analytical studies for evaluation of internal (i.e. within facilities) emergency-protection measures; in particular, since mid-1991, large-scale studies at the UPTF system in Mannheim have been carried out within the new project, "Transients and Accident Management" (TRAM), concerning issues of internal emergency protection. - Improved description of processes that occur during hazardous reactor incidents.

Measure	Remarks
	- Analysis of complex system sequences on the test stand for simulation of incident sequences and the effectiveness of countermeasures, - Studies of safety-related characteristics of new reactor systems, - Probabilistic safety-analysis studies of boiling water reactors, - Continuation of basic research on the creation of final storage sites in salt domes and other geological formations, - Further development of methods and procedures for testing and proving the long-term safety of final storage sites (geomechanics, scenarios and models of leakage spreading), - Completion of the technical tests for direct final storage, with regard to proof of the maturity of this technology, - Optimisation of measures for monitoring fissile material, in cooperation with EURATOM and IAEO. Institutionally supported research on nuclear energy
	In the major research establishments in Jhlich (KFA) and Karlsruhe (KfK), nuclear energy research has lost most of its former importance. The work that is continuing there is mostly long-term research on increasing the safety of nuclear fission facilities and on nuclear-waste disposal.
(51) Nuclear-fusion research	Nuclear fusion, in addition to solar energy and breeder reactors, is one of the options for a long-term, safe energy source that conserves the environment and available resources. Tapping this energy source is a major challenge that can be met only through long-term efforts. The German fusion programme is part of the European programme. It is receiving institutional support. In three major research establishments, the Max Planck Institute for Plasma Physics (IPP), Garching; the Jhlich Research Centre (KFA); and the Karlsruhe Research Centre (KfK), studies in plasma physics and technical development of nuclear fusion are being carried out, on a work-sharing basis, in major experiments and large test facilities.

Measure	Remarks
	According to current estimates and planning, commercial fusion reactors could become available at about the middle of the next century.
(52) Research into thermal treatment of waste	The Federal Ministry for Research and Technology has concentrated most of its funding for the development and optimisation of incineration technology in the following three areas: " Waste preparation and processing prior to incineration, in order to achieve evener waste input, greater energy yield from the homogenised incinerated matter and improved flue-gas cooling and cleaning. " Incineration-chambre and boiler-area designs that are optimised to reduce fire corrosion and to maximise thermal yield to district-heating systems. " Flue-gas cleaning and treatment of solid incineration residues. The development of methods for reducing emissions has enabled inclusion, in the Ordinance on Incineration Systems for Waste and Similar Combustible Substances (17. BImSchV), of scientifically founded maximum emission standards that are many times lower than those of the Technical Instructions on Air Quality Control (TA Luft). Additional thermal processes that are worthy of mention include pyrolysis, of which experts have been aware for some time, and conversion, hydration and distillation. The last three processes are new developments that have only recently been studied as processes for thermal waste treatment. Following promising tests on a proof-of-concept scale, this work is now entering into the pilot phase, which will provide the opportunity for long-term optimisation on an operational scale.
(53) Test project entitled "Generation of heat and power from renewable raw materials"	In 1992, in order to improve the opportunities for using renewable raw materials for heat and power generation, especially for clarifying some relevant open questions in the areas of logistics and combustion technology, the Federal Government launched a multi-phase model test project entitled "Generation of heat and power from renewable raw materials". The aim of this project is to test, for the first time, larger biomass-combustion plants with outputs between 1 and 40 megawatts. The Federal Ministry of Food, Agriculture and Forestry is providing some 30 million DM in funding for this project.

Measure	Remarks
	Phase 1 of the project - preparation and evaluation of feasibility studies - was completed in September 1993. Phases 2 and 3 will comprise planning, construction and operation of the combustion plants. One aim of these phases is to minimise the plant's emissions.
(54) Geothermic energy	Research into geothermic energy is funded through the Federal Ministry for Research and Technology and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. In 1993, the Federal Ministry for Research and Technology provided approx. 6 million DM for specific projects; in 1994, it is providing 8.4 million DM. For 1995 to 1997, this ministry has committed 8.9 million DM to this area. In 1994, the Federal Ministry of Economics is also supporting geothermic projects - with an estimated 10 million DM in funding.

Agriculture and forestry:

Measure	Remarks
(55)Joint task "Improvement of Agricultural Structure and Coastal Protection"	This Federal/L@nder programme is supporting - extensive methods of cultivation, - extensive management of grassland, - ecologically oriented cultivation methods, - use of renewable energies in agriculture and - investments in energy saving in agriculture.
(56) Bonuses for land set-asides	Pursuant to an EC Agricultural Council proposal for a fertilizer ordinance, dated May 1993, land-set-aside bonuses will also be paid if renewable raw materials for energy uses are grown on the "set-aside" land.
(57) Improvement of animal digestive efficiency as part of animal husbandry, in order to reduce methane emissions	The primary effect of the Federal Government's measures for improving animal digestive efficiency as part of animal husbandry is a reduction of methane emissions per animal. Ruminant methane emissions are reduced if the animals make better use of nutrients; the result is a decrease of CH_4 emissions per milk/meat unit. As a result of the Animal Husbandry Act (Tierzuchtgesetz) of 22 December, 1989, animal husbandry progress can be expected primarily in improvements in animal digestive efficiency. Through the use of certain feed additives permitted by the Feedstuffs Ordinance, contributions to emissions reduction can be achieved both directly - for example, by influencing stomach metabolism - and indirectly - through improvements in yields. In addition, scientific studies have been commissioned for development of new procedures for keeping livestock - that are acceptable under labour-economic criteria - in which straw is added to manure to help reduce liquid-manure production, thus helping to reduce an additional methane source.

Measure	Remarks
(58) Support for extensive methods of agriculture	Agricultural CO_2 emissions are produced through direct energy use (of fuels, heating oil, electricity, etc.) and indirect use (mineral fertilizers, pesticides, herbicides and fungicides, feedstuffs, seed and young plants, machines, lubricants, farm buildings, etc.). By reducing indirect energy use, extensive methods of production, including ecologically oriented cultivation methods, can make an important contribution to reduction of CO_2 emissions in agriculture. Substantial promise for reducing CO_2 emissions in agriculture and forestry is found in the use of raw materials with a favourable CO_2 balance in chemical-technical applications, and in the energy sector. On the other hand, the competitiveness of such materials in the energy sector, which is far more significant than other sectors in terms of the volumes involved, is still lacking, in part. Measures pursuant to the Council Ordinance of 30 June 1992 on environmentally compatible methods of agriculture that protect natural habitats are being implemented in Germany through increased support for environmentally compatible production methods. The emphasis of these supporting measures is on support for the following areas: " extensive cultivation methods, " extensive management of grassland and conversion of cultivated land into extensively managed grassland and " ecologically oriented cultivation methods. In 1992, some 1% of all farms in Germany were practising ecologically oriented farming. Ecologically oriented farming is expected to retain its market share in the foreseeable future. More extensive production methods and land set-asides will reduce emissions of climate-relevant gases in the agricultural sector and help save energy. But it must be remembered that the agricultural sector accounts for only about 3% of consumption of fossil fuels in Germany, meaning that any CO_2 reduction brought about by these measures will be, at most, of a similar magnitude.
(59) Conservation of existing forests	Since 1982, with its action programme, "Save the Forests" (Rettet den Wald), the Federal Government has

Measure	Remarks
	been introducing wide-ranging measures for combatting new types of forest damage caused primarily by air pollution.
(60) Support for new afforestation	In Germany, new afforestation has been supported for many years within the "joint-task" framework. This support consists of two components: - Subsidies to help defray initial investment costs. Particular emphasis is placed on planting of near-natural deciduous and mixed-species forests. Up to 85 % of eligible costs are reimbursed for planting of deciduous stands; up to 75 % of eligible costs are reimbursed for planting of mixed-species stands. - Since 1991, a new-afforestation bonus has also been paid: farmers and forest owners receive, for up to 20 years, a bonus as compensation for losses of income due to set-asides of agricultural land. In 1993, this support was improved still further: the amount of the bonus - depending on the soil quality of the newly afforested farmland or grassland, and on the trees species selected - now ranges up 1,400 DM per year and hectare.
(61) Forest-management measures	Stable, high-yield forests with large biomass and carbon reserves, and that produce large yearly biomass and carbon increments, are considered valuable - valuable also with regard to the carbon cycle. In this light, forest-management techniques in which clear-cutting is largely avoided gain considerable significance, since they also avoid the releases of CO and nutrient losses that occur when humus is temporarily lost through clear-cutting. Forest management is thus be a substantial factor in preserving, or developing, optimum forest-ecosystem structures. For this reason, the Federal Government, in conjunction with the L@nder - and within the joint task "Improvement of Agricultural Structure and Coastal Protection" - is supporting numerous forest-management measures with this aim.
(62) Tax exemptions for pure rape methyl ester (RME)	Pure RME has been completely exempted from mineral-oil tax. This also applies when RME is added to other fuels in motor-vehicle fuel tanks. In pure form, RME can be used as a fuel in approved conventional diesel engines. One manufacturer has already approved one model for use with this "biodiesel fuel". Older vehicles may require conversion before manufacturers will approve them for use with this fuel. RME reduces

Measure	Remarks
	CO_2 emissions when used as a substitute for diesel fuel.
(63) Agency For Renewable Raw Materials (Fachagentur Nachwachsende Rohstoffe)	In October 1993, the Federal Government established the "Agency For Renewable Raw Materials" within the area of responsibility of the Federal Ministry of Food, Agriculture and Forestry. The tasks of this agency, which is located in Ghstrow (Mecklenburg - West Pomerania) include research and development regarding the complete process of production of renewable raw materials - from cultivation to use, including disposal, and taking into account factors such as cost-effectiveness, environmental factors, collection and preparation of technical information, advising and public relations. In the 1994 fiscal year, the agency has a budget of 56 million DM for support of research and development concerning renewable raw materials.
(64) Proposal for a fertilizer ordinance	The fertilizer ordinance currently under preparation, which will establish proper practice in fertilizer use, will also implement the requirements of the EC nitrate directive. Its regulations will also reduce N_2O emissions from agricultural fertilization.

Waste management:

Measure	Remarks
(65) Ordinance o	The ordinance on packaging regulates, within the framework of the Waste Avoidance and Waste Management Act, the obligations of manufacturers/sellers to take back and to recycle packaging and to emphasise recycling of materials (came into force in 1991).
(66) Technical Instructions on Municipal Waste Management (TA-Siedlungsabfall)	This administrative provision was issued within the framework of the Waste Avoidance and Waste Management Act, with the purpose of reducing the amount of solid municipal waste that must be stored in dumpsites, and of promoting waste separation and recycling. It also requires old dumpsites to collect and thermally exploit dumpsite gas. This provision provides a reduction of CO_2 and CH_4. The TA Siedlungsabfall came into force on 1 June 1993.
(67) Technical	In 1990, the TA Abfall, Part 1, was issued to define the

Measure	Remarks
Instructions on Waste Management (TA-Abfall), Part 1	state of the art for recycling and other disposal of waste requiring particular supervision. It sets high standards for the establishment, operation and post-care of facilities for storage (including long-term storage), chemical/physical and biological treatment and incineration of waste. Its strict requirements for pre-treatment of waste bring about a reduction of CO_2 and CH_4 emissions during storage. TA Abfall, Part 1, came wholly into force on 1 April 1991.
(68) Waste Management and Product Recycling Act (Kreislaufwirtschafts- und Abfallgesetz)	Development of the existing Waste Avoidance and Waste Management Act into a new Waste Management and Product Recycling Act, with the intent of conserving resources and avoiding waste through the material-flow principle. The Act provides for the following order of priority: - Avoidance of waste, - Recycling or thermal treatment and exploitation, - Disposal. Execution of this Act will reduce both CO_2 emissions and CH_4 emissions.

Overarching measures:

Measure	Remarks
(69)Improvement of training and continuing training for architects, engineers, technicians and craftsmen	The programme that has been carried out in this area for many years, in which funding is provided for informational and training events focusing on thrifty and efficient energy use, is being continued. In the area of vocational training, similar learning goals are already being regularly included within revision/new preparation of training ordinances for the relevant occupations. In this context, the Federal Government has commissioned the Federal Chambre of Architects (Bundesarchitektenkammer) to prepare curricular units for continuing training/education of architects, engineers and craftsmen in the areas of efficient, thrifty energy use and use of renewable energies.
(70) Support programme of the Deutsche Bundesstiftung Umwelt (DBU)	The Deutsche Bundesstiftung Umwelt (DBU) is an environmental foundation located in Osnabrhck that was established at the initiative of the Federal Government, by a resolution of the German Parliament. It began its work in 1991, and it is now one of the largest European foundations. The main areas in which it provides support include: 1. Future-oriented, environmentally focused management methods, products and technologies, 2. Innovative processes for recycling, disposal and emissions reduction, 3. Efficient energy use and renewable energies, 4. Environmental precautions, applied environmental research, 5. The environment and agriculture, 6. The environment and traffic/transport, 7. Providing environmental information and environmental advising, 8. Environmental education, 9. Protecting and preserving cultural treasures and monuments that have been damaged by environmental pollution. This environmental foundation has also established a stipend programme to promote young scientists working in environmental protection in the area of the former GDR. To support environmental research and teaching in the area of the former GDR, the foundation is also funding the establishment of (foundation) academic chairs. Some of the projects supported by the Deutsche Bundesstiftung Umwelt will help to reduce emissions of CO_2 and other greenhouse gases.

Measure	Remarks
(71) Investment programme for reducing environmental pollution	This programme of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety accepts applications from businesses and municipal authorities (contact the Federal Environment Agency - Umweltbundesamt - in Berlin). It provides investment subsidies, as well as interest subsidies for loans from the Kreditanstalt fhr Wiederaufbau reconstruction bank or the Deutsche Ausgleichsbank, within the framework of the KfW environmental programme or the supplemental programme III. Support is provided for large-scale projects demonstrating, in model form, how - Facilities can be adapted to the state of the art, in order to reduce pollution, - Advanced processes can be used to avoid environmental pollution and - Environmentally more compatible products and substitute materials can be manufactured and used.
(72) Environmental programme of the Kreditanstalt fhr Wiederaufbau (KfW) reconstruction bank	The KfW environmental programme supports investments that help to improve the environmental situation in Germany substantially. Supported investments include those made to eliminate or avoid air pollution; to reduce smell emissions, noise and vibrations; and to improve wastewater treatment and waste disposal and treatment. Those eligible to apply for the programme include businesses from Germany and from abroad, for measures in Germany (manufacturing, crafts, retail, other types of services and entrepreneurs in agriculture and forestry), as well as free-lance professionals from Germany. The programme provides low-interest loans; as a rule, of up to 10 million DM of financing requirements, and up to two-thirds of the total investment sum. For projects of companies with less than 100 million DM annual turnover (including turnover of associated companies), loans are provided for up to three-fourths of the required investment sum. Those interested in applying should apply through their home banks, to the Kreditanstalt fhr Wiederaufbau, Frankfurt/Main. Loans provided through this programme can also be granted as supplementary loans to ERP loans, and in addition to other public funding.
(73) Environmental programme of Deutsche Ausgleichsbank	The environmental programme of Deutsche Ausgleichsbank supports investments in all areas of environmental protection, especially projects for the avoidance or reduction of environmental pollution (preventive, integrated environmental protection). The programme

Measure	Remarks
	provides low-interest loans of up to 75% of total investments (normal case). Applications may be submitted by - Businesses, especially small and medium-sized companies, and - Freelance professionals, through their own home banks, to Deutsche Ausgleichsbank, Bonn.
(74) Environmental protection guarantee programme: liability exemption in connection with the supplementary loans programme III (Erg@nzungsdarlehen III) for subsidising manufacturers of preventative environmental protection technology	This programme provides assistance for investments for the manufacture of innovative, environmentally compatible products and production systems. Products and production systems must be able to prevent environmental pollution, or to reduce it over the long term. Small and medium-sized businesses are eligible to apply for the programme. The size of the liability exemptions provided is up to 80 % of the relevant loan amount, to a maximum of 1 million DM. Total liability is limited to 50 % of the relevant investment sum. Interested parties should apply through their home banks, using application forms provided by Deutsche Ausgleichsbank, Bonn.
(75) Federal/L@nder joint task "Improvement of the regional economic structure"	The purpose of this programme is to improve regional economic structures. Businesses and public-law authorities are eligible to apply.
	In former West Germany, the programme subsidises commercial investments at a level of up to 18%; in the area of the former GDR, it subsidises at a level of up to 23%. Subsidies are granted only in the support areas defined in the relevant framework plan. The area of the former GDR has been given special status, lasting until the end of 1996, for regional economic support. Before subsidies can be granted, reviews are necessary to determine whether the claimed prevention or maximum emissions limitation, and proper waste treatment, are indeed occurring. For investment projects meeting the prerequisites for support, the L@nder can provide guarantees that the Federal authorities then assume. Projects eligible for support within this joint task include energy-supply facilities, wastewater-treatment and waste-disposal facilities and projects to restore the health of

Measure	Remarks
	industrial operations.
(76) Financial support of the economic in-frastructure in the area of the former GDR - improvement of the regional economic structure in connection with support for municipal infrastructures	The group of those eligible to apply includes communities and districts, as well as private persons and legal entities (chambres, associations) not operating for profit. Applications can be submitted to the district administration responsible for the investment area in question (authorisation authority) or to the relevant agricultural ministry. The projects eligible for support include construction or expansion of energy and water supply lines and distribution systems, as well as of facilities for disposal or purification of wastewater and or for waste disposal.
(77) Advising concerning thrifty, efficient energy use, provided by the Arbeits-gemeinschaft der Verbraucher-verb@nde (AgV) consumer associa-tions' working group, on commission to the Federal Ministry of Economics	The AgV, in conjunction with the consumer advising centres of the L@nder, provides energy advising in 330 major cities - financed by the Federal Ministry of Economics. Advising is provided to interested persons on all questions related to thrifty and efficient energy use, including use of renewable energies. Advising in the centres is supplemented by year-round mobile advising services - five busses that systemati-cally visit smaller and medium-sized communities to ensure that energy advising is available throughout the country.
(78) Support for advising of small and medium-sized com-panies concerning environmental protection and energy use	This programme provides support, among other emphases, for advising to help companies deal with problems arising from environmental protection requirements (environmental protection advising), as well as advising concerning economic, technical and organisational problems related to thrifty, efficient and environmentally compatible energy use, including use of renewable energies (advising on saving energy). The group of those eligible to apply includes small and medium-sized businesses in trade and industry, free-lance professionals and agricultural companies. Subsidies are provided to cover up to 50% of the advising costs, up to a maximum of 4,000 DM. Applications should be submitted, after completion of the relevant advising, to an administrative office approved by the Federal Ministry of Economics. The authorisation authority is the Federal Economics Office (Bundesamt fhr Wirtschaft).
(79) Orientation advising on environmental	This programme provides subsidies for orientation advising in environmental protection designed to help companies take economic, technical, organisational and

Measure	Remarks
protection for small and medium-sized companies (area of the former GDR)	legal measures to deal with environmental pollution and meet stricter environmental standards. Legally independent businesses in the areas of trade and industry, and with annual turnover of up to 50 million DM, as well as private persons seeking to go into business for themselves, are eligible to apply. Subsidies of up to 85% of invoiced advising costs, up to a maximum of 3,400 DM, are paid. The programme ends on 31 October 1994. Applications should be submitted to the responsible chambre of commerce, after the relevant advising has been completed, by companies providing the advising.
(80) Orientation advising on environmental protection for com-munities in the area of the former GDR	This programme provides support for orientation advising that provides the applicant with the necessary knowledge of the particularly important national laws applying in his case. In addition, the advising should identify possible solutions and promising action strategies for organisational and technical, environmental protection concepts, plans and measures - and related questions of financing. Cities, communities, community associations, community interest groups, development companies and rural districts in the area of the former GDR are eligible to apply. Subsidies of up to 85% of invoiced advising costs, up to a maximum of 3,400 DM, are paid. The programme ends on 31 October 1994. Applications should be submitted to the Deutsche Institut fhr Urbanistik.
(81) Community loan programme - area of the former GDR	This programme supports community real investments, especially those made to improve the economic infrastructure, and including emphases in community environmental protection and energy saving. The group of those eligible to apply comprises communities, districts, community associations, interest groups, other authorities and public-law institutions and companies of community authorities - with predominantly community sponsorship - in the area of the former GDR. Investments are supported through low-interest loans. This programme terminated in 1992.
(82) Air quality control programme of the European Recovery Programme (ERP)	This programme provides support for construction and expansion of air quality control facilities, as well as facilities that eliminate or reduce noise, smell or vibrations, and environmentally compatible production facilities. Businesses in the areas of trade and industry are eligible to apply; small and medium-sized companies

Measure	Remarks
	receive preferential consideration. The programme provides low-interest loans of up to 50% of investments, to a total of 1 million DM. In exceptional cases of particular environmental policy significance, this loan-amount maximum can be exceeded, however. Applications may be submitted through any bank. ERP loans are disbursed through the Kreditanstalt fhr Wiederaufbau (KfW) reconstruction bank, Frankfurt.
(83) Technical information concerning efficient energy use and use of renewable energies	The Federal Ministry for Research and Technology is supporting specialised information resources relative to efficient energy use and use of renewable energies. The support is concentrated especially on the "Citizens' Information on New Energy Technologies" (Bhrgerinformationen Neue Energietechniken - BINE), provided by the Karlsruhe Technical Information Centre (Fachinformationszentrum Karlsruhe - FIZ-Karlsruhe); the "Information on Community Energy Supply" (Informationen zur kommunalen Energieversorgung - KEV); the "Information Centre for Heat Pumps and Refrigeration Technology" (Informationszentrum fhr W@rmepumpen and K@ltetechnik - IZW) located within the FIZ-Karlsruhe; the "Central Office for Solar Technology" (Zentralstelle fhr Solartechnik - ZfS) in Hilden; the "Institute for Industrialisation of Construction" (Institut fhr Industrialisierung des Baues), Hannover; and the "Indoor-Climate Technical Institute" (Fachinstitut Geb@ude-Klima), Bietigheim-Bissingen, which provides information on indoor climate control.
(84) Studies on optimising the CO_2-reduction programme	The various ministries participating in the "CO_2-reduction" IWG have commissioned numerous studies, within their own ministry research programmes, that are focusing on optimising and implementing the CO_2-reduction programme.
(85) Amendment of the Fee Table for Architects and Engineers (HOAI)	On 15 March 1994, the Federal Government approved the 5th Ordinance for Amendment of the Fee Table for Architects and Engineers (HOAI). The amendment provides for "special services" in the interest of efficient energy use and use of renewable energies, applying to cases in which services provided exceed the services generally required to properly fulfill contractual obligations. The purpose of the amendment is to give architects and engineers financial incentives to increase services on behalf of CO_2 reduction, use of renewable energies and efficient energy use.

