Annex 1

Third Report by the Government of the Federal Republic of Germany in accordance with the Framework Convention of the United Nations

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I Introduction

The present report on climate protection in Germany is the third report of the Federal Republic of Germany to the Conference of the Parties pursuant to Article 12 of the Framework Convention on Climate Change. Prepared on the basis of the "UNFCCC reporting guidelines on national communications" and the Federal Republic of Germany's national climate-protection programme of 18 October 2000, it continues the series of national reports begun with the previously submitted national reports of September 1994 and April 1997.

The Federal Government acted early to develop a comprehensive climate-protection strategy, and it has enacted a climate-protection programme with measures to reduce emissions of CO_2 and other greenhouse gases, such as CH_4, N_2O, HFCs, PFCs and SF_6, as well as measures to protect and expand CO_2-storage in forests and wood products. The Federal Government's climate-protection programme is refined at regular intervals and it is being implemented on an ongoing basis.

By resolution of 13 June 1990, the Federal Government established "CO_2-Reduction" Interministerial Working Group, which is charged with identifying the potential for reduction of emissions of greenhouse gases (especially CO_2). In the framework of this Interministerial Working Group ("CO_2-Reduction" IWG), and under the chairmanship of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), working parties were established for the following topic areas: "energy supply" (chaired by: Federal Ministry of Economics and Technology (BMWi)), "transport" (chaired by: Federal Ministry of Transport, Building and Housing (BMV)), "buildings and structures" (chaired by: Federal Ministry of Transport, Building and Housing (BMV)), "new technologies" (chaired by: Federal Ministry of Economics and Technology (BMWi)), "agriculture and forestry" (chaired by: Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL)) and "emissions inventories" (chaired by: Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU); resolution of the Federal Government of 18 October 2000). The constitutional session for the "emissions inventories" working party took place on 15 January 2002.

Fig. I.1 "CO_2-Reduction" IWG

"CO_2-Reduction" IWG

WP I	WP II	WP III	WP IV	WP V	WP VI
Energy supply	Transport	Buildings and structures	New technologies	Agriculture and forestry	Emissions inventories

To date, the "CO_2-Reduction" has submitted five reports on climate-protection strategy to the Federal Cabinet: in November 1990, December 1991, September 1994, November 1997 and October 2000. It is continuing its work, and it has been requested by the Federal Cabinet to submit a 6th report in 2003.

II Framework data

The framework data for Germany's 3rd national report primarily cover the period 1990 through 1999. Data is provided for the areas of legislation, population, geography/land use, the economy, energy, transport, agriculture and forestry, waste management and housing.

II.1 The state framework

II.1.1 Environmental protection as a state objective

Since 27 October 1994, protection of the natural bases for life (environmental protection) has been enshrined as a state objective in the Basic Law (constitution) of the Federal Republic of Germany (Art. 20 a GHG). As a result, and also as a consequence of its responsibility for future generations, the state is responsible for protecting the natural bases for life, through the state's legislative, executive and judicial organs, within the framework of the constitutional order and in keeping with the principles of law and justice.

II.1.2 State structure

The Federal Republic of Germany is a federal state. Its Basic Law distributes tasks and competencies between the Federal Government and the Länder. The Länder have the authority to structure their organisations autonomously, and they differ in their administrative structures. In general, each Land divides itself into Land administrative districts (Regierungsbezirke), rural districts (Landkreise), communities (Gemeinden) and non-district cities (kreisfreie Städte). Communities are entitled to regulate their own affairs, within the legal framework and under their own responsibility.

Table II.1.2.1 provides an overview of Germany's administrative structures.

Tab. II.1.2.1 Germany's administrative divisions

		Districts			
Federal Länder	Land administrative districts	Total	Of these: non-district cities	Of these: rural districts	Communities
16	32	440	117	323	13 854

Source: 2000 Statistical Yearbook

II.1.3 Legislation

In the Federal Republic of Germany, legislative competencies are divided between the Federal authorities and the Länder. Federal authorities have sole legislative jurisdiction in certain areas, assigned to them by the Basic Law (such as foreign affairs, defence and currency), as well as the right to enact "competing" (priority) legislation in certain areas (such as waste management, air quality control and noise abatement) and the right to issue framework legislation in certain areas (such as nature conservation, landscape management and water-resources management). As a result of this division of competencies, the Federal Government has sweeping powers to shape environmental legislation. Where the Basic Law gives Federal authorities no legislative jurisdiction, the Länder have such jurisdiction.