Measure	Remarks
	The amendment is currently being deliberated in the Bundesrat (upper house of parliament). Bundesrat approval is required before the amendment can come into force. It is hoped that if Bundesrat approves the amendment, it can come into force this year.
(86) Research into specific approaches to regulatory instruments	The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety has commissioned a range of projects in which specific regulatory instruments are to be analysed regarding their effectiveness, their parameters and their chances for success. This analysis is focusing particularly on the following issues: - Third-party financing, - Continuing education for architects, - Active management in district-heating companies, - The Ordinance on Heat Use and the CO_2/energy tax, in concrete applications, - The Merseburg energy-supply concept, - The economic basis for using geothermal energy.
(87) System analysis within the Instruments for Climate-gas-reduction Strategies (IKARUS) project	In December 1990, the Federal Ministry for Research and Technology commissioned the Jhlich Research Centre (prime contractor) to prepare a range of tools with which interested users (scientists, industry, associations, unions and federal ministries) can develop and analyse climate-gas reduction strategies.
	As part of the IKARUS project, computer models of the German energy system are being developed (for Germany as a whole and for the separate areas of traffic and transport, indoor heating, district heating/electricity and industry) and databases are being established. The databases contain data on emissions factors and costs of all technologies of relevance for the German energy system, for the years 1989, 2005 and 2020. In addition, status quo data, where available, is also being stored: for housing structures, industrial processes and for transport systems. The tools can be used, for example, to identify the technologies that will be required in the year 2005 to achieve the aim of reducing CO_2 emissions by 25% - 30%, while minimising the costs to the economy as a whole. They are also expected to provide answers to many detailed questions, in such sectors as households, traffic and transport, industry and district heating/electricity. IKARUS is expected to help increase understanding of the overall functions and reactions of our strongly networked energy system, and to provide a better

Measure	Remarks
	foundation for further strategic considerations. The gases for which data is to be stored include carbon dioxide (CO_2), methane (CH_4), methane-free hydrocarbons, nitrogen oxides (NO_x), as NO_2, nitrous oxide (N_2O), carbon monoxide (CO), and stratospheric water vapour. To ensure that databases are available for a wide range of uses, the tools are being developed for personal computers (IBM and IBM compatibles). Development work is placing particular emphasis on user-friendliness, as well as on data comparability (transparency) and plausibility of the strategies developed with the system. The IKARUS project advisory board serves as a liaison to the "CO_2-reduction" IWG, and thus to the affected Federal Government ministries and their subordinate agencies. This board, which supports the project, is headed by the Federal Ministry for Research and Technology, and is identical with working group 4 of the "CO_2-reduction" IWG, "New technologies".
(88) Environmental certification mark (Umweltzeichen)	Since 1977 the environmental certification mark has been used to call consumers' attention to products that support efficient, thrifty energy use, as well as use of renewable energies. Such products include - CFC-free and energy-saving refrigerators and freezers, - Low-emissions oil-atomizing burners, - Special gas-fired boilers, - Combination water heaters and circulation heaters for gaseous fuels, - Burner/boiler units with gas burners and fans, - Oil-burner/boiler units, - Solar-powered products, - Natural gas condensing boilers - Gas room heaters and gas heating elements, - Lubricants and forming oils that biodegrade rapidly.

Part B. Measures that are currently being approved by the relevant decision-making bodies, or whose approval is currently being prepared or is currently planned:

Energy supply:

Measure	Remarks
(89)Amendment to the Energy Management Act	The amendment to the Energy Management Act will accompany the energy-law reform announced by the Federal Government in its report on securing the future of Germany as an economic region (Zukunftssicherung des Standorts Deutschland), whose aim is the introduction of effective competition within the electricity and gas industries. These efforts also are aimed at eliminating exclusive rights of passage and demarcation contracts, as well as improving network access for third parties, taking into account considerations of European and regional policy, and not limiting communities' rights to levy taxes on concessions. This reform is in line with EU-wide efforts to achieve greater competition between providers of line-bound energy.
(90) Proposal for an Ordinance on Heat Use	A Cabinet resolution of 7 November 1990 provides for the issuing of an Ordinance on Heat Use (W@rmenutzungsverordnung) pursuant to the Federal Immissions Control Act (BImSchG). A draft of such an ordinance is currently being prepared.

Traffic and transport:

Measure	Remarks
(91)Raising of the minimum EU levels for mineral-oil tax	As of 1 January, 1994, fuel tax and price levels in many neighbouring countries are lower than those in Germany. Consequently, there is a risk that more and more motorists will go abroad to refuel. This occurred after the last mineral-oil tax increase. Therefore, the Federal Government is striving to achieve greater harmonisation of mineral-oil taxes, i.e. further increases in minimum levels, in Brussels.
(92) Emissions-oriented motor-vehicle tax (2nd phase)	On 1 April, 1994, the new version of emissions-oriented taxation of commercial vehicles with a total permissible weight over 3.5 t was introduced, in a first phase. Plans call for introducing emissions-oriented taxation for automobiles, in a second phase. Conversion of automobile taxation (and including light commercial vehicles and motorcycles) to an emissions-oriented system is currently being prepared; its details remain to be determined. The introduction of emissions-oriented motor-vehicle taxation should provide incentives for the development and implementation of new motor-vehicle technology that will result in vehicles with considerably lower emissions.
(93) Road-use tolls	The introduction of road-use tolls can make an important contribution to the harmonisation of tax systems, and for juster allocation of road costs among traffic participants. In addition, such tolls have positive effects on traffic control, they can help increase driver awareness concerning motor-vehicle use and they can support desired shifts of traffic to other, environmentally compatible modes of transport. In June 1993, the Council of EU Ministers of Transport reached agreement concerning a system for allocation of road costs for the Community's goods transports on roads. As a result, Germany, in conjunction with the Benelux countries and Denmark, can introduce, beginning on 1 January 1995, a time-oriented motorway-use toll for trucks of at least 12 t total permissible weight. With this arrangement, both German and foreign trucks - for the first time - will share in paying German road costs.

Measure	Remarks
	Germany does not yet have a basis for decisions concerning the "whether" and "when" regarding introduction of electronic route-oriented road-use tolls (road-pricing) on German motorways, which for reasons of EC law, will not be possible before 1998.
(94) CO_2 emissions of new motor vehicles	Preliminary work has been accomplished for an EU directive defining guide values for CO_2 emissions of motor vehicles. By the year 2005, newly registered automobiles are to have a mean fuel consumption of 5 litres per 100 km, if at all possible. This is to be achieved by means of - gradual reduction of guide values (in stages, over time) for CO_2 emissions, - the new European driving cycle as the measurement procedure and - current fuel specifications. The Council has been unable to approve a resolution, which was originally scheduled for 1992, for a proposed directive, since the EU Commission has not yet submitted the relevant proposal. The EU Commission had commissioned the Motor Vehicle Emission Group (MVEG) to prepare a CO_2-reduction concept. This group has now presented various proposals. The European Commission's decision is still pending.
(95) German railways' site concept	The German railways' site concept for combined rail/road transports calls for new construction and expansion of railway freight stations at 44 sites in the Federal Republic of Germany. A total of 4 billion DM in investments are being planned for this purpose. By the year 2010, approx. 90 - 100 million t of total freight transports are to be transported by rail, as combined rail/road transports, for the majority of the transport distance.
(96) Use of modern information technology for preventing and regulating traffic (telematics)	The Federal Government is supporting the use of modern data-gathering, communications, control and information-technology systems that will help prevent and regulate traffic. Support is currently being provided for the development of an integrated telematics concept, i.e. a concept that takes account of all traffic sectors. Telematics can make a substantial contribution to achieving the aim of reducing CO_2 emissions. Telematics helps prevent superfluous traffic by enabling better use of the infrastructure, by networking and linking the infrastructure, by

Measure	Remarks
	shifting traffic as necessary and by contributing to a road-pricing system.
(97) Taxation of aircraft fuels	Within the EU, aircraft fuels for commercial air transport are exempted from mineral-oil tax, pursuant to Art. 8 para 1 letter b) of directive 92/81/EEC. Since this directive is binding for EU Member States, aircraft fuels can be made subject to mineral-oil tax only with the agreement of the other EU Member States. As part of the review of the tax exemptions set forth in Art. 8 of the above-mentioned EU directive, which is scheduled to occur by 31 December 1997, the Federal Government plans to reiterate its support for the elimination of this tax exemption.
(98) Amendment of the Common Rules of Procedure (Gemeinsame Gesch@ftsordnung) of the federal ministries	The first report of the "CO_2-reduction" IWG contained the proposal that, in order to reduce CO_2 emissions from traffic, future drafts of proposed laws and ordinances should describe the legislation's expected effect on traffic and the environment. This proposal has now been taken account of in the addition to Art. 40 para. 2 no. 3 of the common rules of procedure (Gemeinsame Gesch@ftsordnung) of the federal ministries, Special Part (GGO II), which is currently being implemented. The new Art. 40 para. 2 no. 3a, which is to be added, reads as follows: "If necessary, it should also be stated which effects on traffic are to be expected." The L@nder and communities should issue similar rules for their national regulations.
(99) Introduction of traffic-effects studies	As a follow-up to the relevant Cabinet resolution, a suitable procedure is to be developed for preventing traffic by means of instruments and procedures. The "traffic effects review" (Verkehrsauswirkungsprhfung) is being envisioned as a review procedure with a strong interdepartmental orientation (somewhat similar to the environmental impact assessment (EIA), although the EIA is used for individual projects) for planners and administrators. The procedure should make it possible to recognise traffic-multiplying decisions in early phases, without creating barriers to investment, and, if necessary, to take such findings into account in further planning.

Measure	Remarks
(100) Shifting of international transit traffic from roads to railways and to ships	The Federal Government plans to prepare measures that will shift international transit transports from roads to railways and ships.

Buildings and structures:

Measure	Remarks
(101)2nd Ordinance for Amendment of the Ordinance on Small Combustion Plants (1. BImSchV)	The Federal Cabinet's second CO_2 resolution, dated 7 November, 1990, contains a mandate for adapting the maximum permissible waste-gas loss standards pursuant to the Ordinance on Small Combustion Plants (1. BImSchV) to the current state of the art. The draft of the 2nd Ordinance for Amendment of the 1. BImSchV is soon to be submitted to the Federal Cabinet for approval.
(102) Instruments for increasing energy efficiency of existing buildings	The potential inherent in existing buildings and structures for reducing CO_2 emissions is a key to the implementation of the CO_2-reduction programme. The new thermal insulation ordinance takes existing buildings into account in that its requirements for subsequent thermal-insulation measures in existing buildings - where technically possible and economically acceptable - have been expanded, for cases in which extent of renovation and modernisation measures exceeds certain limits. Nonetheless, it is not possible to require comprehensive subsequent measures, since the investments required to exploit potential for saving energy are not cost-effective, given current energy prices, and would place unreasonable burdens on citizens. For this reason, the Federal Government plans to examine whether, and by what means, it would be possible to accelerate energy-saving investments in existing buildings.
(103) Special relevant privileges accorded within the building code	On 23 June, 1994, the German Parliament, as part of the amendment of the law for the promotion of traditional farm structures in agriculture (Gesetz zur F`rderung der b@uerlichen Landwirtschaft), approved the addition to Art. 35 para 1 of the Construction Code (Baugesetzbuch) of a new no. 7 that provides special arrangements for wind-power systems. The addition reads as follows: "Outdoor

Measure	Remarks
	projects are permissible only when the public interest does not preclude them, when the site is properly developed and their purpose .....7. is research, development or use of wind energy or other renewable energies". The Bundesrat has requested the parliamentary mediation committee to deliberate on this matter.
(104) Standardisation of authorisation practices for renewable energy systems	A lack of standardised L@nder and communities' authorisation requirements and criteria is hampering expansion of use of renewable energies. Impetus must be given to standardising authorisation practices of the L@nder and to eliminating legal uncertainties in this area. The Federal Government expects the various bodies of the working group of L@nder ministers responsible for matters of construction, housing and development (ARGEBau) to review this question again.

Overarching measures:

Measure	Remarks
(105)Improvement of the framework for vocational training and for continuing education and training	The Federal Government is working to ensure that the Federal Chambre of Architects, the Federal Chambre of Engineers and the Standing Conference of Ministers of Education and Cultural Affairs of the L@nder (KMK) increasingly give regard to renewable energies and efficient energy use in connection with amendments and additions to the framework ordinances for vocational training/education and for continuing training/education.
(106) Support for provision of information concerning third-party financing models	The EU-SAVE directive calls on Member States to promote use of third-party financing in the public sector. Any budgetary and public-procurement problems that remain, however, must be solved within the framework of the national implementation of the SAVE directive, in order to permit broad use of third-party financing in the public sector.
(107) Introduction of an (at-least) EU-wide CO_2/energy tax that has a neutral effect with regard to competition and total tax-revenue volume	An important element of the CO_2-reduction programme is the introduction of a CO_2/energy tax that has a neutral effect with regard to competition and total tax-revenue volume, and is in effect at least throughout the EU. It should also be ensured that the CO_2/energy tax has a guidance effect. The second report of the "CO_2-reduction" IWG reported in detail concerning the need for an EU-wide approach, at least, for taxation of CO_2 emissions. For this reason, the Federal Government has welcomed the European Commission's relevant proposed directive of May 1992 and has continued to support it. But even intensive negotiations have been unable to bring about the necessary unanimous approval. Currently, some Member States have diverging positions on this matter; therefore, it is unclear when the EU-level deliberations will produce a final result. Therefore, the Federal Government plans to continue striving to convince all EU partners of the need for such a taxation instrument. It also plans to support an internationally coordinated approach within the OECD framework. During the German Presidency, the Federal Government is continuing to emphasise the question of an EU-wide CO_2/energy tax that is neutral with respect to competition and total tax-revenue volume.
(108) Law on mandatory labelling with	The future improvement of information available to consumers concerning energy consumption of household

Measure	Remarks
regard to energy consumption	electric appliances is one of the informational measures that are being carried out following EU-level approval. In September 1992, the EC Council approved a framework directive by which certain household appliances must be sold with a label and data sheet providing information about their specific energy consumption. Currently, the European Commission, in cooperation with the Member States, is preparing execution directives for specific types of appliances. An execution directive for refrigerators and freezers has been approved. As part of the implementation of this directive, the Federal Government plans to present a draft for a law requiring products to carry energy-consumption-data labels. This law is expected to have a marked influence on consumer energy awareness.
(109) Planning of the parliament and government district in Berlin with regard to environmental protection requirements, especially climate-protection requirements	The future structures and energy supply in the parliamentary and government district in the Berliner Spreebogen area must both meet strict environmental policy requirements and guarantee reliability. Pursuant to the Cabinet resolution of 11 December, 1991 for the reduction of CO_2 emissions in the Federa Republic of Germany, the Federal Government plans to "...make intensive efforts to set a good example, on its properties, for low energy consumption, and to use renewable energies". A final energy concept is currently being prepared. The appropriate specifications are being given to architects and planners to ensure that buildings meet high energy standards. In the areas of both passive (structurally integrated) thermal insulation, and modern heating technology, solutions must be chosen that far exceed minimum standards.

5.2.2 Possibilities for binding carbon dioxide in reservoirs/by sinks (forestry and the lumber industry)

5.2.2.1 Conservation of existing forests

Conserving existing forests is the most important forestry-related measure for protecting the climate and binding CO_2 (cf. measure 61 in Tab. 5.1). Only if forests are protected over the long term,

- Will forests, which are important carbon reservoirs, be preserved,
- Will carbon continue to be bound,
- Can all other forestry-related measures for reducing climate change be successful.

In Germany, the Federal Forest Act provides the legal basis for preserving and adding to existing forest areas. Currently, the amount of area covered by forests is increasing.

Germany's forests are subject to a wide variety of stresses. The reasons for the so-called "new" forest damage in Germany are complex. Air pollution plays a central role. Air pollution impairs forests' balance of substances and growth. The Federal authorities and the L@nder closely monitor the condition of forests and report annually on it (for example, in the Federal Government's forest-condition report - Waldzustandsbericht). At an early date, the Federal Government initiated comprehensive measures to reduce emissions of pollutants. Nearly all measures for reducing air pollution contribute directly or indirectly to reducing emissions of climate-relevant trace gases.

The Federal Government will continue its resolute air-quality policies on the national and international levels, and it plans to refine them. In addition, it is assisting forestry companies in their complementary forest-management efforts to protect forest ecosystems against new damage.

5.2.2.2 Possibilities for new afforestation

Planting new forests on land not previously used for silvicultural purposes (new afforestation) is a particularly useful way of increasing carbon binding. As a rule, such additional forests provide a multitude of other benefits as well (productive, protective and recreational functions of forests).

For years, new afforestation has been promoted in Germany by means of investment subsidies within the framework of the Joint Scheme to Improve the Agricultural Structure and Coastal Protection" (cf. measure no. 60 in Tab 5.1). In 1991, incentives for new afforestation of agricultural land were considerably enhanced through the introduction of an additional 20-year new-afforestation bonus for farmers and forest owners.

The effects of this bonus on the rate of new afforestation remain to be seen. It is expected, however, that through this arrangement up to 12,000 hectares will be newly afforested annually.

As a result, the total amount of forest land could increase by 150,000 hectares by the year 2005. The new forests in place by that date would store an additional 0.5 million tonnes of carbon, or 2 million tonnes of CO_2, annually. This would represent a 0.2% contribution to overall reduction, with respect to national CO_2 emissions in 1990.

Consequently, the potential for CO_2 binding through new afforestation is limited.

The following points must be taken into account in connection with new afforestation:

- The decision in favour of new afforestation of agricultural land lies primarily with the (private) owner of the land, and thus depends on a range of different subjective considerations.

- In a country as densely populated and intensively used as Germany, new afforestation is not always reasonable or possible - for ecological (for example, nature conservation), social and cultural (for example, changed landscape image) reasons.

- The time during which carbon binding - its net effect - occurs is limited to the growth phase of the new forests.

5.2.2.3 Increasing biomass levels of existing forests

Other measures under discussion to increase carbon storage of forests include longer rotation periods and optimum use of increments. The Federal Government holds the view that in Germany such measures can make only a relatively modest contribution to improving the CO_2 balance.

5.2.2.4 Increased use of wood

With regard to the problem of climate, use of wood has a number of advantages. For this reason, it is important to increase wood use.

Wood has a neutral impact on the carbon cycle when used for energy; i.e. the amount of carbon released - including carbon released in CO_2 - is the same as the quantity drawn from the atmosphere as the wood grew. For this reason, increased use should be made of wood and wood products as energy sources (burning/gasification).

Increased use of wood products helps reduce greenhouse gases

- when such products are used as a substitute for raw materials with a less favourable greenhouse-gas balance in production, processing and disposal,
- in that carbon remains bound in wood (if not burned) for long periods of time.

The above-mentioned use of wood in long-lasting products expands the potential of wood as a CO_2 reservoir. According to estimates of the Federal Research Agency for the forestry and lumber industry (Bundesforschungsanstalt fhr Forst- und Holzwirtschaft), over 325 million tonnes of carbon (equivalent to 1 billion tonnes of CO_2) are currently stored in wood products. Wood products thus have an important function as intermediate CO_2 reservoirs.

5.2.2.5 Summary of all possible silvicultural measures

Estimating the impact silvicultural and forest-management measures will have with respect to CO_2 reduction is extremely difficult and subject to considerable uncertainty. One reason for this difficulty is that it is currently not possible to determine when forests have reached a maturity stage at which they can no longer bind additional amounts of CO_2. According to findings so far, it seems possible, using the above-mentioned options, to improve the national CO_2 balance by approx. 5-10 million tonnes of carbon per year (20-40 million tonnes of CO_2). This would correspond to a ratio of 2-4% of total national annual CO_2 emissions. This would not suffice to make urgently required measures to limit greenhouse-gas emissions unnecessary, however.

5.3 Other involved parties

The success of the Federal Government's climate-protection policy also depends on the cooperation of all those involved. By itself, the Federal Government will not be able to implement, on the local level, a programme that so intensively affects economic and social structures. In the Federal Government's opinion, diffusion of climate-protection strategy since 1990 to the different levels and concerned parties involved has been extremely successful.

5.3.1 Lander

Gradually, the Lander are also preparing their own Land-specific climate-protection programmes. The Federal Government welcomes the development and implementation of such programmes - especially for the reason that in many areas the Lander have executive competency. The Federal Government and the Lander are coordinating their efforts within the "Environment and Energy" working group of the Conference of Ministers of the Environment.

5.3.2 Cities and communities

Since 1990, numerous communities have begun developing and implementing community CO_2-reduction concepts, often on the basis of existing energy-supply concepts. Far more than 100 such concepts have now been prepared. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, in conjunction with the Federal Environment Foundation (Bundesstiftung Umwelt) is attempting to support this trend by developing guidelines for community CO_2-reduction concepts. Head community associations are giving this topic increasing attention.

In addition, communities are organising themselves into a European-level climate-protection alliance. This alliance has set itself the very ambitious goal of reducing CO_2 emissions in its member communities by 50% by the year 2010, in relation to 1987 levels.

In February 1992, the Federal Government, in cooperation with the German Society for Technical Cooperation (Deutsche Gesellschaft fhr technische Zusammenarbeit), Eschborn, and the Berlin Senate, sponsored an international experts' conference on the topic of "Promoting community environmental protection - strategies and approaches". The conference approved recommendations of the Rio Conference in the form of a "Berlin Declaration". This declaration lists strategies and approaches for strengthening community environmental protection in both industrial and developing countries. The list has been included in the corresponding chapter of the Agenda 21.

5.3.3 Industrial and economic associations

In November 1991, six central German industrial associations presented an initiative paper on world-wide climate protection. In the paper, German industry emphasises that it is willing to do its part to stem the greenhouse effect. The paper also makes clear that the industry considers self-commitment declarations and compensation solutions to be effective climate-protection instruments. Since 1992, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Federal Ministry of Economics and the Federal Ministry of Finance have been conducting intensive discussions with industrial representatives to find ways of implementing this initiative paper. To date, these discussions, in spite of the efforts of the Federal Government and industry, have been unsuccessful. The Federal Government plans to continue its discussions with German industry.

5.3.4 Other involved parties

In addition to the above-mentioned involved parties, the topic of climate protection is being currently discussed very intensively by unions, environmental associations, consumer organisations, the churches and other social groups. The aim of these initiatives is to make clear to each individual that he or she can make a decisive contribution to combatting the global greenhouse effect. In the opinion of the Federal Government, these initiatives are extremely important. The Federal Government assists these efforts wherever it is able to do so.

Measures for reducing greenhouse gases covered by the Montreal Protocol are not included here. In addition, other specific measures that have taken by the Federal Lander and by communities to reduce emissions of CO_2 and other greenhouse gases are not listed here

6. Emissions scenarios

6.1 The reliability of predictions and scenarios

In all political areas, and on all political levels, predictions and scenarios are indispensable tools for obtaining a concept of that which could occur in the future and for estimating the effects of possible measures. In the area of energy policy, predictions and scenarios have always played an important role, on the national level (Federal authorities, Lander), on the European level (EU, ECE) and on the international level (IEA, World Energy Council, UN).

Predictions and scenarios have had particular importance since consultations began to formulate a globally coordinated climate-protection strategy. In both the IPCC and the INC frameworks, countless predictions and scenarios, with a wide range of territorial and chronological frames of reference, have been presented and discussed. In many cases, the impression was confirmed that predictions have been appropriated for certain aims and interests. This was also the result of a study entitled "Analysis of the most recent energy-requirements predictions for important nations with regard to the avoidance of energy-related greenhouse gases" (*Analyse jhngster Energiebedarfsprognosen fhr wichtige Nationen im Hinblick auf die Vermeidung energiebedingter Treibhausgase*) that was carried out by the Fraunhofer Institute for System Technology and Innovation Research, on commission to the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Again and again, participants in political discussion overlook that there is no certain knowledge of the future, and that predictions cannot be more than "if-then statements."

Predictions thus always depend closely on the conditions on which they are based, and the results of scenarios always depend on the premises from which they begin. This means that a number of different descriptions of the future, all of which are consistent and free of contradictions, can always be made simultaneously, with each depending on the assumptions made concerning the further development of economical, demographic and political parameters, and on the way interconnections relative to energy consumption are assessed. In addition, it has proven to be the case over the last three decades that there is a tendency to overestimate actual energy consumption; clearly, this tendency is systematically caused. According to the Jhlich Research Centre's studies of the period between 1970 and 2000, 21 of 24 consumption curves obtained through energy predictions lay markedly over the actual development. Only three predicted curves were below actual development. The discrepancy between predicted and actual development was particularly pronounced for the two oil-price crises of 1972/73 and 1979/80.

It would be wrong, however, to develop a reproach on the basis of such mistaken predictions. Neither predictions nor scenarios can take account of unforeseen external shocks or other externally caused parameter changes. This fact should always be remembered in connection with the interpretation of predictions and scenarios.

An additional reason for the relative nature of predictions and scenarios concerning energy consumption and the development of greenhouse-gas emissions is, purely and simply, that the future effects of certain measures cannot be predicted, even with the best possible methods. The following are typical examples, taken from the Federal Government's climate-protection strategy (including the CO_2-reduction programme), of measures whose effects cannot be predicted:

- The amendment to the Energy Management Act,

- The amendment to the Fee Table for Architects and Engineers (HOAI),

- Measures for improving consultation and availability of information,

- Measures for improving training/education and continuing training/education.

Furthermore, it must be remembered that, due to interdependencies between individual measures, the sum as a rule is greater than simple addition of effects of individual elements.

Such qualifications concerning the reliability of predictions and scenarios notwithstanding, scientific predictions and scenarios remain important instruments for preparing decisions - when they clearly identify the unavoidable subjectivity and relativity of their assumptions and underlying interrelationships, and when they systematically impart to the political decision-maker information about economic, social and technological structure-changing influences that would otherwise not be available.

It is in this light that the results summarised in table 6.1 of selected predictions and scenarios must be evaluated. The Federal Government has not adopted any of the statements made by these predictions, but it does take account of their results in shaping its policies. And the following holds for all results of the predictions/scenarios presented in the following section, in all studied variations: it was only possible to give them partial consideration in the Federal Government's climate-protection strategy, and in its CO_2 -reduction programme. The Rhine-Westphalian Institute for Economic Research (*Rheinisch-Westf@lisches Institut fhr Wirtschaftsforschung - RWI*), Essen, and the ifo Institute for Economic Research (*ifo-Institut fhr Wirtschaftssforschung*), Munich, were commissioned by the Federal Ministry of Economics to carry out a study entitled "Overall economic effects of CO_2-reduction strategies" (*Gesamtwirtschaftliche Auswirkungen von CO_2 -Minderungsstrategien*); this study attempts to close this gap, by means of the appropriate methods, to the best possible extent (cf. the above remarks on this subject).

Tab. 6.1: Results of selected predictions and scenarios for energy consumption and CO_2 emissions in Germany

Prediction	Prediction period	Development	
		of energy consumption	of CO_2 emissions
SHELL 1993	1991 - 2020 New horizons falling barriers	 + 18.4 % - 4.3 %	 + 2.2 % - 15.7 %
ESSO 1992	1991 - 2010	- 1.0 %	- 11.0 % (- 17.0 % (1987 - 2005)
PROGNOS 1991	1989 - 2010 Reference case Sensitivity case	 - 1.0 % - 7.9 %	 - 7.7 % (- 11 % (1987 - 2010)) - 16 % (- 18.4 % (1987 - 2010))
RWI/Ifo (tentative intermediaterepo rt)	1987 - 2005 Reference case Measures scenario		 - 9.8 % - 18.1 %

Source: Federal Ministry for the Environment, Nature Conservation and Reactor Safety

6.2 Reducing emissions of the greenhouse gases CH_4 and N_2O, and the ozone-precursor substances NO_x, NMVOC and CO, by the year 2005

On 11 December, 1991, the Federal Cabinet directed the "CO_2-reduction" IWG to "continue its work on a global concept for CO_2 reduction, taking into account other climate-relevant greenhouse gases".

The purpose of this chapter is to identify possibilities, as well as corresponding measures, for reduction in Germany of the greenhouse gases methane (CH_4), nitrous oxide (N_2**O**), nitrogen oxides (NO_x), methane-free volatile organic compounds (NMVOC) and carbon dioxide (CO).

Only seldom do emissions occur in "isolated" form; i.e. in many transformation and production processes, a number of different greenhouse gases are released simultaneously. This also means that in many cases, measures for reduction of CO_2 emissions also result in reduction of other greenhouse-gas emissions. But possibilities and measures for effectively reducing other greenhouse gases - independently of any CO_2 reduction - must also be identified.

The following section presents the results of estimates made by the Federal Environmental Agency (*Umweltbundesamt - UBA*) of future trends for other greenhouse gases, separated into trends for energy-related and trends for non-energy-related emissions. The emissions figures do not correspond to the IPCC structure. In light of the limitations of predictions and scenarios (cf. chapter 6.1), the figures should be viewed as data for orientation.

6.2.1 Perspectives for the development of other energy-related greenhouse-gas emissions by the year 2005

The Federal Environmental Agency's estimates of energy-related greenhouse-gas emissions were based on the following studies: a study carried out by the "Prognos" institute, Basel, entitled "Energy-industry development in the Federal Republic of Germany until the year 2010, including development in the five new Federal Lander" (*Die energiewirtschaftliche Entwicklung in der Bundesrepublik Deutschland bis zum Jahre 2010 unter Einbeziehung der fhnf neuen Bundesl@nder*), and commissioned by the Federal Ministry of Economics; for the traffic and transport sector, a study carried out by the Institute for Energy and Environmental Research (*Institut fhr*

Energie- and Umweltforschung - Ifeu), Heidelberg, entitled "Traffic-related emissions of greenhouse gases, on the basis of current traffic development in unified Germany" (*Verkehrsbedingte Emissionen von Treibhausgasen auf der Basis der aktuellen Verkehrsentwicklung im wiedervereinigten Deutschland*), and commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. By and large, these studies take into account CO_2 -reduction measures that are already effective or that have at least been initiated, but they do not take full account of the catalogue of CO_2 -reduction measures approved by the Federal Government in its resolutions to date. The Federal Government is aware of the methodological difficulties involved in the preparation of such predictions, as well as of those arising in the Federal Environmental Agency's estimates.

Methane (CH_4)

The sector of extraction and distribution of fossil fuels is the largest source of energy-related CH_4 emissions; it accounts for nearly 90 percent of them.

The remaining 10 percent of energy-related CH_4 emissions occur in (incomplete) combustion of fossil fuels.

Of the energy-related methane emissions from the source group extraction and distribution, some 75 percent originate in hard-coal mining, and 20 percent are caused by local natural-gas distribution. The remaining emissions in this category are caused by production of lignite, oil and natural gas.

According to these estimates, energy-related CH_4 emissions could be reduced by 40 percent, in relation to the 1987 level, by the year 2005.

Nearly 30 percent of the pit gas that occurs in active mines is drawn off. Of this amount, some 76% is currently exploited for energy purposes. According to figures of the German hard-coal mining industry, a maximum of 78% of the captured gas can be so used. This use level is expected to be reached by the year 2005.

As local gas networks are modernised, CH_4 emissions from local gas distribution will decrease considerably, both specifically and absolutely. In relation to 1987 levels, CH_4 emissions from these sources could decrease by 60% by the year 2005.

EC directives have been introduced for limiting hydrocarbon emissions from motor vehicles. As of result, emissions of CH_4, a hydrocarbon, will also be reduced.

Directive 91/441/EEC has been introduced to reduce automobile emissions. In a first phase that began in 1992, it sets limits for hydrocarbon emissions by including them in a maximum permissible sum that also includes nitrogen oxide emissions. Stricter limits will be introduced in a second phase beginning in 1996.

EC Directive 91/542/EEC, for commercial vehicles, has been in force since 1992/93. It also provides for stricter limits in a second phase, which, in this case, will begin in 1995/96.

With these directives, motor-vehicle CH_4 emissions can be reduced by 40% by the year 2005 (i.e. a reduction of 30,000 tonnes), in relation to 1990, or by one-third (20,000 tonnes), in relation to 1987 levels.

For both of the above EC directives for limiting traffic emissions, Germany has put forward proposals for a third phase, beginning in 1999, in which still stricter limits would apply. With these additional measures, motor-vehicle-related CH_4 emissions could be reduced by an additional 20%.

6.2.1.2 Nitrous oxide (N_2O)

About half of energy-related N_2O emissions are caused by power plants and district-heating plants. Among stationary emissions sources, only hard-coal firing plants employing fluidised-bed technology produce significant N_2O emissions.

Exhaust-gas scrubbing technology (for example, desulphurisation/denitrification facilities) has been found to have very little or no influence on magnitude of N_2O emissions. Increased N_2O emissions were detected with use of SNCR procedures (selective catalytic reduction), especially when urea was added. But increased use of SNCR technology is not expected to bring noticeable increases of the N_2O factor (retrofitting of old plants as part of execution of the Technical Instructions on Air Quality Control (*TA Luft*) and the Ordinance on Large Combustion Plants (13th Federal Immissions Control Ordinance - *13. BImSchV*) has been completed in former West Germany; limited use in new plants and in the area of the former GDR).

Potential for reducing N_2O emissions in the energy sector is seen primarily in fluidised-bed combustion systems. Measures for reducing N_2O emissions in fluidised-bed combustion are currently being studied (for example, increasing the combustion-chambre temperature; catalytic N_2O reduction). The measures are still untested and require further development.

It is assumed that use of suitable measures for reducing N_2O emissions in fluidised-bed combustion systems will not have a noticeable effect on emissions by the year 2005.

In road traffic, an increase of N_2O emissions is expected, as a result of an increase in the number of vehicles equipped with catalytic converters (required by environmental policy);

N_2O and other substances tend to form within catalytic converters. N_2O occurs as a by-product of NO_x transformation within the catalytic converter; this is explained as a reaction between nitrogen monoxide (NO) and CO and hydrogen (H_2), the last two of which are present in exhaust in small percentages. Since NO_x concentrations become smaller in front of the catalytic converter as the fuel mixture becomes richer, while CO and H_2 concentrations increase, the formation of an N_2O maximum in the lambda less than 1 region (rich mixture) can be explained. Catalytic-converter technology will have to be improved before such N_2O formation can be reduced or eliminated. In current converters, mixture richness is optimised in the cold-start phase and under full-load conditions, in order to reduce formation of undesirable substances.

It should be noted here that the largest possible contribution to reducing N_2O emissions does not lie in the energy sector (cf. chapter 6.2.2). Energy-related N_2O emissions in Germany could increase to 60 kilotonnes by the year 2005 (1990: 30 kilotonnes). This doubling would be due increases in traffic N_2O emissions which, from a current perspective, are expected to continue increasing.

6.2.1.3 Nitrogen oxides (NO_x)

In 1987, road traffic was the largest single source of these emissions, accounting for 45 percent, followed by power plants and district-heating plants with 27 percent.

Energy-related NO_x emissions could be reduced by about one-third by the year 2005, in relation to the 1987 level - or one-fourth, in relation to the 1990 level. Road traffic could then account for 70 percent of total emissions, while the percentage for power plants and district-heating plants could decrease to 15 percent.

Excellent progress in NO_x reduction in large combustion plants has been made through execution of the Ordinance on Large Combustion Plants (*13. BImSchV*) of 22 June 1983 (in connection with the definition approved by the Conference of Environmental Ministers, on 5 April 1984, of the technical state of the art for reducing nitrogen oxide emissions from large combustion plants).

For medium-size combustion plants, process combustion, gas turbines and stationary gas and diesel engines, NO_x limits pursuant to the TA Luft of 27 February, 1986 are applied. Execution of the regulation for old plants will be completed in former West Germany in 1994; in the area of the former GDR, it will continue until 1999.

The Ordinance on incineration systems for waste and similar combustible substances (*Verordnung hber Verbrennungsanlagen fhr Abfalle und ahnliche brennbare Stoffe - 17. BImSchV*), of 23 November 1990, considerably tightened the TA Luft's requirements for such plants.

For small combustion plants, the Ordinance on Small Combustion Plants applies (*1. BImSchV*).

Modernisation of small combustion plants, and designation of particularly efficient and low-emitting plants with the *Blauer Engel* ("Blue Angel") environmental certificate, are also helping to reduce emissions in this emissions group.

The EC directives 91/441/EEC and 91/542/EEC provide for NO_x standards for motor vehicles (among other standards) to be tightened in phases. These directives mandate further tightening of standards now.

6.2.1.4 Methane-free volatile organic compounds (NMVOC)

For this emissions group as well, the largest energy-related source is road traffic, which accounts for some 80 percent of NMVOCs. About 10 percent of the emissions occur in the sector "extraction and distribution of fossil fuels", in refilling and storage of petrol, and in motor-vehicle refuelling.

As a result of already-introduced measures, energy-related NMVOC emissions will decrease by 70 percent by the year 2005 (in relation to 1987) or by 66 percent (in relation to 1990).

NMVOC emissions of motor vehicles, together with motor-vehicle CH_4 emissions (discussed above), will be reduced as a result of the hydrocarbon-emissions limits mandated by EC directives 91/441/EEC and 91/542/EEC.

The 20th Ordinance on the Federal Immissions Control Act (*20. BImSchV*) was issued to limit NMVOC emissions from petrol within the chain defined as "transport from refinery-storage tanks (if not subject to special authorisation) to petrol station tank".

The 21th Ordinance on the Federal Immissions Control Act (*21. BImSchV*) places limits on emissions occurring in refuelling motor vehicles with petrol.

Limits for NMVOC emissions from plants subject to special authorisation (refineries, large tank-storage facilities) have been set by the TA Luft.

The aim of the German proposal for introducing a third phase into both of these EU directives, beginning in 1999, is a further decrease of NMVOC emissions. This measure could decrease motor-vehicle-related NMVOC emissions by an additional 20 percent.

The Federal Government is also seeking further fuel-quality improvements. Benzine emissions are to be reduced by decreasing the benzine and aromatic-substance content of petrol. Other fuel parameters (vapour pressure, distillation range, sulphur content) are to be modified as well; consequently, overall hydrocarbon emissions from petrol-fuelled motor vehicles will be reduced.

In October 1992, the Federal Government requested the EU, in a memorandum, to present proposals for increasing the environmental quality of all fuels, because, according to recent findings, other fuel components, in addition to benzine, also contribute to environmental pollution. The EU Environmental Council's resolution of 2/3 December 1993, which extends the directive on automobile emissions standards, obligates the European Commission to present proposals for new fuel quality standards by the end of 1994, as a means of reducing environmental pollution. As part of its effort in this area, the European Commission has initiated the so-called "Auto/Oil programme".

6.2.1.5 Carbon monoxide (CO)

The main source of CO emissions is road traffic, which accounts for about 56 percent, followed by households and small consumers, which account for 20 percent.

Carbon monoxide emissions could be reduced by about 60% (in relation to 1987 levels), or by about 52 percent (in relation to 1990 levels), by the year 2005. Driving these reductions would be the same regulations listed in connection with reduction of NO_x emissions.

Emissions from traffic could decrease by 55 percent; those from households could be reduced by 70 percent.

These estimates are based on the same regulations mentioned above in connection with NO_x-emissions limitations.

In general, large combustion plants now reliably meet CO-emissions standards established by the 13th Ordinance on the Federal Immissions Control Act (*13. BImSchV*), and most plants' emissions are considerably below these standards. In medium-size combustion plants (TA Luft), emissions reductions are achieved by means of

- Conversion to low-emissions fuels,
- Improvement of burn-out behaviour of wood and coal-dust combustion systems and (in the area of the former GDR) heating-oil and gas combustion systems.