On the federal level, bills (proposed legislation) can be introduced by members of the German Bundestag (Parliament), by the Bundesrat (Länder chamber) or by the Federal Government.

When a bill is introduced, the following procedure is carried out: after the Bundesrat (in connection with initiatives of the government) or the Federal Government (in connection with Bundesrat initiatives) has responded officially, the bill is sent to the Bundestag, within certain deadlines, for deliberation. Bills introduced by parliamentary factions or parliamentary groups are placed directly on the agenda of the Bundestag's plenary session.

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

If a bill is rejected by the Bundestag, it is considered to have failed (although it can be re-introduced later).

If the Bundestag passes the bill: if the legislation is subject to the Bundesrat's approval (i.e. legislation touching on Länder interests; such bills are known as "consent laws" - Zustimmungsgesetze) the Bundesrat must also pass it before it can become law, and the Bundestag cannot override rejection by the Bundesrat. With other types of legislation, the Bundesrat can override rejection by the Bundesrat ("objection laws"). In connection with both consent-law and objection-law legislation, the Bundesrat may forward the matter to a Mediation Committee, which is composed of members of the Bundestag and Bundesrat. In connection with consent-law legislation, the Bundestag and the Federal Government may also forward the matter to the Mediation Committee.

Once a bill has passed, it is signed by the Federal Chancellor and the concerned Federal Ministers and then forwarded to the Federal President for approval. Once the Federal President has signed it, the bill is considered 'signed into law. After it has been promulgated in the Federal Law Gazette, the new law comes into force at the time specified within the law itself or on the fourteenth day after the day on which the relevant issue of the Federal Law Gazette appears.

To protect the basic rights and freedoms guaranteed by the Basic Law, the Federal Constitutional Court can review the new law, upon application and in the framework of a judicial review or a constitutional complaint, for constitutionality.

The Federal Government or a Federal ministry can be empowered by law to issue ordinances and administrative provisions regulating further details of the execution of the new law, within the defined empowerment framework. In addition, the Federal Government may issue general administrative provisions. Ordinances are subject to the consent of the Bundesrat, if so specified by the basis for the empowerment, or if the law is to be executed by the Länder, through representative administration, and no other provision is made in the empowering law. In cases of representative administration, administrative provisions are always subject to the Bundesrat's consent. This is the norm in the environmental sector.

II.1.4 Execution of legal provisions

Federal laws, ordinances and administrative provisions are normally executed by the Länder under their own responsibility; this also applies to the environmental sector. Some areas are reserved for federal administration, and in some areas the Länder execute federal laws on behalf of the federal authorities (for example, laws concerning the safety of nuclear installations and radiation protection); these latter areas are subject to federal supervision.

Länder laws are executed by the Länder themselves.

II.2 Population

From 1990 to 1999, Germany's population grew by 2.8 million inhabitants. In the old Federal Länder, the population increased, while in the new Federal Länder it decreased (cf. Table II 2.1).
The increase in the old Federal Länder, especially that occurring since the end of the 1980s, is due to new arrivals from the new Federal Länder and from other countries.

In its age structure, Germany's population is somewhat skewed toward older age groups; this is result of increasing life expectancies and a low birth rate.

Germany's population density varies considerably by region. The country has densely settled urban and industrial regions, especially in its western part, with population densities of over 1,200 inhabitants per km^2. It also has rural areas, especially in its eastern and northern regions, with fewer than 100 inhabitants per km^2.

Tab. II.2.1 Population development in Germany from 1990 to 1999 (annual average population in millions)

Year	**Old Federal Länder**	**New Federal Länder**	**Total**
1990	63.3	16.1	79.4
1991	64.1	15.9	80.0
1992	64.9	15.7	80.6
1993	65.5	15.6	81.2
1994	65.9	15.6	81.4
1995	66.2	15.5	81.7
1996	66.4	15.5	81.9
1997	66.7	15.4	82.1
1998	66.7	15.3	82.0
1999	67.0	15.2	82.2

Source: 2000 Statistical Yearbook

II.3 Geography and land use

The Federal Republic of Germany has an area of 357,028 km^2 = 35.703 million ha.