In small combustion system, emissions reductions are being achieved through conversion to fuels with lower emissions, improved equipment technology and the product requirements mandated by the environmental certificate (*Umweltzeichen*).

The EC directives on motor-vehicle emissions limits also mandate reductions of CO emissions, in two phases.

Introduction of a third phase, as provided for by the EU directives 91/441/EEC and 91/542/EEC, could reduce energy-related CO emissions by an additional 5 percent.

6.2.1.6 Other energy-related greenhouse-gas emissions until the year 2005

Tab. 6.2 summarises the Federal Environmental Agency's estimates for energy-related greenhouse-gas emissions, which employ trend assumptions.

Tab. 6.2: Energy-related greenhouse-gas emissions in Germany for 1987 and 1990, and estimates made by the Federal Environmental Agency for the year 2005, using trend assumptions (cf. chap. 6.2.1)

	Emissions in kt/a														
	CH_4			N_2O			NO_x (NO_2)			NMVOC			CO		
	1987	**1990**	**2005**	**1987** 1)	**1990**	**2005**	**1987**	**1990**	**2005**	**1987**	**1990**	**2005**	**1987**	**1990**	**2005**
Total (rounded off); of this:	**1850**	**1750**	**1100**	**20**	**30**	**60**	**3700**	**3150**	**2350**	**1900**	**1700**	**570**	**12000**	**10300**	**4900**
Power plants, district heating plants	10	10	11	9	14	14	990	590	370	9	10	11	980	810	100
Other energy transformation; processing; of this:	24	19	10	4	4	5	340	290	250	21	18	13	1250	1150	700
- Other energy transformation	4	3	2	1	1	1	--	--	--	4	3	2			

- Other mining and processing	20	16	8	3	3	4	--	--	--	17	15	11			
Households and small consumers	130	110	55	4	5	5	150	120	100	130	110	55	2550	2050	800
Traffic; of this figure:	65	75	45	3	7	35	2200	2150	1650	1550	1400	490	7200	6300	3250
- Road traffic	60	70	40	2	6	30	1650	1650	1050	1400	1250	410	6750	5950	3050
- Other traffic	4	4	2	2	2	3	320	320	360	150	130	75	460	350	210
- High-seas bunkering	--	--	--	--	--	--	220	160	220	--	--	--	--	--	--
Extraction and distribution of fossil fuels	1600	1550	990	--	--	--	2	2	2	200	210	19	--	--	--

All figures rounded off
[1)] Only former West Germany

Source: Federal Environmental Agency

6.2.2 Perspectives for the development of other non-energy-related greenhouse-gas emissions until the year 2005

The descriptions of emissions developments in the following section focus on portions of the emissions of specific industrial branches that are not related to fuel extraction, distribution and combustion. For this reason, no predictions are made concerning overall development of emissions of the industrial branches concerned.

Basis for the data:
The available basic data and evaluations used to predict development of emissions, until the year 2005, of the greenhouse gases CH_4, N_2O, NO_x, NMVOC and CO from production processes, from product use, from agriculture and from waste management come from a range of sources. They vary in quality. For cases in which data for 2005 is lacking, and for which no emissions increase seems likely until then, the most recent available figures were extrapolated to 2005, using the "conservative method".

For certain aspects of the area of the former GDR, data was lacking; in such cases, data from former West Germany was adopted or adapted for Germany (where this has been done, a note to that effect has been included).

6.2.2.1 Methane (CH_4)

Tables 6.3 and 6.4 show CH_4 emissions for 1987 and 1990, along with two predictions for the period until the year 2005. The two predictions show the effects of already initiated measures and of additional measures, respectively.

In 1990, methane emissions from production processes and from agriculture and the waste-management industry amounted to approx. 4,500 kilotonnes. Dumpsites account for some 50 percent of total non-energy-related CH_4 emissions. In 1990, agriculture accounted for about 46 percent of non-energy-related CH_4 emissions. The majority of these emissions is caused by enteric fermentation in ruminants, while the remaining CH_4 emissions are produced by raw materials of animal origin. Methane emissions from production processes, in relation to total emissions, are insignificant (less than 1 percent).

The measures that have been initiated are expected to bring about a 50% reduction by the year 2005.

By means of additional measures, CH_4 emissions could be reduced by an additional 12 percent; consequently, a total reduction of some 60%, in relation to the 1990 level, could be achieved.

Tab. 6.3: Non-energy-related CH_4 emissions from production processes, agriculture and the waste-management industry in Germany for 1987 and 1990, and an estimate for the year 2005 (in keeping with current parameters)

	CH_4 emissions in kt/a			
	1987	**1990**	**2005**	**Parameters**
Total (rounded off); of this:	**4600**	**4450**	**2200**	
Production processes; of these:	14	11	11	-
- Refineries	3	3	3	
- Coking plants	2	1	1	
- Iron and steel industry	9	6	6	
Agriculture; of this:	2200	2050	1850	EC agricultural reform (reduction of beef-cattle inventories)
- Fermentation	1500	1450	1300	

- Animal wastes	680	620	560	
Waste management; of this:	2400	2400	300	
- Wastewater treatment plants[1)]	80	55	55	
- Sewage-sludge recycling	25	25	20	
- Dumpsites	2300	2300	20	TA Siedlungsabfall, TA Abfall

All figures rounded off;
[1)] = Area of the former GDR, (psychrophilic sludge stabilisation)
Source: Federal Environmental Agency

Tab. 6.4: Non-energy-related CH_4 emissions from production processes, agriculture and the waste-management industry in Germany for 1987 and 1990, and an estimate for the year 2005 (with additional measures)

	CH_4 emissions in kt/a			
	1987	**1990**	**2005**	additional measures
Total (rounded off); of this:	**4600**	**4450**	**1700**	
Production processes	14	11	11	
- Refineries	3	3	3	
- Coking plants	2	1	1	
- Iron and steel industry	9	6	6	
Agriculture	2200	2050	1450	Further reduction of livestock inventories
- Fermentation	1500	1450	1000	Better quality and more efficient use of feedstuffs
- Animal wastes	680	620	430	Collection of generated biogas and use for energy purposes
Waste management	2400	2400	260	
- Wastewater treatment plants[1)]	80	55	5	use for energy purposes
- Sewage-sludge recycling	25	25	20	
- Dumpsites	2300	2300	230	

All figures rounded off;

1) = Area of the former GDR (psychrophilic sludge stabilisation)
Source: Federal Environmental Agency

Parameters:

The Technical Instructions on Municipal Waste Management (*TA-Siedlungsabfall*), which came into force on 1 June, 1993, mandates that by 1 June, 2005, at the latest, only mineralised and inert waste may be stored. Dump-site gas from old dump sites, from both operational and closed dump-site sections, is to be collected and exploited, following a transition period. Combustion without use of the resulting energy is permitted only in authorised exceptions.

Over the long term, these regulations will almost completely eliminate emissions of climate-relevant gases from dump sites.

In the medium term, increased combustion of dump-site gas in combustion plants and internal combustion engines after the TA Siedlungsabfall comes into force will produce a marked reduction of methane emissions.

The EC agricultural-sector reform will reduce both agricultural production and producers' prices. A slow decrease in beef-cattle inventories is expected to take place by the year 2005.

Additional measures:

- Additional emissions reductions could be achieved in the agricultural sector by means of further reduction of livestock inventories, increases in animal productivity and more efficient use of feedstuffs.

  As to animal waste, optimisation of storage conditions for manure (covered liquid-manure storage containers, exploitation of "biogas") could achieve further emissions reductions in this area.

It is assumed that, over the medium and long terms, effective application of various emissions-reduction measures in animal husbandry and in storage of animal waste could achieve total CH_4-emissions reductions of 25 to 30 percent by the year 2005, in relation to the 1990 level.

- Exploitation of the energy in sewage gas, and enclosure of wastewater-treatment tanks, in combination with exhaust-gas scrubbing (for example, using SNCR technology), could also achieve reductions in this area (favourable by-product: reduction of smells).

6.2.2.2 Nitrous oxide (N_2O)

In 1990, non-energy-related N_2O emissions amounted to 190 kilotonnes. They consisted of emissions from nitric-acid and adipic-acid production, and from product use (laughing gas), and of emissions from agriculture and the waste-management industry.

The 1987 figures are incomplete, for both former West Germany and for the area of the former GDR, so no evaluation of the development from 1987 to 1990 is possible.

The main sources of non-energy-related emissions are production processes, which account for some 50 percent (mainly adipic-acid production), and agriculture, as a result of fertilizer use and production of animal residues, which accounts for 42 percent. Emissions from use of laughing gas and from wastewater treatment plants are relatively low (3 percent and 2 percent, respectively).

The only (indirect) effect of ammonia that has relevance for climate is that in the atmosphere, ammonia is rapidly transformed into ammonium ions. From the air, they enter natural and agricultural ecosystems. In the soil, they are microbially transformed into N_2O emissions; the magnitude of such transformation is on the order of a few percent of the deposited nitrogen. In light of the uncertainties and the relative insignificance of this portion of emissions, it was not considered in the N_2O emissions calculations.

If it is assumed that N_2O emissions from adipic-acid production can be virtually completely eliminated, an approx. 40% reduction of total non-energy-related N_2O emissions can be expected by the year 2005 (in relation to the 1990 level). By means of additional measures, a 60% reduction of non-energy-related N_2O emissions, in relation to the 1990 level, could be achieved (cf. Tables 6.5 and 6.6).

Parameters:

Reductions of production-process emissions can be expected in adipic-acid production. One of the two adipic-acid producers in Germany has developed and patented a procedure in which N_2O is broken down thermally into its two components, oxygen and nitrogen. The corresponding facility has been installed, with total investments of ca. 7 million DM. Once this facility has gone into operation, this production plant will emit no more than traces of N_2O. It is assumed that the second adipic-acid producer will reduce his N_2O emissions to a similar degree. As a result, a total reduction of about 90 percent could be achieved in this area.

Emissions reductions in agriculture can be expected to result from the following measures:

- Various Land-level programmes for support of environmentally more compatible agriculture,

- The EU Ordinance on ecologically oriented farming,
- The EU agricultural reform (set-asides and reduction of livestock inventories).

Additional measures:

- Possibilities for reducing N_2O emissions are also found in nitric-acid production.
- In agriculture:

  Integrated, appropriate (for the site) methods of cultivation;

  Nitrogen fertilization in keeping with plant requirements - as well as with the amounts of nitrogen removed by plants from the soil, the typical amounts of additional nitrogen supplied by the site and the potential harvest;

  Reduction of nutrient losses, by means of optimal soil preparation, crop rotation and irrigation;

  Efficiency increases by improving fertilizer dosage;

  Improvement of expert advising regarding fertilizer use;

  Selection of the suitable type of fertilizer;

  Preparation of nitrogen balance sheets as a basis for fertilization;

  Ordinance on fertilization also as a means for implementation of the EU nitrate directive;

  Specification of properly required fertilization in keeping with proper practice; the ways this can be accomplished include prescribed soil testing, proper determination of fertilizer requirements, limitations on spreading of liquid manure and requirements for documenting fertilizer use;

- N_2O emissions from wastewater treatment plants could be reduced by enclosure of treatment tanks, in combination with waste-gas scrubbing (for example, using SNCR technology).

Tab. 6.5: Non-energy-related N_2O emissions from production processes, product use, agriculture and the waste management industry, in Germany, for 1987 and 1990, and estimates for the year 2005 (in keeping with current parameters)

	N_2O emissions in kt/a			
	1987	**1990**	**2005**	**Parameters**
Total (rounded off); of this:	**100** (incomplete)	**190**	**110**	
Production processes[1)]; of this:	n.a.	100	20	
- Nitric acid production	15	11	10	
- Adipic acid production	n.a.	85	9	Emissions reduction by manufacturers
Product use[1)]; of this:	n.a.	5	5	
- Laughing gas	n.a.	5	5	
Agriculture; of this:	85	80	80	
- Animal wastes	11	10	9	EU agricultural reform (including reduction of beef-cattle
- Fertilizer use	75	70	70	

				inventories)
Waste management[1]; of this: - Wastewater treatment plants	0 0	4 4	4 4[2]	

All figures rounded off
[1] Data for the area of the former GDR not available
[2] An additional increase, which to date is still not quantifiable, is expected from denitrification

n.a. = Data not available
Source: Federal Environmental Agency

Tab. 6.6: Non-energy-related N_2O emissions from production processes, product use, agriculture and the waste management industry, in Germany, for 1987 and 1990, and estimates for the year 2005 (with additional measures)

	N_2O emissions in kt/a			
	1987	**1990**	**2005**	additional measures
Total (rounded off); of this	**100** (incomplete)	**190**	**70**	
Production processes[1)]; of this:	n.a.	100	10	
- Nitric acid production	15	11	1	Reduction in production
- Adipic acid production	n.a.	85	9	
Product use[1)]; of this:	n.a.	5	5	
- Laughing gas	n.a.	5	5	
Agriculture; of this:	85	80	55	
- Animal wastes	11	10	7	Among other measures, further reduction of livestock inventories
- Fertilizer use	75	70	50	

				Fertilizer ordinance
Waste management[1]; <u>of this:</u>	0	4	1	
- Wastewater treatment plants	0	4	1	

All figures rounded off

[1] Data not available for the area of the former GDR

n.a. = Data not available
Source: Federal Environmental Agency

6.2.2.3 Nitrogen oxides (NO_x)

Table 6.7 shows the non-energy-related NO_x emissions from production processes for 1987, 1990 and 2005.

In 1987, they amounted to 25 kilotonnes.

Because of a lack of data for the area of the former GDR, the overall assessment is based on data for former West Germany.

The main source of non-energy-related production-process emissions is the chemical industry, which produced nearly 70% of total emissions in 1987. Reductions by 1990, in this industrial branch alone, to about half the 1987 emissions level, resulted in a total emissions reduction of 36% over this period.

Emissions from the iron and steel industry, and from the glass industry remained constant between 1987 and 1990. In 1990, these two areas, respectively, accounted for about 19% and 25% of total emissions.

Tab. 6.7: Non-energy-related NO_x (NO_2) emissions from production processes, in Germany, for 1987 and 1990, and estimates for the year 2005 (in keeping with current parameters)

	NO_x (NO_2) emissions in kt/a			
	1987	**1990**	**2005**	**Parameters**
Total[1)] (rounded off); of this:	**25**	**16**	**16**	TA Luft
- Iron and steel industry - Glass industry - Chemical industry	3 4 17	3 4 9	3 4 9	

All figures rounded off

[1)] Data not available for the area of the former GDR

Source: Federal Environmental Agency

6.2.2.4 Methane-free volatile organic compounds (NMVOC)

The NMVOC emissions from production processes and solvent use have been estimated in great detail for 1986, on the basis of various studies of several different institutions. Because of this great detail, and in order to highlight further development by source groups, this year has been included in tables 6.8 and 6.9. The emissions-reduction estimates, based on introduced measures, have been made for 1995. In keeping with a "conservative estimate", these emissions figures were also used for the predictions for the year 2005 that take introduced measures into account.

In 1987, non-energy-related NMVOC emissions in Germany amounted to 1,400 kilotonnes.

Emissions from solvent use account for 90 percent of total NMVOC emissions. The corresponding percentage for the area of the former GDR is approx. 11 percent.

The data for 1986 has been divided according to:

- Plants subject to authorisation (4th Ordinance on the Federal Immissions Control Act - *4. BImSchV*),
- Plants not subject to authorisation (2nd Ordinance on the Federal Immissions Control Act - *2. BImSchV*),
- Other plants not subject to authorisation,
- Products.

Within the solvent-use category, the largest emissions percentage, 32 percent, occurs in product use, followed by emissions from plants subject to authorisation (*4. BImSchV*) and those from other types of plants (not subject to authorisation), each of which accounts for 28 percent. Emissions from industrial cleaning plants (*2. BImSchV*) account for some 11 percent of total emissions.

Measures for reducing NMVOC emissions have already been introduced. On the basis of the introduced measures, an approx. 20 percent reduction of emissions from solvent use in Germany can be expected by 1995 (and 2005), in relation to the 1987 level (cf. Tab. 6.8).

Tab. 6.8: Non-energy-related NMVOC emissions from production processes and solvent use, in Germany, between 1986 and 2005 (in keeping with current parameters)

	NMVOC emissions in kt/a					
	1986	**1987**	**1990**	**1995**	**2005**	**Parameters**
Production processes (Area of the former GDR)	25	25	17	17	17	
Production processes (former West Germany)	110	100	100	100	100	
- Refineries	25	24	25			
- Chemical industry	45	45	45			
- Iron and steel industry	12	10	7			
- Particle-board production	4	4	4			
- Mixed asphalt production	3	3	3			
- Food and luxury food sector	17	17	18			
Solvent use (Area of the former GDR)	160	160	160	160	140	
Solvent use (former West Germany)	1100	1100	1050	900	900	
	310			240	240	
- Plants subject to authorisation (4. BImSchV)	120			80	80	TA Luft 86; in part, specific
	70			60	60	implementation of the "dynamisation

- Paint processing	120			100	100	clauses"
- Chemical industry						
- Other uses	120			20	20	
- Plants not subject to	120			20	20	Amendment of the 2. BImSchV of 10
authorisation	310			320	320	December 1990
(2. BImSchV)						
- Industrial cleaning						none (in part, use of low-solvents
- Other plants not subject	130			120	120	production, to avoid need for
to authorisation	50			45	45	authorisation)
	130			160	160	
	350			330	330	
- Paint processing						
- Reproduction processes						
- Other uses						Self-commitment by the paint industry,
- Products						TRGS floor-covering glues, Amendment UZ
						12a
Total (rounded off)	1400	1400	1350	1200	1150	

All figures rounded off

Source: Federal Environmental Agency

Tab. 6.9: Non-energy-related NMVOC emissions from production processes and solvent use, in Germany, between 1986 and 2005 (with additional measures)

	NMVOC emissions in kt/a					
	1986	**1987**	**1990**	**1995**	**2005**	additional measures
Total; of this:	**1400**	**1400**	**1350**	**1200**	**500**	
Production processes; of this	140	130	120	120	120	
- Refineries	25	24	25			
- Chemical industry	45	45	45			
- Iron and steel industry	12	10	7			
- Particle-board production	4	4	4			
- Mixed-asphalt production	3	3	3			
- Food and luxury food sector	17	17	18			
Solvent use (area of the former GDR)	160	160	160	160	75	
Solvent use (former West Germany);	1100	1100	1050	900	300	
of this				240	100	
- Plants subject to	310				25	
authorisation				80	30	
(4. BImSchV)	120				50	

- Paint processing				60		
- Chemical industry	70				0	
- Other uses				100	0	
	120				120	
- Plants not subject to				20		
authorisation				20	40	
(2. BImSchV)	120			320	15	
- Industrial cleaning					60	
- Other plants not subject	120			120	80	
to authorisation				45		
	310			160		
- Paint processing				330		
- Reproduction processes						
- Other use	130					
- Products						
	50					
	130					
	350					

All figures rounded off
Source: Federal Environmental Agency

Parameters:

The reduction achieved is due mainly to implementation of the approved measures - the TA Luft from 1986 and the 2. BImSchV from 1990. Further improvements in plant technology can be expected. In the area of automobile painting (series production), specific implementation of the TA Luft's "dynamisation clause" will in itself bring a reduction of solvent use. On the other hand, the CFC-halon-prohibition Ordinance will have some unfavourable effects on the emissions situation. In the areas of aerosols, industrial cleaning and foam propellants, some of the CFCs were replaced by NMVOC, resulting in a partial emissions increase.

In addition to the legal regulations, some voluntary measures have also been implemented, with varying success. In the do-it-yourself area of the house-paint sector, low-solvents product carrying the environmental certification (*Umweltzeichen*) UZ 12a have obtained a considerable market share (over 50 percent).

With the help of the Technical Rule no. 610 for Dangerous Substances (*Technische Regel fhr Gefahrstoffe - TRGS 610*), "Substitutes and use restrictions for primers and floor-covering glues with high solvent content" (*Ersatzstoffe and Verwendungsbeschr@nkungen fhr stark l`semittelhaltige Vorstriche and Bodenbelagsklebstoffe*), it proved possible, for work-safety reasons, to considerably increase the market share of low-solvent and solvent-free glues already available on the market.

In another measure carried out between 1986 and 1991, the paint industry made a voluntary commitment to reduce solvent use by 20 to 25 percent. The industry proved unable to fulfill this self-commitment, and a slight increase in solvent use occurred - in conjunction with an increase in production. This market area has shown how necessary it is to improve product information for the consumer - and how successful such improvement can be.

Additional measures:

The European Commission is currently preparing an EU solvents directive.

6.2.2.5 Carbon monoxide (CO)

Table 6.10 shows the non-energy-related CO emissions from production processes in 1987 and 1990, as well as an estimate for the year 2005.

In 1987, CO emissions from production processes amounted to 600 kilotonnes. Due to a lack of data for the area of the former GDR, figures for former West Germany were used for Germany as a whole.

Emissions levels in 1990 were slightly higher - 2 percent - than they had been in 1987. This was due to a slight increase of process emissions in the iron and steel industry. That industry is the main source of CO emissions from production processes; in 1990, it accounted for some 82 percent of total emissions in this category.

Aluminium production accounts for approx. 18 percent of CO emissions. Emissions from carbon-black production are insignificant (less than 1 percent).

As a result of initiated measures, a 16 percent reduction of CO emissions is expected by the year 2005, in relation to the 1990 level.

Tab. 6.10: Non-energy-related CO emissions from production processes, in Germany, for 1987 and 1990, and estimates for the year 2005 (in keeping with current parameters)

	CO emissions in kt/a			
	1987	**1990**	**2005**	**Parameters**
Total (rounded off)[1)]; of this:	**600**	**610**	**510**	TA Luft
- Iron and steel industry	490	500	400	
- Black carbon production	2	2	2	
- Aluminium production	110	110	110	

All figures rounded off

[1)] Data not available for the area of the former GDR

Source: Federal Environmental Agency

6.2.3 Global prediction of other greenhouse-gas emissions until the year 2005

Table 6.11 summarises the data, in absolute figures, for energy-related (chapter 6.2.1) and non-energy-related (chapter 6.2.2) emissions of methane (CH_4), nitrous oxide (N_2O), nitrogen oxides (NO_x), methane-free volatile organic compounds (NMVOC) and carbon monoxide (CO). For non-energy-related greenhouse-gas emissions, the figures are in keeping with current parameters; additional measures would bring about further reductions, as described in chapter 6.2.2.

Tab. 6.11: Greenhouse-gas emissions in Germany in 1987 and 1990, and trend-based estimates of the Federal Environmental Agency for the year 2005 (energy-related emissions as described in chapter 6.2.1 and non-energy-related emissions as described in chapter 6.2.2)

	Emissions in kt/a														
	CH_4			N_2O			NO_x (NO_2)			NMVOC			CO		
	1987	**1990**	**2005**	**1987**	**1990**	**2005**	**1987**	**1990**	**2005**	**1987**	**1990**	**2005**	**1987**	**1990**	**2005**
Total (rounded off); of this:	**6450**	**6200**	**3250**	**120**[3]	**220**	**170**	**3700**	**3150**	**2350**	**3300**	**3050**	**1750**	**12600**	**10900**	**5350**
Power plants, district heating plants	10	10	11	9	14	14	990	590	370	9	10	11	980	810	100
Other energy transformation; processing; of this:							340	290	250				1250	1150	700
- Other energy transformation	4	3	2	1[2]	1	1				4	3	2			
- Other mining und manufacturing	20	16	8	3[2]	4	4				17	15	11			
Households and small consumers	130	110	55	4	5	5	150	120	100	140	120	55	2550	2050	800

Traffic; of this:	65	75	45	3[2)]	7	35	2200	2150	1650	1550	1400	490	7200	6300	3250
- Road traffic	60	70	40	2[2)]	6	30	1650	1650	1050	1400	1250	410	6750	5950	3050
- Other traffic	4	4	2	2[2)]	2	3	320	330	360	130	110	75	400	310	210
- High-seas bunkering	0	0	--	--	--	--	220	160	220	20	16	--	55	35	--
Extraction and distribution of fossil fuels	1600	1550	990	--	--	--	2	2	2	200	210	19	0	0	--
Production processes	14	11	11	15[2)3)]	100[2)]	20[2)]	25[2)]	16[2)]	16[2)]	130	120	100	600[2)]	610[2)]	510[2)]
Product use	--	--	--	--	6[2)]	5[2)]	--	--	--	1250	1200	1050	--	--	--
Agriculture	2200	2050	1850	85	80	80	--	--	--	--	--	--	--	--	--
Waste management	2400	2400	300	0	4[2)]	42[2)]	--	--	--	--	--	--	--	--	--

All figures rounded off

2) Data not available for the area of the former GDR

3) Not including adipic acid production

Source: Federal Environmental Agency

Table 6.12 summarises the emissions reduction for other greenhouse gases (both energy-related and non-energy-related) by the year 2005, in relation to emissions in 1987 (where the relevant data is available) and 1990, in percent. Further reductions of greenhouse-gas emissions could be achieved through additional measures (cf. chapters 6.2.1 and 6.2.2).

Tab. 6.12: Change in emissions of the greenhouse gases CH_4, N_2O, NO_x, CO and NMVOC, by the year 2005, in relation to levels in 1987 and 1990, in percent, and based on trend estimates (for energy-related and non-energy-related emissions)[1)]

	Emissions change in %	
	1987 - 2005	1990 - 2005
Methane (CH_4)	-50	-48
Nitrous oxide (N_2O)	n.a.	-25
Nitrogen oxide (NO_x)	-36	-25
Carbon monoxide (CO)	-58	-51
Methane-free volatile organic compounds (NMVOC)	-47	-43

[1)] On the basis of other premises, the Federal Environmental Agency has carried out model emissions estimates, for the year 2005, for the Federal Government's 5th immissions-control report. According to these estimates, considerably greater reduction, in relation to 1989, are achieved (cf.: *5. Immissionsschutzbericht der Bundesregierung*, BT-Drucksache 12/4006,

p. 41)
n.a. = No figures provided, due to a lack of data
Source: Federal Environmental Agency

6.2.4 Determination of CO_2 equivalents

Tables 6.13 through 6.15 summarise greenhouse-gas emissions in Germany, using mass-based CO_2 equivalents expressed in millions of tonnes. The tables also give the corresponding percentages for CO_2, CH_4 and N_2O for the time horizons of 0, 20, 100 and 500 years, in relation to emissions in 1987, 1990 and 2005 (with current knowledge levels, these figures still contain considerable uncertainties). The CO_2 equivalents for CFCs have not been included.

Tab. 6.13: **CO_2 equivalents (mass-based), in relation to greenhouse-gas emissions in 1987, in Germany**

Substance	**Emissions 1987**	**GWP direct effects**				**CO_2 equivalents**							
Time horizon (years)		0	20	100	500	0		20		100		500 500	
	Mt					**Mt**	%	**Mt**	%	**Mt**	%	**Mt**	%
CO_2	1087	1	1	1	1	1087	74	1087	89	1087	94	1087	98
CH_4	6.5	58	35	11	4	377	26	228	11	72	6	26	2
N_2O	n.a.	206	260	270	170	--	--	--	--	--	--	--	--
Total [1)]						1466	100	1215	100	1159	100	1113	100

[1)] Not including CFCs and N_2O
GWP = Global Warming Potential

Source: Federal Environmental Agency

Tab. 6.14: CO_2 equivalents (mass-based), in relation to greenhouse-gas emissions in 1990 in Germany

Substance	**Emissions 1990**	**GWP direct effects**				**CO_2 equivalents**							
Time horizon (years)		0	20	100	500	0		20		100		500 500	
	Mt					**Mt**	**%**	**Mt**	**%**	**Mt**	**%**	**Mt**	**%**
CO_2	1031	1	1	1	1	1031	72	1031	79	1031	89	1031	94
CH_4	6,2	58	35	11	4	360	25	217	17	68	6	25	2
N_2O	0,22	206	260	270	170	45	3	57	4	59	5	37	3
Total						1436	100	1305	100	1158	100	1093	100

[1] Not including CFCs
(GWP = Global Warming Potential)

Source: Federal Environmental Agency

Tab. 6.15: CO_2 equivalents (mass-based) in the year 2005, in Germany, in relation to greenhouse-gas emissions in 1987, and in keeping with the measures that have been introduced (cf. chapters 6.2.1, 6.2.2 and 6.2.3)[1)]

Substance	**Emissions 2005**	**GWP direct effects**				**CO_2 equivalents**							
Time horizon (years)		0	20	100	500	0 0		20 20		100 100		500 500	
	Mt					**Mt**	**%**	**Mt**	**%**	**Mt**	**%**	**Mt**	**%**
CO_2	980	1	1	1	1	980	82	980	86	980	92	980	96
CH_4	3,25	58	35	11	4	183	15	114	10	36	3	13	1
N_2O	0,17	206	260	270	170	35	3	44	4	46	4	29	3
Total [3)]						1198	100	1138	100	1062	100[2)]	1022	100

(**GWP** = Global Warming Potential)

[1)] This emissions estimate does not take account of complete implementation of the Federal Government's CO_2-reduction programme

All figures rounded off

[2)] Sum P 100 due to error in rounding off

Source: Federal Environmental Agency

[3)] not including CFCs

The mass-based GWP-figures (Global Warming Potential) comprise only the direct radiation effects.

The influences on climate of indirect chemical effects, such as ozone formation through methane oxidation, can still only be qualitatively estimated (cf. IPCC-Supplement Report 1992). For this reason, no quantitative predictions are made concerning the influences on climate of CO, NO_x and NMVOC.

The "0 years" time horizon gives the CO_2 equivalents for the direct radiation effect of climate gases at the time of emission.

For time horizons greater than 0 years, the radiation effects figures given for climate gases take into account the gases' persistence in the atmosphere. The contribution of gases with short persistence, such as methane (about 10 years), decreases as the time horizon increases.

For the "0 years" time horizon, the CO_2 equivalent determined for 1987 amounts to a sum of 1,466 million tonnes for the two most significant (apart from CFCs) anthropogenic greenhouse gases, CO_2 and CH_4. The percentages per gas for this case are approx. 74 percent for carbon dioxide and approx. 26 percent for methane (this does not include the CFC and N_2O components).

For the "0 years" time horizon, the CO_2 equivalent determined for 1990 amounts to a sum of 1,436 million tonnes for the three most significant (apart from CFCs) anthropogenic greenhouse gases, CO_2, CH_4 and N_2O. Percentages per gas for this case are approx. 72 percent for carbon dioxide, approx. 25 percent for methane and about 3 percent for nitrous oxide (this does not include the CFC components).

Current evaluations of mass-based GWP figures indicate that the momentary influence on climate of the greenhouse gas methane is 58 times greater than that of carbon dioxide; the momentary influence of nitrous oxide is over 200 times greater. The significant factors within the context of proven influence on climate, however, are the harmful gas' percentage of the overall CO_2 equivalent, and the assumed gas persistence within the atmosphere that has been used to obtain this value.

Consequently, after 20 years, the methane component decreases by 40 percent; after 100 years, it decreases by about 80 percent. On the other hand, during the same period the climate-influencing power of nitrous oxide increases by 27 percent over the same period. Only after a time horizon of 500 years has it decreased somewhat - by 17 percent.

Both greenhouse gases (CH_4 and N_2O) help to reinforce the anthropogenic greenhouse effect - even if their contributions differ. After 20 years, this delayed shift increases carbon dioxide's percentage of the additional greenhouse effect, among these three gases, to some 80 percent; after 100 years, to some 90 percent.

As a result of initiated measures, a 17 percent decrease of CO_2 equivalents for momentary influence on climate, for the above-mentioned three gases, and in relation to 1990 levels, can be expected by the year 2005 (not taking CFCs into account). An additional reduction can be achieved by the year 2005 by means of additional measures.

If CFCs and their CO_2 equivalents are included in these considerations, the following picture results:

Assuming that CO_2-reduction goals are achieved - i.e. a reduction of 25 - 30 percent is achieved by the year 2005, along with concomitant reductions of other energy-related climate-relevant gases; and assuming that the CFC-halon-prohibition Ordinance takes effect, and that reduction requirements for NO_x and VOC are implemented, pursuant to the relevant ECE protocols and the additional declaration on NO_x reduction, a reduction of CO_2 equivalents on the order of 50 percent could be achieved in Germany by the year 2005 (in relation to emissions levels in 1987).

7. Research and systematic observation

7.1 National activities and contributions to international research and development programmes

7.1.1 Objective and task of research

To an increasing degree, human intervention is influencing climate and the entire environment and endangering living conditions for people alive today and for future generations. Environmental research and technology development must meet the challenge of helping create a solid and implementable concept for viable, ecologically sustainable development of human society. From this need are derived three central and closely interrelated areas of research:

1. **System research** seeks to understand environmental systems, together with their interrelationships with civilisations systems, and to predict their development. With regard to the climate system, it is seeking to obtain reliable information concerning the development of global and, especially, regional climate.

2. **Effects research** seeks to assess the effects of human intervention on the environment, as well as the effects of anthropogenically modified environmental systems on the environment itself, on humans, on human health and on the socio-economic basis for human life. Research into the results of climate change is concerned with the possible effects of climate change on natural systems and on civilisation's systems.

3. **Research into solution technologies** uses findings from system and effects research to prepare options for action to solve environmental problems. It seeks to provide knowledge for action to reduce emissions of greenhouse gases, as well as the necessary technologies for implementing such knowledge. It also aims to prepare options for action to deal with the effects of climate change on natural systems and on civilisation's systems.

Scientific and technical understanding of environmental problems is not enough to solve these problems permanently. Increasingly, approaches developed through social and economic science must also be included in these efforts, in order to obtain holistic proposals for solutions.

7.1.2 Coordination and support of research

In view of the complex and global nature of environmental problems, intensified interdisciplinary and international cooperation is urgently required. The framework for such cooperation is currently formed by major international research programmes, such as the International Geosphere and Biosphere Programme (IGBP) and the World Climate Research Programme (WCRP). An internationally coordinated approach to scientific inventory-taking and evaluation with regard to the problem of climate change and its effects, and to the preparation of options for action, is being pursued by the Intergovernmental Panel on Climate Change (IPCC), which was jointly established by the World Meteorology Organisation (WMO) and the United Nations Environment Programme (UNEP). On the national level, the Federal Government established a "Scientific Advisory Board on Global Environmental Change" in April 1992. This board prepares an annual report on the status of global environmental change and its consequences, and provides recommendations on how to eliminate and prevent undesirable developments.

In addition to the Federal Ministry for Research and Technology, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the Federal Ministry of Food, Agriculture and Forestry, the Federal Ministry for Economic Cooperation and Development, the Deutsche Forschungsgemeinschaft (DFG) and the German Federal Environment Foundation (DBU) also provide significant funding for environmental research. The Federal Ministry of Transport funds environmentally relevant applied research in its subordinate agencies. The Federal Government alone (not including the L@nder) spends over 1 billion DM annually on environmental research and technology development.

The Federal Ministry for Research and Technology employs two funding instruments: institutional funding and project funding. The advantages of institutional funding include the availability of large scientific equipment; available management structures for a sophisticated technical infrastructure; interdisciplinarity in personnel; and continuity of research, which permits long-term participation in international programmes. Some 50% of all of the funds expended by the Federal Ministry for Research and Technology throughout the environmental sector are spent on institutional funding. Project funding is an instrument with which it can focus on important topic areas and respond flexibly to new questions.

7.1.3 Relevant priority research areas

The following section describes relevant priority research areas. Measures in other research areas are listed under nos. 22, 27, 36 and 86 in Table 5.1.

7.1.3.1 Climate-system research

The aim of climate-system research is to obtain reliable information on global-climate developments and on their concomitant regional manifestations, including weather extremes.

The climate system, which is highly complex, can be understood only through process simulation. For the area of global climate modelling, the Federal Ministry for Research and Technology, together with other sponsors, has established the German Climate Computing Centre (*Deutsches Klimarechenzentrum*) in Hamburg. The centre and the hierarchy of climate models developed there, are available to scientific groups; the centre also assists in coordinating research work.

The German contributions to climate research are concentrated primarily on the following three emphases:

Water cycle

Description, within the climate models, of the hydrological cycle is being improved. These efforts involve including findings about relevant land-surface processes, obtained within the IGBP sub-programme "Biosphere Aspects of the Hydrological Cycle" (BAHC), as well as findings concerning the energy and water balance in large areas such as the Baltic (Baltic Sea Experiment - BALTEX, undertaken within the WCRP subprogramme, "Global Energy and Water Cycle Programme - GEWEX).

Trace-substance cycles

It is hoped that understanding of biogeochemical cycles of important climate-relevant trace substances will be furthered through the IGBP sub-programmes International Global Atmosphere Programme (IGAC) and Global Analysis, Interpretations and Modelling (GAIM). The tasks of these projects include quantifying sources and sinks, by means of field measurements; measuring and studying the behaviour of trace substances, in space and over time, as well as their chemical processes in the atmosphere; and developing and improving numerical models for simulation of atmospheric and biological processes.

Natural variability and signal recognition

This work is to provide, in future, important contributions to WCRP sub-programmes, especially within the framework of the Climate Variability and Predictability (CLIVAR) programme, as well as to the IGBP sub-programme GAIM. Understanding of natural climate variability is to be improved, by means of systematic analysis and modelling of observation data. In addition, characteristic area-time structures of climate changes - both naturally and anthropogenically caused - are to be determined, by means of scenario computations and sensitivity studies. Finally, optimised procedures for quantitative evaluation of climate-change signals are to be developed.

Within the framework of comparative paleoclimate research, German research groups, including those in the IGBP sub-programme "Past Global Changes" (PAGES) and in the international Ocean Drilling Programme (ODP), are participating in relevant tasks for reconstruction of climate development in relevant historical periods.

7.1.3.2 Research into the results of climate change

Research into the results of climate change must include estimation of the possible effects of climate change (for example, a rise in ocean levels, shifts of climate zones) on sensitive habitats and economic sectors (production shortfalls in agriculture, disappearance of freshwater resources, etc.). In addition, it must include description of the socio-economic consequences and formulation of possible options for political action.

The task of research into the consequences of climate change includes, on the one hand, illumination of the interrelationships between climate and sensitive natural and civilisation-produced systems, as well as description of possible results of climate change on a regional level. On the other hand, it includes support for conversion of climate-research findings into concrete political decisions and measures, to permit protection of the earth's atmosphere through targeted avoidance and assistance strategies - and development of strategies for adaptation to the results of irreversible atmospheric damage that has already occurred.

Since the effects of global climate change are of a predominantly regional nature, regions must be studied on the basis of high-resolution climate predictions that take account of each region's specific geographic, ecological and socio-economic conditions. In addition to these regional models, global climate models must also be improved - for example, their atmosphere-ocean-biosphere linkage must be improved - since these models provide the input data for system modelling within research into the consequences of climate change.

Research into the results of climate change is currently still at an early stage. The Potsdam Institute for Climate Impact Research (*Potsdam Institut fhr Klimafolgenforschung - PIK*), which was founded in 1991, has the following dual function:

- To develop, evaluate and apply interdisciplinary theories and models of the interaction between nature and civilisation, with respect to global climate change,

- To serve as a centre for national research on this subject area.

Initially, German research into the results of climate change is concentrating on the area "climate change and coastlines". Research on this subject has begun within the framework of the Federal/L@nder programme of the same name. In addition, research on the consequences of climate change in agriculture and forestry, and on climate change and water availability, has begun; in some areas, it is being prepared.

7.1.3.3 Atmosphere research

The results of atmospheric pollution - such as forest damage, damage to materials, impairment of human health and depletion of the stratospheric ozone layer - necessitate illumination of the physical and chemical processes of atmospheric trace substances. Of particular importance in this context is to produce reliable data for effects research, by obtaining a complete picture of pollutant cycles (cf. Chapter 7.1.3.4). In addition, transport and transformation of anthropogenic trace substances, as well as to deposition of such substances. The emphases of research in this area are:

- The EUROTRAC project, a joint European environmental project within the EUREKA initiative; in it, the transport and transformation of environmentally relevant trace substances within the troposphere over Europe are being studied,

- The ozone research programme, which aims to determine the nature and extent of changed stratospheric ozone concentrations, to discover their chemical and dynamic causes and to predict future change. The programme is focusing on the Northern Hemisphere, and has been integrated into international programmes, primarily European ones (for example, EASOE and SESAME). In future, this work is to be expanded to include measurements of UV-B radiation, in order to provide current UV-B radiation data and, possibly, trend reports for research into the effects of UV-B radiation (among other purposes), a closely related area.

- The "Pollutants caused by Aviation" (*Schadstoffe in der Luftfahrt*) research programme, which was designed by the German Aerospace Research Establishment (DLR), in cooperation with industry - a subprogramme of this programme, "Atmosphere Research", is studying emissions of pollutants, their distributions and their effects on the earth's radiation balance (cf. measure no. 26 in Table 5.1).

- Since the end of 1990, the wide-ranging integrated project "Scientific Accompanying Programme for Clean-up of the Atmosphere over the New Federal Lander" (*Wissenschaftliches Begleitprogramm zur*

Sanierung der Atmosphare hber den neuen Bundeslandern - SANA), has been studying the effects of restructuring in the area of the former GDR, as well as of the environmental policy measures now taking effect there.

7.1.3.4 Research on terrestrial ecosystems

Both nationally and throughout the world, the significance of environmentally more compatible, sustainable land use in preserving natural resources is growing. The aim of the terrestrial-ecosystem research being funded by the Federal Government is a better understanding of the functions of rural ecosystems, of their influences on each other and of their development in area and over time as a function of different kinds of use, and of different anthropogenic impact.

By integrating the findings from individual disciplines into a new understanding of ecosystems, this work should permit early identification of the potential for danger caused by anthropogenic environmental pollution. An understanding of such interconnections is required, if effective cultivation and care practices, tending toward permanently environmentally compatible use, are to be developed. As part of these efforts, climate change is being considered and evaluated in connection with other anthropogenic impacts; in addition, effects of ecosystems on climate processes are being investigated.

Primarily, this research is aimed at finding integrated solution approaches for restoring and revitalising polluted ecosystems, and at preparing concepts for near-natural rural development. In the process, usage and protection are to be harmonised to the greatest possible extent, and to receive varying degrees of emphasis.

Terrestrial-ecosystem research is concerned with

- Forests,
- Agrarian landscapes,
- Urban and industrial areas,
- River and lake environments,

as well as the substance cycles by which they are interconnected.

Internationally, German ecosystem research has been integrated into the following programmes:

- The UNESCO programme "Man and the Biosphere" (MAB),
- The IGBP. Important contributions are being made, with regard to rural ecosystems, within the IGBP subprogramme "Global Change and Terrestrial Ecosystems" (GCTE).

7.1.3.5 Polar and marine research

As one part of marine research, the oceans' role in the climate system is being studied. The emphasis of this work is on studying the oceans' large-scale currents and atmospheric influence. Within the World Ocean Circulation Experiment (WOCE), satellite measurements, process studies and model calculations are being carried out. In addition, the IGBP sub-programme Joint Global Ocean Flux Study (JGOFS) is sponsoring research on global processes responsible for the oceans' carbon balance, for exchange between the oceans and the atmosphere and between the ocean floor and the coastlines. The interaction between ocean and atmosphere in low latitudes is particularly significant for atmospheric circulation and, thus, for climate, because of the large energy transfers involved.

This interaction is the focus of the WCRP sub-programme Tropical Ocean and Global Atmosphere Programme (TOGA), in which German research groups are participating. An additional emphasis is on paleoclimate research, which aims to decipher the climate information frozen within marine sediments.

The polar regions have a decisive influence on climate. They provide early indication of global climate change, for example, in the mass balance of their ice. In addition, cold, deep currents form in the polar regions. Even small changes in polar sinking zones can influence deep-water formation, thereby influencing climate through oceanic currents. Polar research, which in Germany is receiving significant support from the Alfred-Wegener Institute, seeks to understand these processes, to install comprehensive observation systems and to develop models that permit reliable predictions.

7.1.3.6 Environmental protection technology

On the one hand, support for innovative environmental protection technology (cf. measure no. 40 in Table 5.1) is aimed at developing methods and procedures for preventing future environmental impact and for cleaning up existing environmental damage; on the other hand, it also seeks to achieve a reliable technological level that can provide legislators with a basis for passing effective laws for environmental protection.

Development of prototype environmental protection technologies draws on findings from research into causes and effects, in order to prevent, minimise, limit and repair environmental damage. In addition to sectoral approaches to relatively narrow problem areas, primarily employing downstream clean-up measures, emphasis in future will increasingly be on global approaches aimed at preventing, reducing and steering material flows and ensuring closed material cycles. This is why the Federal Ministry for Research and Technology has developed a support concept entitled "production-integrated environmental protection" (*Produktionsintegrierter Umweltschutz*). This concept was presented for the first time in January 1994.

The ecological aim of providing funding in the area of low-emissions technologies and products is primarily the prevention, or reduction, of particularly large pollutant loads, and of non-degradable, or poorly degradable, pollutants.

Since the late 1980s, an emphasis has been placed on finding and using substitutes for volatile organic compounds (VOCs). Initially, these efforts focused on halogenated carbons (CCs, CFCs); since 1991, they have also concentrated on substitutions for non-halogenated organic compounds, which are used in large amounts as solvents in painting, printing and gluing processes.

As a result of the development of suitable substitutes and alternative technologies in the three main areas of application - surface treatment, foamed plastics and refrigeration/air conditioning - a contribution to discontinuation of most CFC use was already being made by the end of 1993 - earlier than originally planned.

Strong requirements exist for technologies to separate out air pollutants containing organic substances and heavy metals. These requirements are strongest in areas where such substances occur in low concentrations in large exhaust-air flows, or where small-volume flows are emitted by a large number of small sources (VOCs, highly toxic trace pollutants, fine dusts). Relevant projects are being funded in the area of catalytic, thermal, sorptive and biological scrubbing procedures. An explicit aim of these funded projects is to return pollutants directly to the relevant production processes, or to destroy them and transform them into harmless substances or embed them (for example, in glass) - rather than transferring them from the air to wastewater or solid waste.

The available measurement and analysis procedures exhibit large shortcomings in comparison to current requirements for effective exhaust cleansing, especially with regard to organic pollutants and fine dusts. For this reason, new, improved, predominantly continuous measurement procedures are being developed to analyse and monitor air pollutants.

7.1.3.7 Energy research and energy technology

The most important starting points for energy-research policy and energy-technology policy are greater efforts toward more efficient energy use, further diversification of the energy supply - taking into account especially the effects of greenhouse gases on climate, as well as intensified development of cleaner final-energy-use technologies. Within the framework of the 3rd "Energy Research and Energy Technologies" programme of February 1990, state energy research is pursuing solutions concerning:

- Environmentally compatible energy supply, including fossil fuels, and especially with regard to the climate problem and in order to conserve finite resources;
- Development of technologies to save energy through

efficient energy conversion and efficient energy use;

- Renewable energies, with an emphasis on wind energy, photo-voltaic systems and integration with existing energy supply technologies.
- Nuclear energy research and technology. Individual measures in the area of energy research and technology are listed under nos. 41 through 54 in Table 5.1.

Table 7.1 provides an overview of the funding to support research into renewable energy sources, into efficient energy conversion and into nuclear power, for the period from 1983 to 1994.

Tab. 7.1: Funding support for research into renewable energy sources, efficient energy use and nuclear energy from 1983 to 1993[1)] [in millions of DM]

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
1.Renewable energy sources and efficient energy use including:	271.5	238.5	221.2	189.4	196.4	210.5	239.6	277.1	322.6	357.5	360.9	333.3
1.1 Photovoltaic systems - Project support	54.0	59.1	53.3	57.8	60.1	70.9	82.5	91.9	104.0	111.0	112.7	88.0
1.2 Wind energy - direct project support	16.0	8.9	10.2	12.1	17.8	16.0	12.4	18.1	9.8	9.3	7.4	9.0
1.3 Wind energy - indirect-specific support	-	-	-	-	-	-	0.2	3.8	8.0	16.4	24.8	32.0
1.4 Geothermal energy and other activities relevant to renewable energies	14.0	14.9	13.3	2.8	4.9	3.3	10.9	14.3	16.7	16.7	20.5	21.9
(Contribution of major research establishments to 1.)	20.3	21.3	23.5	25.8	22.4	24.2	30.2	32.6	46.6	71.2	57.9	69.0
2. Nuclear energy research and technology, funding for the IAEO (including major research establishments) including:	1 678.9	1 582.9	1 558.3	1 082.8	757.4	716.7	635.4	661.5	630.7	529.7	500.6	497.8
2.1 Nuclear energy research and technology (excluding 2.2 and 2.3)[2)]	1 178.9	1 131.4	1 142.1	699.8	404.5	360.2	304.5	288.7	275.1	170.5	154.0	131.9
2.2 Disposal of nuclear facilities[2)]	2.4	4.3	0.8	1.5	11.6	61.7	164.7	85.5	129.2	212.7	162.9	205.0
2.3 Funding for the International Atomic Energy Organisation (IAEO)	22.5	25.7	30.8	29.5	26.4	29.1	32.1	33.4	37.3	37.0	39.3	40.9

1) To 1993 actual; 1994 planned; as of 1 March, 1993

2) The contributions of major research establishments that go to 2.2 are contained in 2.1; for this reason, some shifting between 2.1 and 2.2 is possible.

Source: Federal Ministry for Research and Technology (BMFT)

To support the preparation of logical overall strategies for reducing emissions, the Federal Government has established the IKARUS project (*Instrumente fhr Klimagas-Reduktionsstrategien* - Instruments for Climate-gas-reduction Strategies) in 1990, placing it under the management of the Federal Ministry for Research and Technology (cf. measure no. 87 in Table 5.1). With the help of a range of instruments, consisting of computer models and databases, the technical options of various strategies for reducing energy-related emissions of climate-relevant gases are to be compared and contrasted in light of existing parameters and optimised - for example, in keeping with a cost-minimisation approach. The most important parameters to be considered include emissions limits, trends in prices of raw materials and products, trends in availability of capital and in capital costs, the dynamics of innovation and general economic trends for 1989, the starting year, and for the milestone years 2005 and 2020. The project comprises the areas of model development, the database, primary energy, energy conversion, final energy, cross-sector technologies and verification measures (monitoring of compliance with commitments made within the Framework Convention on Climate Change).

7.2 National activities and contributions to international measuring and monitoring programmes

7.2.1 Monitoring and research programmes

As part of the WMO's Global Atmosphere Watch (GAW) programme for monitoring long-term atmospheric changes, the Federal Government is establishing a global station and several regional stations.

The Federal Government is currently preparing a German contribution to the establishment and expansion of the Global

Climate Observing System (GCOS). The purpose of the GCOS is to support international observation programmes for climate monitoring, climate prediction and early identification of climate changes. The meteorological observations and measurements that are exchanged internationally within the World Weather Watch (WWW) have an important function in this context. The German Meteorological Service (*Deutscher Wetterdienst - DWD*) maintains various measurement networks, of varying purposes, and is participating in international exchanges of meteorological observations and measurements, as well as in aerological probes of the troposphere (ranging up into the stratosphere), through the Global Telecommunications System (GTS). Many merchant ships, on all the world's oceans, voluntarily make weather observations; the German Meteorological Service collects and archives this data. The German Meteorological Service supports over 550 merchant ships in such efforts. It also ensures that standard instruments are used within the "Voluntary Observations Ships" (VOS) mobile network. In 1994, the German Meteorological Service, together with the British Weather Service, has begun operating the Global Collecting Centre (GCC), which is ensuring that ship observations meet uniform quality standards. The German Meteorological Service's meteorological observations integrate continuous, long-term measurements and observations relevant to radiation (including UV-B radiation), ozone profiles, atmospheric structure and precipitation and clouds with application-oriented research in these areas. These observatories will continue to carry out numerous monitoring tasks relevant to long-term atmospheric changes.

Changes in the chemistry of the earth's atmosphere (especially stratospheric-ozone depletion) also influence the passage of the sun's ultraviolet radiation through the atmosphere. The Federal Institute for Radiation Protection (*Bundesamt fhr Strahlenschutz*) and the Federal Environmental Agency are jointly operating a UV-B measurement network with the aim of assessing continuously measured radiation intensity. The German Meteorological Service plans to establish a UV-B measurement network that will be focused on climatology and trend analysis; it will require even more sophisticated measuring equipment.

The Fraunhofer Institute for Atmospheric and Environmental Research (*Fraunhofer-Institut fhr Atmospharen- und Umweltforschung*) and the German Meteorological Service's Hohenpeißenberg meteorological observatory are participating in the European Stratospheric Monitoring Stations (ESMOS) network. Stations of the Alfred-Wegener Institute and of the German Meteorological Service will participate in the Network for the Detection of Stratospheric Change (NDSC), which has been initiated by the US.

Within the framework of the Integrated Global Oceanographic Services System (IGOSS) and the International Oceanographic Data and Information Exchange (IODE), oceanographic observation data collected within national programmes is being made available to efforts to describe the oceans' contribution to climate. The Federal Institute for Navigation and Hydrography maintains a measurement network of oceanographic stations in the German Bight and in the Western Baltic. Within the IGOSS framework, it operates its own measurement programmes. The data from these programmes is distributed through the GTS. This institute is also participating in the establishment of the GCOS' oceanic component, the Global Ocean Observing System (GOOS).

7.2.2 Space-based earth monitoring

Germany is the primary participant in the missions of the ERS-1 European Remote Sensing satellite, which is being used for environmentally relevant space-based earth monitoring. Germany is also taking a central role in evaluating the data gathered by this satellite.

Germany also has an important role in the POEM-1 programme approved by the European Space Agency's Council Conference, which was held in Munich in 1991. This programme comprises the ENVISAT-1 environmental satellite and METOP-1 meteorological operational satellite missions. The emphasis of ENVISAT will be on climate and atmosphere research and on continuing the ERS missions' oceanographic measurements. In a national initiative, Germany is developing a portion of the ENVISAT payload: the SCIAMACHY sensor, which is expected to make an important contribution to atmospheric sensing. As part of the same initiative, Germany is expanding the German Remote Sensing Data Centre (*Deutsche Fernerkundungs-Datenzentrum*) into a user-oriented centre that will archive and distribute environmentally relevant satellite data. METOP-1 is a cooperative programme, involving ESA and the European organisation for the operation of meteorological satellites (EUMETSAT), and with a focus on operational global weather and climate monitoring.

With its participation in the METEOSAT programme, Germany is also making a significant contribution to a satellite system that will provide complete global data collection, and that will guarantee long-term availability of earth-observation data, until the year 2012 - which is an important prerequisite for detection of climate changes.

In addition, the STRATO 2C high-altitude manned research aircraft is currently being developed in Germany. Use of this aircraft is expected to make important contributions to ozone and climate researchers' understanding of relevant processes.

7.3 Databases, data centres and information management

In view of the continually increasing amounts of data that must be dealt with, the significance of databases and data centres is growing. In addition, efficient information management is growing more and more important due to the increasing complexity and interdisciplinarity of the questions involved. Close cooperation between the various disciplines involved, and inclusion of existing databases and data centres, and of tested networks and data-exchange systems, plays an important role in these research efforts. In Germany, such research is able to draw on a wide range of existing relevant institutions.

7.3.1 Data centres and databases

At the Karlsruhe nuclear research centre, a list has been compiled of the databases gained through measurement and observation programmes that are available in Germany. In order to improve provision of climate-relevant data, a national databank is being established, under the management of the German Climate Computing Centre. All authorities, scientific institutions and major research establishments that have climate-relevant data will participate. The German Weather Service plans to establish a German climate-monitoring centre.

As part of the WWW of the WMO and the GOOS, measurement data from the German Weather Service's measurement networks is being collected, processed, checked for quality and archived in a central climatological databank that also contains the international data provided through the GTS. The Federal Institute for Navigation and Hydrography is collecting the oceanographic data collected by German institutions, and is making them available as a contribution to the IODE of the International Oceanographic Commission (IOC).

The Federal Environmental Agency's environmental planning and information system contains important environmental protection data, including emissions data for climate-relevant substances. The UFOKAT environmental research catalogue provides an overview of research projects in Germany that have an environmental orientation. UV-B data is also being collected, together with that of the Federal Office for Radiation Protection (*Bundesamt fhr Strahlenschutz*), and that of the Lander, in a central database at the Federal Environmental Agency.

The German Remote Sensing Data Centre established at the German Aerospace Research Establishment in Oberpfaffenhofen collects, manages and evaluates satellite remote sensing data.

As part of the World Climate Research Programme, international data centres have been established in Germany for data relevant to the global water cycle. The Global Precipitation Climatology Centre (GPCC) operated by the German Meteorological Service provides evaluated precipitation area averages that it produces on the basis of precipitation data gathered around the world. In a similar fashion, the Federal Institute for Water Science (*Bundesanstalt fhr Gewasserkunde*), within the Global Runoff Data Centre (GRDC), provides surface-runoff data collected around the world. Both centres are important components of the Global Climate Observation System.

Central archives for data collected worldwide have been established at the secretariat of the Joint Global Ocean Flux Study (JGOFS), at the University of Kiel, and for paleoclimatology at the University of Hohenheim.

7.3.2 Information management

Efficient information management comprises a wide range of elements such as requirements analysis, efficient data collection, assurance and monitoring of data quality, appropriate data processing, data availability and user support. Currently, an important task for science and operational services is to develop such comprehensive information management for the totality of environmental data, based on the metadatabase principle and integrating the existing infrastructure. The Federal Ministry for Research and Technology supports these efforts.

UNEP's Harmonization of Environmental Measurement (HEM), located in Munich, in involved in the international harmonization of environmental data, environmental monitoring programmes and taxonomies.

At the Fraunhofer Institute for Atmospheric Environmental Research (*Fraunhofer-Institut for Atmospharische Umweltforschung*), one of the four data-quality assurance/monitoring centres planned worldwide is being established within the GAW framework.

As part of the WCRP sub-programme World Ocean Circulation Experiment (WOCE), data is being assimilated at a Special Analysis Centre of the German Climate Computing Centre (*Deutsches Klimarechenzentrum*, located in Hamburg), in cooperation with the Federal Institute for Navigation and Hydrography - i.e. data is being dynamically interpolated with the help of global models.

At the German Remote Sensing Data Centre in Oberpfaffenhofen, the Intelligent Satellite Data Information System (ISIS) is being developed for network linking and data-user support.

The German Meteorological Service is establishing a climate information system that will describe means of accessing and using the climate-relevant data stored in the Service's climate database.

An important part of the information management network is located at the GSF Research Centre for Environment and Health, located in Neuherberg near Munich. An environmental information system (*Umweltforschungsinformationssystem - UFIS*) is being established to collect the existing models and data from environmental research projects funded by the Federal Ministry for Research and Technology - and to analyse them with a view to defining general principles of modelling and data collection.

8. Training, education, public awareness

Global climate change poses a special challenge, which will continue to present itself in the coming century and beyond: taking responsible, precautionary action. Education and training, and promotion of public awareness, are of decisive importance in meeting this challenge, because (among other reasons) response to climate change must not be put off until the consequences of climate change have already occurred.

Public awareness and environmental information

Protecting the environment, together with safeguarding peace and protecting jobs, are among the issues that during the last 10 years have been the most important focuses of public discussion in Germany. In keeping with this importance, perspectives of environmental protection have been integrated into a great variety of social and personal areas, including such areas as individual consumption, recreational habits, education in schools and vocational training and areas in which social and world views are formed and cultivated.

The younger generation has particularly strong environmental awareness. While environmental problems were one of the issues treated in education of middle and older generations, they did not become a strong part of those generations' awareness. The younger generation, on the other hand, has found itself confronted with this problem from the very beginning and tends to view it as a future threat.

If environmental policy is to be effective and successful over the long term, it must be shaped and imparted in such a manner that the entire population, if possible, will embrace it and be willing to help carry it out. In keeping with the principles of cooperation and precaution, all citizens are called on to translate their high degree of environmental awareness into a willingness to act and to take measures today to prevent future environmental damage. This is why the

Federal Government considers the comprehensive range of environmental information that it provides to be an important instrument of its environmental policy. The Federal Government, along with the Länder ministries and authorities, conduct intensive informational activities concerning the topic of climate protection - especially concerning the possibilities of preventing climate change. For example, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety supported a campaign conducted by the German Association for the Environment and Nature Conservation (*Bund für Umwelt und Naturschutz Deutschland - BUND*) in 1993 and 1994 on the topic of "climate and traffic". The main purpose of this effort is to increase the environmental awareness of large portions of the population - to foster awareness of more than simply technical solutions. This campaign is being carried out in cooperation with radio stations and with other environmental groups. Table 5.1 lists additional measures in this context, under the nos. 10, 11, 21 and 77.

In addition, a great deal of information material aimed at specific target groups is published, including brochures, pamphlets and posters. Increasingly, such efforts are also employing electronic tools such as video, computer games and the *Bildschirmtext* online computer information service - in addition to trade fairs and exhibitions.

Training and education

The Länder are responsible for providing and administering school education. Environmental protection has been firmly integrated into curricula, and teachers often have relatively wide latitude in selecting and treating environmental topics.

The following section lists typical examples of activities in the area of training and education (cf. also measures nos. 69 and 106 in Tab. 5.1):

- The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety published the results of its project, "Continuing education relative to climate protection, for architects" (*Fortbildung zum Klimaschutz für Architekten*),

- The Federal Ministry of Education and Science published the findings of the commission for implementing the recommendations of the Enquete Commission on "Preventive Measures to Protect the Earth's Atmosphere" (*Vorsorge zum Schutz der Erdatmosphäre*); the publication was entitled, "Protecting the Earth's atmosphere - a challenge for education". It summarises the findings of various working groups concerning the consequences of the Enquete Commission's recommendations, with regard to the areas of general school education, vocational training, institutes of higher education and continuing education;

- The Federal Ministry of Education and Science, the Länder and independent sponsors have initiated concrete projects for development and testing of pedagogical concepts for teaching, in the area of "climate and energy", of various target groups of teachers and learners. The following two projects are particularly noteworthy: a school and teacher-training project being carried out by several Länder that is being funded as a model test by the Federal Ministry of Education and Science; a project, initiated by the Federal Ministry of Education and Science, of the Pedagogical Office of the German Adult Education Association (*Pädagogische Arbeitsstelle des Deutschen Volkshochschulverbandes*) and of the "Nature and Environmental Education" working group (*Arbeitsgemeinschaft Natur- und Umwelterziehung*), for target groups in the area of general adult education,

- A project of the Climate Alliance of European Cities, entitled "Action-oriented documentation and evaluation of environment- and development-policy educational activities in German climate-alliance communities", was funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety,

- In 1992, the German Sparkassen- and Giroverband bank association launched a competition for young people entitled "The climate challenge" (*Herausforderung Klima*). 5 national winners were selected from 122 prize-winning efforts of pupils. In addition, the prize-winning entries were included in exhibits at the IGA-EXPO '93 exhibition in Stuttgart and in the Federal Environmental Agency.

Communities, institutes, universities, environmental associations and churches continue to sponsor seminars, lectures, courses, etc. on the topic of climate protection.

Involvement of non-government organisations in reporting

The report "Climate Protection in Germany - National Report of the Federal Government for the Federal Republic of Germany in anticipation of Article 12 of the United Nations Framework Convention on Climate Change" was completed in August 1993; then it was sent to numerous institutions and associations with a request for a response. The comments that these organisations provided have been taken into account in the revision of the present report.

9. International cooperation in the areas of technology and finance

9.1 Principles and priorities for cooperation with other countries

The Federal Government is voicing strong support for conformance with the guidelines set forth in Rio Declaration, and it is orienting its bilateral and multilateral development assistance to the aim of implementing Agenda 21.

Internationally, the Federal Government is strongly supporting a coordinated approach. Coordination is taking place within the European Union (EU) and through multilateral government organisations, such as the OECD, IEA, ECE, UNEP and WMO. With regard to issues of climate change, the Framework Convention on Climate Change and the IPCC, which is jointly sponsored by the UNEP and WMO, have particular significance.

9.2 Bilateral cooperation

9.2.1 Developing countries

Tab. 9.1 shows distribution of worldwide primary energy use in 1991.

Tab. 9.1: Distribution of world-wide primary energy use

1991	Industrial countries		Developing countries	
	Millions of tonnes of oil units	%	Millions of tonnes of oil units	%
Fossil fuels Coal Oil Gas	 1 502 2 211 1 333	 25 37 22	 884 730 222	 28 23 7
Subtotal	5 046	85	1 836	58
Renewable energy sources Hydroelectric power Biomass	335 169	6 3	169 1 147	5 36
Subtotal	524	9	1 316	41
Nuclear energy	377	6	27	1
Total	5 947	100	3 179	100

Source: UN Energy Statistics

In developing countries, population trends and economic growth will, in future, result in considerable increases in energy demand.

A total of 90 percent of global population growth is taking place in developing countries; each year, the population in these countries grows by some 90 million people. This factor alone - assuming that per-capita energy consumption remains as it is today in these countries - will increase energy demand by some 65% by the year 2020. In addition, a large portion of the world's population remains isolated from any central energy supply and must rely on biomass - primarily wood and charcoal - for energy. The urbanisation and industrialisation of developing countries, in conjunction with a sharp increase in traffic, have resulted in a rapid increase in consumption.

Fossil fuels will continue to be required, primarily for meeting basic requirements. An important factor in establishing a self-sustaining development process in developing countries, including modernisation of agriculture and commerce, construction of infrastructures and industrialisation, is provision of sufficient energy to both urban population centres and to rural areas (especially to meet basic requirements such as cooking and heating).

In its development assistance, the Federal Government is aiming to bring about a process of economic, social and institutional change - a process that will achieve high energy-supply efficiency while meeting needs for long-term ecological sustainability.

The following factors are of particular importance in this context:

- Use of the cleanest possible fuels,
- Use of technologies with low environmental impact,
- Energy extraction, distribution and use that conserves resources and
- Increased use of renewable energies.

The Federal Government is using the means available to it within multilateral financing institutions (especially, the World Bank, and regional development banks) in order to carry out these strategies internationally, and thus to prepare the way for more environmentally compatible, efficient energy policies. For example, in December 1991, it successfully introduced, into deliberations of OECD ministers for the environment and for cooperation, a motion that electric-power rates cover minimum costs.

The Federal Government has also made the area of energy supply a sectoral emphasis of its bilateral cooperation with developing countries.

In this context, the Federal Government's support strategy is concentrated on the following areas:

- Political dialogue, consultation, participation in energy-sector adaptation programmes (especially those of the World Bank),
- Support for conventional energies and for more efficient energy use,
- Support for renewable energies.

From 1961 to 1993, the Federal Government provided a total of some 13 billion DM within the framework of financial cooperation, and some 1.1 billion DM within the framework of technical cooperation, for support of the energy sector in developing countries.

Of this funding, the following amounts were invested in support of renewable energies: approx. 2.5 billion DM for hydroelectric power, and approx. 500 million DM for solar and wind power and for use of biomass and biogas in energy generation and in small and very small hydroelectric power plants. The funding percentages for hydroelectric power plants are expected to decrease, due to the increasing difficulties of finding suitable sites for such plants.

The Federal Government provides considerable funding to help other countries conserve their tropical rain forests. Since 1988, some 300 million DM have been spent annually, within the framework of development assistance, for projects for forest conservation and development. The emphasis of this funding assistance is on support for protection and sustainable management of tropical forest ecosystems. In addition, support of agro-forest systems, rehabilitation of damaged forests and reafforestation are a major part of these efforts. Participation of local citizenry in measures and in the fruits of proper forest management is of decisive importance.

At the International Rice Research Institute (IRRI), of which Germany is a supporter, studies are being carried out in Asia (including China) to determine amounts of CH_4 and N_2O emissions as a function of soil characteristics, water management, organic inputs into soils and cultivation measures. In addition, means of reducing emissions without reducing rice yields are being sought.

Reduction of methane emissions has been made an important emphasis of planning and support of projects for promoting animal husbandry in developing countries. Among measures being carried out in this area are efforts to increase yields per animal, to reduce risks to health, to improve use of feedstuffs and to advise responsible local authorities.

In fulfillment of commitments made in Rio, the Federal Government promptly provided 5 million DM of special funds, to prepare measures in connection with the greenhouse effect - i.e. to support developing countries prepare national reports. Some 10 countries are being assisted with this funding.

In 1992, a traffic-sector research project focusing on possibilities for reducing CO_2 emissions in selected cities was carried out. Pilot projects are now planned to test the feasability of the proposals developed in this project, as well as their potential applicability to developing countries.

9.2.2 Countries in transition to market economies

The countries that are now undergoing transition to market-oriented economic systems are finding that replacing a centrally planned system with a market economy is a difficult task. But such difficulty must not mean that the question of long-term sustainable development receives short shrift.

Environmental policy instruments and institutions must be created to deal with this question. There is a lack of adequate legal and economic instruments and technical standards, as well as of capacities for developing, enforcing and monitoring such instruments. Such capacities are required in the form of government-agency structures on the subnational level (including community level authorities).

Fresh starts in economic policy provide a unique chance to plan and carry out industrial and economic reconstruction in a manner that also gives consideration to environmental policy requirements. Business-administration and management criteria, applied to the construction of new production facilities, will help provide an environmentally compatible energy supply.

In 1992, the Federal Government established a consultation assistance programme for central and eastern European countries (cf. chapter 9.3.4). The task of this programme is to help countries help themselves in building democratic structures and in creating market economic systems. Assistance is to be provided in the form of consultancy, training and continuing training and provision of the necessary equipment and facilities for such training. Bilateral treaties, which Germany has signed with almost all of these countries, provide a significant basis for this cooperation. By 1993, over 150 consultancy projects in the area of environmental protection had been carried out within the Federal Government's consultancy programme.

In addition, the Federal Government has given direct support, in the form of investment subsidies, to selected environmental protection projects in central and eastern Europe that will result in a reduction of cross-border pollution. In 1992 and 1993, a total of 40.75 million DM was provided for ecologically oriented conversion of two major power plants in Ukraine and the Czech Republic.

9.3 Multilateral cooperation

9.3.1 Framework Convention on Climate Change

The UN Framework Convention on Climate Change, which came into force on 21 March 1994, has established an internationally binding basis for global climate protection. The International Negotiation Committee (INC), which negotiated the Convention, still exists. It is currently preparing the 1st Conference of the Parties to the Framework Convention on Climate Change, which will take place in Berlin from 28 March to 7 April, 1995. Germany is taking an active role in this conference.

9.3.2 Global Environmental Facility

During a pilot phase lasting from 1991 to 1993, the Federal Republic of Germany paid 147 million US$ into the central fund of the Global Environmental Facility (GEF). During the pilot phase, the GEF was given approx. 1 billion US$ worth of special drawing rights (central fund plus cofinancing).

For the period lasting from mid-1994 to mid-1997, the Federal Republic of Germany has declared its willingness to pay the amount of 240 million US$ - or about 12 percent of the overall volume of approx. 2 billion US$ - to the Global Environmental Facility.

9.3.3 Cooperation in the European Union

9.3.3.1 Environment and energy policy

On 29 October 1990 and 13 December 1991, the Joint Environment and Energy Council approved resolutions by which the EC made a political commitment to stabilise CO_2 emissions at the 1990 level, by the year 2000. In this context, the EU's 5th environmental action programme should also be mentioned; it sets forth a strategy for improving energy efficiency and for developing technology programmes for CO_2 reduction by the year 2000.

On 25 September 1991, the European Commission presented a European strategy for limiting CO_2 emissions and for improving energy efficiency. In 1992, the European Commission presented to the Council four specific instruments that would be the elements of this strategy. Of these, three were approved:

- With the "Council decision concerning a system for monitoring emissions of CO_2 and other greenhouse gases in the Community", a standardised data-collection and evaluation instrument is now available for national climate protection programmes and for the Community's concept for reducing carbon dioxide emissions and improving energy efficiency. The monitoring system represents an intermediate step in the EU's reporting relative to the Framework Convention on Climate Change.

- The Council approved a comprehensive programme for promoting energy efficiency within the Community (SAVE programme). Among this programme's elements is the "Council directive for limiting CO_2 emissions by means of efficient energy use" (SAVE directive), which was approved in 1993. This directive requires Member States to carry out programmes and measures, by the end of 1994, in the following areas:
    * Energy certification for buildings,
    * Billing heating, air-conditioning and water-heating costs on the basis of actual consumption,
    * Promotion of third-party financing of energy-saving investments in the public sector (cf. measure no. 106 in Tab. 5.1),
    * Thermal insulation for new buildings,
    * Regular inspection of boilers,
    * Accounting of energy use in companies with high levels of energy consumption.

    The SAVE programme also provides an additional 35 million ECU of funding, with a five-year term, for support of sectoral pilot projects, for establishing norms and regulations and for creating an information network.

- The "Council decision for promotion of renewable energy sources in the EC (ALTENER programme)" is intended to improve the economic framework for use of renewable energies. The programme was launched in 1993, with a term of 5 years and funding of 40 million ECU.

The European Commission's proposal for a Council directive on the introduction of a tax on carbon dioxide emissions and energy, of 4 June 1992, is still being intensively discussed by the Council (cf. measure no. 107 in Tab. 5.1). In this context, the Federal Government considers it an urgent requirement that use of market-economic instruments in environmental protection be internationally coordinated, so that relevant national and EU-wide aims can be reached at the minimum cost. For this reason, the Federal Government supports introduction of a CO_2/energy tax, effective at least throughout the EU, and neutral with respect to competition and total revenue volume. In principle, it supports the European Commission's proposal for a relevant directive.

Also worthy of mention is the THERMIE energy-technology promotion programme, for which funding in the amount of approx. 700 million ECU has been made available between 1990 and 1994. This programme supports innovative technologies for efficient energy use, use of renewable energies, efficient transformation of solid fuels and exploration, extraction, transport and storage of hydrocarbons.

In the interest of conserving forests, which are a natural CO_2 sink, publication of national programmes for implementing forest-management principles was resolved. Germany presented its national forest report in April 1994, in fulfillment of this commitment.

In the PHARE programme, Community funding is being provided for restructuring and privatisation of companies in central and eastern Europe. The funding may be used either for broader sectoral or regional development programmes or for improving energy industries. The TACIS assistance programme for the countries formed from the former Soviet Union has a similar approach.

In the COST programme, "Science and research in the service of better air quality in large European cities" (CITAIR), a global research concept was prepared that integrates interests of northern, southern and southeastern European countries. Research cooperation within this programme focuses on the aspects of monitoring technologies, networks and models, establishment of institutions and information policies and on determining effects of measures with regard to mobile and stationary emissions sources. An important aim of this cooperation is to develop economically and politically feasible modernisation programmes for urban industrial areas.

9.3.3.2 Agricultural policy

Environmental considerations play a role in the approved agricultural policy reform. In addition to measures in the area of market regulations, which will tend to reduce cultivation intensity (for example, marked grain-price reductions, provision of price-compensation payments for beef cattle, with payments tied to reduction of animal density per hectare of grazing area), a range of supporting agricultural policy measures was also approved whose aims, in part, involve environmental protection.

For example, the "Council Ordinance of 30 June 1992 concerning environmentally compatible agricultural production procedures that protect the natural environment", and the "Council Ordinance of 30 June 1992 for the introduction of Community assistance regulations for afforestation measures in agriculture", provide for area-oriented assistance for the following measures:

- Considerable limitation of the use of fertilizers and pesticides/herbicides, and retention of existing limitations,
- Reduction of beef-cattle and sheep inventories,

- Extensive (i.e. non-intensive) land use,
- Care for areas on which agricultural use has been discontinued,
- Long-term set-asides of cultivated land (up to 20 years), for effective environmental protection and nature-conservation measures (cf. measure no. 56 in Tab. 5.1),
- Afforestation of land previously used for agriculture.

When given the proper specific form, these measures will help reduce climate-relevant emissions. For example, reduction in use of mineral and organic nitrogen fertilizers will reduce N_2O emissions. In addition, methane and ammonia emissions will be reduced through support for reductions of beef-cattle and sheep inventories.

The following measures in particular are reducing climate-relevant emissions from animal husbandry:

- Reduction of beef-cattle inventories, especially as a result of restructuring in the area of the former GDR, by 19 percent, to 11.2 million large animal units, from 1989 to 1992,

- Further reduction of beef production, by means of EC measures such as gradual reduction of the intervention price and of the intervention amount (from 750 to 350 kilotonnes), from 1993 to 1997,

- Reduction of beef-cattle and sheep inventories through support of extensive grassland use in connection with herd reductions to a maximum of 1.4 large animal units (eating raw fodder) per hectare of main grazing area,

- Reduction of the emissions rate per large animal unit, by means of proper adaption of feeding to nutrient requirements, as well as of improvement of animal digestion efficiency by means of breeding and management,

- Reduction of emissions of N_2O from animal excrement in stalls, through reduction of the emissions area (for example, partly slatted floors, instead of completely slatted ones), and through reduction of the water content in liquid manure. This can be achieved for example, by ventilation of droppings in poultry-cage facilities; outside of stalls, it can be achieved through proper covering of liquid-manure containers and by low-immissions procedures for spreading liquid manure.

Extensive means of production, and long-term area set-asides, reduce emissions of climate-relevant gases and help save energy. In addition, afforestation of land previously used for agriculture helps increase CO_2 sinks.

9.3.4 Multilateral cooperation with central and eastern European countries

An environmental action programme for central and eastern Europa was developed at the "Environment for Europe" European Conference of Environmental Ministers, which took place from 28 to 30 April 1993 in Lucerne. This programme, in continuing work accomplished at the 1992 Rio Conference, develops the idea of overall social responsibility for preserving the natural basis for life with respect to the special tasks in central and eastern Europe. Three multilateral bodies, which began working by the end of 1993, have been established to shape the post-Lucerne process:

- The Task Force for the implementation of the environmental action programme, in which western and eastern European partners cooperate as equals in carrying out the programme.

- The Project Preparation Committee, of the countries providing funding and international financial institutions; its aim is to arrange for financing of environmental projects.

- The ECE working group "Environment for Europe", which is responsible for organising and preparing the contents of the next European Conference of Environmental Ministers, which will take place in 1995 in Sofia.

9.3.5 Cooperation within the framework of international organisations

In 1989, the seven leading industrial nations (G7) declared their intention to contribute to solving the climate problem. Germany has a central role in the G7's climate-policy initiatives.

Implementation of the Agenda 21 chapter, "Protection of the earth's atmosphere" is being monitored by the UN Commission for sustainable development of the UN Economic and Social Council.

Within an ECE framework, a number of measures have been taken for reduction and stabilisation of climate-relevant emissions. Among the results of the Geneva Treaty on extensive cross-border air pollution of 13 November 1979 are the "Sofia-Protocol of 31 October 1988, regarding the combatting of nitrogen oxide emissions (NO_x), and their cross-border movement", and the "Geneva Protocol of 19 November 1991 regarding the combatting of volatile organic compound (VOC) emissions, and their cross-border movement".

The Sofia Protocol contains an internationally binding obligation to reduce annual nitrogen oxide emissions, and their cross-border movement, to 1987 levels, by 1994. Germany, along with 11 other countries, has committed itself additionally, in a political declaration relative to the Sofia Protocol, to reduce annual NO_x emissions by 30 percent by 1998, in relation to a one of the years between 1980 and 1985. According to current findings, the measures enacted will suffice to attain this aim.

Basically, the Geneva Protocol contains an internationally binding obligation to reduce annual emissions of volatile organic compounds by at least 30 percent, by 1999, in relation to the 1988 level. According to calculations of the Federal Environmental Agency, VOC emissions in Germany will decrease by 40 - 50 percent, by 1999, as a result of the measures in force.

In October 1990, the ECE established the "Energy Efficiency 2000" initiative, which had been approved by a ministerial declaration, made in Bergen in May 1990, on long-term sustainable development. The aim of this ECE project is to improve trade and cooperation, with regard to environmentally compatible and energy-efficient technologies and industrial methods, and especially between formerly centrally controlled economies and market economies. The instruments with which this goal is to be achieved include trade fairs, seminars, reference works, information networks, handbooks and consultancy in ECE countries undergoing transition to market economies. At the 1993 Hanover Trade Fair, and within the framework of this ECE programme, the Federal Government carried out the workshop "Entrepreneurial opportunities in connection with the reduction of energy-related greenhouse gases".

The work programmes of the ECE Commitee on Human Settlements and the Inland Transport Commitee also have energy-saving aspects.

In May 1994, a workshop took place focusing on potential uses of renewable energy sources in central and eastern Europe.

The Federal Government considers its work within the OECD and the IEA to be of great significance.

The OECD working group "Energy and Environment" has established a programme entitled "Global climate change", the purpose of which is to study the economic aspects of climate change. These include cost-benefit-relationships, application of economic instruments and distribution of economic assistance among developing countries, to help them comply with the requirements of the Framework Convention on Climate Change. It will also analyse means and ways of overcoming institutional and economic barriers to improving energy efficiency, to other environmentally compatible technologies and to economic instruments - in connection with support of energy technologies with reduced greenhouse-gas emissions.

Both the OECD and the IEA are carrying out extremely significant work relative to the specification, implementation and refinement of the Framework Convention on Climate Change. In 1993, at ministerial meetings of both organisations, the threat inherent in current global pollution was emphasised, and the necessity of undertaking increased, joint efforts to develop and implement an effective strategy for reducing greenhouse-gas emissions was stressed.

The OECD and IEA have carried out a number of projects that relate to reduction of greenhouse-gas emissions. They include:

- Preparation of recommendations for a common format for national reporting within the framework of the Framework Convention on Climate Change. In January 1994, as part of these efforts, IEA/OECD, in conjunction with the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, sponsored an experts' conference in Berlin,
- Development of methodological approaches for estimating the economic consequences of climate change (cost/benefit analysis) in the areas of agriculture and rises in sea levels,
- Completion of studies on the topic of "economic costs of CO_2 reduction",
- Development of models for assessing the economic consequences of effective CO_2-reduction policies,

- Studies concerning the introduction of CO_2 taxes and negotiable emissions rights,
- Study of the use of possibilities for compensation, entitled "Joint implementation", on the basis of the Framework Convention on Climate Change,
- Studies on use of revenue from a world-wide CO_2 tax,
- The OECD/IEA conference on economic issues related to climate change,
- Development and establishment, by the IEA, of the GREENTIE system of information exchange concerning greenhouse-gas-relevant technologies.

The OECD has established various project groups concerned with environmental and developmental issues - and, especially, with climate-protection strategies of cities. The aim of the project group "Improving the environment through urban energy management" is to bring together "pilot cities", from throughout the OECD region, in the various areas of action on community energy policy, in order to promote exchange of experience. Such exchange is being accomplished in a range of workshops being held by participating cities. In Germany, the cities of Saarbrhcken and Heidelberg are participating in this project. In June 1993, Saarbrhcken held a workshop on the topic of "Municipal services companies and energy consultation"; in September 1994, Heidelberg will hold the final event for the entire project. Findings from this project will be compiled and published within a "Handbook of the best municipal practice" (*Handbuch der besten kommunalen Praxis*).

The UN Commission for Human Settlement (UNCHS) has made implementation of Agenda 21, with regard to aims in the area of development of cities and settlements, one of its central tasks. The Federal Government, in agreement with the other EU Member States, has successfully proposed that the HABITAT II world conference on questions of human settlement, which will meet in 1996 in Istanbul, make environmentally compatible development of settlements one of its central topics.

10. Outlook

If climate-protection measures are fully implemented, it is to be expected that a large portion of the CO_2 reduction achieved in the area of the former GDR will be permanent.

If the Federal Government's goal of reducing CO_2 emissions by 25 to 30 percent by the year 2005, in relation to the 1987 level, is to be attained, all involved, i.e. the Federal authorities, the Länder, cities, industry, the scientific sector, the educational sector and the population, will have to make active contributions.

This process has already begun on the Länder and community levels: Länder-specific greenhouse-gas-reduction programmes and 60 urban reduction concepts have been produced.

German industry, with its "Initiative for world-wide climate protection" (*Initiative für eine weltweite Klimavorsorge*), has committed itself to making a contribution to climate protection.

The "CO_2-reduction" Interministerial Working Group (IWG), commissioned by the Federal Cabinet, is presenting its third report in summer 1994. This report gives special consideration to other climate-relevant greenhouse gases, in addition to CO_2. The work of the "CO_2-reduction" IWG is being continued. And the Federal Government will continue helping to combat the global, anthropogenic greenhouse effect by means of efficient implementation and continuation of the national climate-protection programme.

The Federal Government plans to integrate its national strategy, on the basis of resolutions of the EC's joint environmental and energy council of 29 October 1990 and 13 December 1991, in the "Community strategy for lower CO_2 emissions and more energy efficiency". The Federal Government considers the introduction of an at-least EU-wide CO_2/energy tax to be particularly important.

The Federal Government will continue to play a highly active role in efforts to achieve world-wide agreement on a strategy for combatting the anthropogenic greenhouse effect. This especially applies to pushing forward the process of achieving further progress on the Framework Convention on Climate Change.

The 1st Conference of the Parties, which will take place in Berlin from 28 March to 7 April, 1995, will review the specific commitments of industrial countries and approve changes, if necessary. The Federal Republic of Germany, as sponsor of the 1st Conference of the Parties, has a special responsibility in preparing this event.

Judged on the basis of scientific criteria and perspectives of precaution, it is clear that the Convention - in spite of its ambitious goals - must be tightened and made more specific, if it is to bring about effective climate protection. This can take place by means of protocols that set specific schedules for stabilising and/or reducing emissions of various trace gases and, especially of carbon dioxide, or in which specific measures are established. The Federal Government plans to urge that preparation of protocols for the reduction of climate-relevant emissions and for binding of greenhouse gases in reservoirs and by sinks begin immediately.

The Federal Government also plans to give impetus to international cooperation for slowing the greenhouse effect. In particular, such impetus is to be provided in the form of support for developing countries and for central and eastern European countries.

The central task of future world-wide policies for slowing the greenhouse effect will be, necessarily, to achieve harmony between satisfying the requirements of a growing world population and fulfilling the requirements of climate protection. Environmental and industrial policies - including energy policy - as well as population policy and other policy areas, will play an important role in this effort.

The Federal Government considers effective, precautionary climate protection to be an indispensable contribution to safeguarding our basis for life and to sustainable development of society, economies and the environment. It considers the Framework Convention on Climate Change, along with step-by-step implementation and refinement of this agreement, to be a significant contribution to protecting the future of the human race and maintaining an intact natural balance.

ANNEX 1

Reference data and relevant emissions factors for determining emissions of greenhouse gases in Germany in 1990

	Source group		Gas
Tab. A 1:	1 A 1	Energy generation and transformation[1]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 2:	1 A 1	Energy generation and transformation[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 3:	1 A 2	Industry[1]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 4:	1 A 2	Industry[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 5:	1 A 3	Traffic (road traffic)[1]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 6:	1 A 3	Traffic (road traffic)[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 7:	1 A 3	Traffic (national air transport)[1]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 8:	1 A 3	Traffic (national air transport)[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 9:	1 A 3	Traffic (rail traffic)[1]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 10:	1 A 3	Traffic (rail traffic)[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 11:	1 A 3	Traffic (coastal and inland shipping)[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 12:	1 A 3	Traffic (coastal and inland shipping)[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 13:	1 A 4	Small consumers[1]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 14:	1 A 4	Small consumers[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 15:	1 A 5	Households[1]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 16:	1 A 5	Households[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 17:	1 A 6	Agriculture and forestry[1]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 18:	1 A 6	Agriculture and forestry[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 19:	1 A 7	Other (military)[1]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 20:	1 A 7	Other (military)[2]	CO_2, CH_4, N_2O, NO_x, CO, NMVOC
Tab. A	1 A 8	Burning of biomass for	CH_4, N_2O, NO_x, CO, NMVOC

21:		energy[1]	
Tab. A 22:	1 A 8	Burning of biomass for energy[2]	CH_4, N_2O, NO_x, CO, NMVOC
Tab. A 23:	1 B 1	Extraction and distribution of oil and gas	CO_2, NO_x
Tab. A 24:	1 B 1	Extraction and distribution of oil and gas	CH_4, NMVOC
Tab. A 25:	1 B 1	Extraction and distribution of oil and gas	CO
Tab. A 26:	1 B 2	Coal mining	CH_4
Tab. A 27:	2	Industrial processes	CO_2
Tab. A 28:	2	Industrial processes	CH_4
Tab. A 29:	2	Industrial processes	N_2O
Tab. A 30:	2	Industrial processes	NO_x
Tab. A 31:	2	Industrial processes	CO
Tab. A 32:	2	Industrial processes	NMVOC
Tab. A 33:	3	Solvent and product use[1]	N_2O, NMVOC
Tab. A 34:	3	Solvent and product use[2]	N_2O, NMVOC
Tab. A 35:	4 A	Agriculture (animal husbandry, fermentation)[1]	CH_4
Tab. A 36:	4 A	Agriculture (animal husbandry, fermentation)[2]	CH_4
Tab. A 37:	4 B	Agriculture (animal wastes)[1]	CH_4
Tab. A 38:	4 B	Agriculture (animal wastes)[2]	CH_4
Tab. A 39:	4 B	Agriculture (animal wastes)[1]	N_2O
Tab. A 40:	4 B	Agriculture (animal wastes)[2]	N_2O
Tab. A 41:	4 D	Agricultural soils	N_2O
Tab. A 42:	5 D	Managed forests	CO_2
Tab. A	6 A	Dump sites - sewage	CH_4

43:		sludge	
Tab. A 44:	6 A	Dump sites - Municipal waste/household waste	CH_4
Tab. A 45:	6 B	Wastewater treatment, sewage-sludge recycling	CH_4
Tab. A 46:	6 B	Wastewater treatment	CH_4
Tab. A 47:	6 B	Wastewater treatment	N_2O

[1] Former West Germany
[2] Area of the former GDR

Tables A1, A2, A3, A4, A5, A6, A8, A9, A10, A11, A12, A13, A14, A15, A16, A17, A18, A19, A20, A21, A23, A24, A25, A27, A28, A29, A30, A31, A32, A33, A35, A36, A37, A38, A40, A41, A43, A44, A45, A46 are not available electronically.

Table A 7

Refernce Data and Emissions Factors for Energy-related Emissions in 1990
Source group 1 A 3 - Transport (national air transports) - from Table 3.3

Former West Germany

	Referent figure Apparent consumption	Emission						Emissions factor					
		CO_2	CH_4	N_2O	NO_x	CO	NMVOC	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
	kt	Mill. t	kt	kt	kt	kt	kt	kg/t	kg/t	kg/t	kg/t	kg/t	kg/t
1 A 3 Transport - national air transports		3	0	n.a.	13	14	2						
Aviation fuels 1)	913	2.9	0	n.a.	13	14	2	3150	0.04	n.a.	13.9	15.5	2.5

Source : Federal Environment Agency

n.a. : not available

1) Because of the small amounts of consumption involved and because the relevant emissions behavior is insufficiently well understood, aviation gasoline is grouped here togerther with aviation turbine fuel.

Table A 22

Reference Data and Emissions Factors for Energy-related Emissions in 1990
Source group 1 A 8 - Traditional Biomass Burned For Energy - from Table 3.4

Area of ther former GDR

	Refernce figure Apparent consumption	Emissions					Emissions factor				
		CH_4	N_2O	NO_x	CO	NMVOC	CH_4	N_2O	NO_x	CO	NMVOC
	kt	kt	t	kt	kt	kt	kg/t	g/t	kg/t	kg/t	kg/t
1 A 8 Traditinal Biomass burned for Energy		6	30	1	51	5					
Fuelwood	483	4.3	20.0	0.8	36.2	2.9	9	41	1.7	75	6
Charcoal production	64	1.0	0.1	0.0	1.3	1.3	15	2	0.5	20	20
Charcoal consumption	16	0.0	0.0	0.0	1.7	0.0	1	0	0.0	105	1
Agriculture residues	200	0.5	10.0	0.5	12.0	1.0	3	50	2.3	60	5

Source: Federal Environment Agency
OECD "Greenhouse Gas Inventory", Workbook, 1994

Table A 26

Reference Data and Emissions Factors for Energy-related Emissions (not combustion related) in 1990
Source group 1 B 2 - Fugitive Fuel Emissions (Coal Mining) - from Tables 3.3 and 3.4 CH_4

	Reference figure Production		CH_4 - Emissions		Methane-formation factor			
	Former West Germany	Area of the former GDR	Former West Germany	Area of the former GDR	Former West Germany		Area of the former GDR	
						Amount of gas used		Amount of gas used
	Mill. t	Mill. t	kt	kt	m³ / t	in percent	m³ / t	in percent
1 B 2 Fugitive Fuel Emissions (Coal Mining)			1202	20				
Hard coal								
Active mines	70.2	-	1069	-	25.7	18	-	-
Storage / processing	70.2	-	40	-	0.8	-	-	-
Closed-down mines	-	-	85 *)	2 *)	-	-	-	-
Lignite								
Strip mines	107.6	248.9	8	18	0.1	-	0.1	-

*) Only estimates of these emissions are available

Source : Federal Environmental Agency
BATELLE- Institut "Ermittlung der Methan-Freisetzung durch Stoffverluste bei der Erdgasversorgung der Bundesrepublik Deutschland", August 1989

Table A 27

Reference Data and Emissions Factors for Industrial Processes in 1990
Source group 2 from Table 3.3 and 3.4 CO_2

	Refernce figure Production quantity		Emissions		Emissions factor	
	Former West Germany kt	Area of the former GDR kt	Former West Germany kt	Area of the former GDR kt	Former West Germany kg / t prod.	Area of the former GDR kg / t prod.
2 Industrial processes			21857	7153		
B Non-ferrous metals						
Primary aluminium pig	720	30	880	37	1222	1222
C Inorganic chemicals						
Ammonia saynthesis	1671	1462	1153	1009	690	690
Soda production	1436	1121	546	482	380	430
E Non-metallic mineral products						
Cement	22871	7316	12922	4134	565	565
Lime	6893	1710	5239	1300	760	760
Glass	5536	956	1117	191	200	200

Source : Federal Environment Agency

Table A 34

Reference Data and Emissions Factors for Solvent Use in 1990
Source group 3 from Table 3.4

Area of the former GDR

	Reference figure	Emissions		Emissions factor	
	Quantity consumed kt	N_2O kt	NMVOC kt	N_2O kg / t prod.	NMVOC kg / t prod.
3 Solvent use		1	140		
A Paint application	111	-	100	-	901
B Degreasing and dry cleaning	n.a.	-	n.a.	-	n.a.
C Chemical products manufacture / processing	40	-	40	-	1000
D Others Solvents in households, printing ink, glues	n.a.	-	n.a.	-	n.a.
Laughing gas	1	1	-	1000	

Source: Federal Environmental Agency

Table A 39

Reference Data and Emissions Factors for Agriculture (Animal Wastes) in 1990
Source group 4 B from Table 3.3 N_2O

Former West Germany

	Reference figure	Emissions *)		Emissions factor
	Number of animals 1000	NH_3 kt	N_2O kt	N_2O kg / Tier x a
4 B Agriculture (animal wastes)		480	7.9	
A 1 Cattle (including calves < 6 month)	14541	335	5.5	0.38
A 2/3 Sheep (including goats)	1784	3	0.1	0.03
A 4 Pigs	22035	118	2.0	0.09
A 5 Horses / mules / asses	406	5	0.1	0.19
A 8 Poultry	81054	18	0.3	0.004

*) The N_2O emissions have been determined on the basis of ammonia emissions from the keeping of livestock. Approximately 1.6 % of the ammonia nitogen is released as N_2O.

Source: **Federal Office of Statistics**
Umweltbundesamt nach Fraunhofer-Institut für Systemtechnik und Innovationsforschung
"Entwicklung der Emissionen nichtenergetisch bedingter klimarelevanter Spurenstoffe in der Bundesrepublik Deutschland", 1993

Table A 42

Reference Data and Emissions Factors for Land Use Change in 1990
Source group 5 D from Tables 3.3 and 3.4 - CO_2

	Reference group		Annual CO_2 binding
	Forest area Mill.. ha	Annual growth increment 1) m^3 / ha	CO_2 Mill. t
5 D Managed forests			20
Former West Germany	7.7	2	14
Area of the former GDR	3.1	2	6

1) preliminary figure; 1 m^3 Wood = 0,092 t CO_2-binding

Source: Federal Environment Agency
Federal Ministry of Food, Agriculture and Forestry

Table A 47

Reference Data and Emissions Factors for the Waste Management Industry in 1990 (Wastewater Treatment) Source group 6 B from Tables 3.3 and 3.4 - N_2O

	Reference figures	Emissions	Emissions factor
	Wastewater volume millions of m³/a	N_2O kt	N_2O g N_2O / m³
6 B Wastewaeter treatment		4	
Former West Germany	6590	4	0.65
Area of the former GDR	0	0	0.65

N_2O emissions occur in wastewater treatment plants that eliminate nitrogen in wastewater

Source Federal Office of Statistics
Federal Environmental Agency, using figures from the Fraunhofer Institute for Systems Technology and Innovation Research "N2O- und Methanemissionen bei der Abwasserreinigung", 1992

ANNEX 2

List of abbreviations

BAHC	Biospheric Aspects of the Hydrological Cycle
BfLR	Bundesanstalt fhr Landeskunde und Raumordnung (Federal Agency for Land and Regional Development)
BALTEX	Baltic Sea Experiment
BMBau	Bundesministerium fhr Raumordnung, Bauwesen und St@dtebau (Federal Ministry for Regional Planning, Building and Urban Development)
BMBW	Bundesministerium fhr Bildung und Wissenschaft (Federal Ministry of Education and Science)
BMFT	Bundesministerium fhr Forschung und Technologie (German Federal Ministry for Research and Technology)
BML	Bundesministerium fhr Ern@hrung, Landwirtschaft und Forsten (Federal Ministry of Food, Agriculture and Forestry)
BMU	Bundesministerium fhr Umwelt, Naturschutz und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
BMV	Bundesministerium fhr Verkehr (Federal Ministry of Transport)
BMVg	Bundesministerium fhr Verteidigung (Federal Ministry of Defence)
BMWi	Bundesministerium fhr Wirtschaft (Federal Ministry of Economics)
BMZ	Bundesministerium fhr wirtschaftliche Zusammenarbeit und Entwicklung (Federal Ministry for Economic Cooperation and Development)
BVWP	Bundesverkehrswegeplan (Federal Traffic Infrastructure Plan)
CLIVAR	Climatic Variability and Predictability
COST	European Cooperation on Scientific and Technical Research
DFD	Deutsches Fernerkundungsdatenzentrum (German Remote-Sensing Data Centre)
DIW	Deutsches Institut fhr Wirtschaftsforschung (German Institute for Economic Research)
DM	Deutsche Mark

DWD	Deutscher Wetterdienst (German Meteorological Service)
EC	European Community
ECE	Economic Commission for Europe
ECU	European Currency Unit
EEC	European Economic Community
ERP	European Recovery Program
ERS-1	European Remote Sensing Satellite
ESA	European Space Agency
ESMOS	European Stratospheric Monitoring Stations
EU	European Union
EUROTRAC	European Experiment on Transport and Transformation of Environmentally Relevant Trace Constituents in the Troposphere over Europe
GAIM	Global Analysis, Interpretation and Modelling
GAW	Global Atmosphere Watch
GCC	Global Collecting Center
GCOS	Global Climate Observing System
GCTE	Global Change and Terrestrial Ecosystems
GDP	Gross Domestic Product
GDR	German Democratic Republic
GEWEX	Global Energy and Water Cyle Experiment
GNP	Gross National Product
GOOS	Global Ocean Observing System
GPCC	Global Precipiation Climatology Centre
GRDC	Global Runoff Data Centre
GTS	Global Telecommunication Network
GVA	Gross Value Added
GWP	Global Warming Potential
HDP	Human Dimension Program
HEM	Harmonization of Environmental Measurement
IEA	International Energy Agency
IFEU	Institut fhr Energie- und Umweltforschung e. V. (Institute for Energy and Environmental Research)
IGAC	International Global Atmospheric Chemistry Project
IGBP	International Geosphere- and Biosphere Program
IGBP-sub-	

programmes:	BAHC, GAIM, GCTE, IGAC, JGOFS, PAGES
IKARUS	Instrumente fhr Klimagas-Reduktionsstrategien (Instruments for Climate-gas Reduction Strategies)
INC	Intergovernmental Negotiating Committee
IRRI	International Rice Research Institute
IOC	Intergovernmental Oceanographic Commission
IODE	International Oceanographic Data und Information Exchange
IPCC	Intergovernmental Panel on Climate Change
IWG	Interministerial Working Group
JGOFS	Joint Global Ocean Flux Study
MAB	Man and Biosphere
MPI Hamburg	Max Planck Institute for Meteorology in Hamburg
NDSC	Network for Detection of Stratospheric Change
ODP	Ocean Drilling Program
OECD	Organization for Economic Cooperation and Development
PAGES	Past Global Changes
Pf	Pfennig
TA	Technische Anleitung (Technical Instructions)
TOGA	Tropical Ocean and Global Atmosphere Program
UBA	Umweltbundesamt (Federal Environmental Agency)
UN	United Nations
UNEP	United Nations Environment Programme
UV-B	Ultraviolet Radiation in the B region (wavelength 280 - 320 nanometer)
VOS	Voluntary Observing Ships
WCRP	World Climate Research Program
WCRP-sub-programmes:	CLIVAR, GEWEX, TOGA, WOCE
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WWW	World Weather Watch

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ANNEX 5

Units of measurement, prefixes, prefix symbols and conversion factors

Units:

%	Percent	ppm	parts per million (10^{-6}),
a	year	ppb	parts per billion (10^{-9}),
EC	degrees Celsius	ppt	parts per trillion (10^{-12}),
g	grammes	t	tonne
ha	hectare	W	Watt
J	joule[1)]		
l	liter		
m	meter		

Prefixes and prefix symbols

Kilo	k	10^3	thousand	Tera	T	10^{12}	trillion
Mega	M	10^6	million	Peta	P	10^{15}	quadrillion
Giga	G	10^9	billion	Exa	E	10^{18}	quintillion

Conversion factors:

Unit	kJ	kWh	kg HCU
1 kJ	---	0.000 278	0.000 034
1 kWh	3 600	---	0.123
1 kg HCU	29 308	8.14	---

1) As of 1 January 1978, in Germany, the legal unit for energy is the joule. Units such as hard coal units (HCU) and crude oil units (COU) (1 HCU = 0.7 COU) may still be used for a transition period, as an additional aid.

ANNEX 6

Chemical formulae and abbreviations

C	carbon
CC	chlorocarbons
CF_4	tetrafluormethane
C_2F_6	hexafluorethane
CFC	chlorofluorocarbons
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
HFC	hydrogenous fluorocarbons
H-CFC	partially halogenated chlorofluorocarbons
N	nitrogen
NO_2	nitrogen oxide
N_2O	nitrous oxide (laughing gas)
NMVOC	methane-free volatile organic compounds
NO_x	nitrogen oxides
O_3	ozone
PFC	perfluorated fluorocarbons (including CF_4 and C_2F_6)
SF_6	sulphur hexafluoride
VOC	volatile organic compounds