II.3.1 Land use

The main trend in land use in Germany is that the area used for settlement and transport is continually increasing, while that used for agriculture is decreasing (land consumption). In 1997, agricultural land accounted for 54 % of the country's total surface area. Nearly two-thirds of this land is under cultivation.

Table II.3.1.1 shows land use, which is determined at four-year intervals, in 1997.

Tab. II.3.1.1 Land use in Germany in 1997

Type of use	**km^2**	**%**
Agriculture	193,136	54.1
Industry	2,515	0.7
Water	7,940	2.2
Buildings + open areas	21,937	6.1
Forest	104,915	29.4
Recreational areas	2,374	0.7
Transport infrastructure	16,785	4.7
Other	7,426	2.1
Total	**357,028**	**100.0**

Source: 2001 Statistical Yearbook

II.3.2 Agriculture

II.3.2.1 Land use by agriculture

In 2000, Germany's agricultural sector used a total of 17.067 million ha., of which 11.804 million ha was farmland. Organic farming was practised on a small, but increasing, share of the total agricultural area. According to data from monitoring procedures within the framework of the EC Regulation on Organic Farming, in 2000 2.8 % of all farms, or 3.2 % of all agriculturally used land, were organically farmed.

II.3.2.2 Fertilisers and livestock

Fertiliser use (cf. Tab. II.3.2.2.1) and livestock (cf. Tab. II.3.2.2.2) are the most significant agriculture-sector sources of emissions of the climate-relevant gases CH_4 and N_2O.

Among fertilisers, it is primarily the nitrogen fertilisers which are climate-relevant; they release a small portion of their nitrogen content (on the average, about 1.25 %) as the greenhouse gas nitrous oxide (laughing gas – N_2O). In the first half of the 1990s, sales of nitrogen, in institutional nitrogen fertilisers, decreased considerably from their levels in the second half of the 1980s. On a long-term average, sales decreased by about one-fourth. In 1998/99 and 1999/2000, sales increased again considerably. They were decreasing again in the 2000/01 fiscal year, however.

Medium-term trends in sales of institutional fertilisers are influenced by the economic framework and by agricultural and environmental policy – for example, by the amount of land which is set aside and by the way in which extensivation programmes are designed.

Tab. II.3.2.2.1 Domestic sales of fertilisers in Germany (in 1,000 t of nutrients)

Year	Nitrogen (N)	Phosphate (P_2O_5)	Potassium (K_2O)	Lime (CaO)
1990/91	1885.3	672.2	1031.7	2407.6
1993/94	1612.2	415.4	644.7	1560.3
1994/95	1787.4	450.7	667.5	1831.6
1995/96	1769.2	401.7	652.2	1886.5
1996/97	1758.0	415.1	645.8	1979.1

1997/98	1788.4	409.6	658.9	2248.5
1998/99	1903.0	406.8	628.7	2264.6
1999/2000	2014.4	420.3	599.2	2508.3
2000/01	1847.6	351.3	544.0	2171.1

Source: Federal Statistical Office, 2001

Livestock has a twofold impact on emissions of greenhouse gases.

Methane (CH_4) is produced when cellulose fibres are broken down in the stomachs of ruminants, and it is produced through microbial decomposition of animal excrement. Emissions produced by the latter process depend both on the type of manure in question and on the way in which it is stored and spread. Biogas systems exploit the microbial decomposition process to produce energy.

Under certain conditions, N_2O can form from animal excrement.

Tab. II.3.2.2.2 Livestock in Germany, in 1000s of livestock units (LU)

Year	**Number of livestock**
1990	18 084
1992	15 400
1994	15 156
1995	NE
1996	15 103
1997	NE
1998	NE
1999	14 640

Source: 2001 Statistical Yearbook, Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL)

From 1990 to 1999, numbers of livestock in Germany decreased by about 19 %, and methane emissions from livestock also decreased, by about 18 %. While the drop in numbers of livestock resulted especially from changes in the new Federal Länder, it also was due to changes in eating habits, to continuing increases in yields from livestock and to overall structural development. Of all types of livestock raised for food, only the poultry population is growing (14 % increase from 1992 to 1999).

Tab. II.3.2.2.3 Livestock in Germany (in 1000s; numbers counted in December; beginning in 1999, numbers counted in May)

Type of animal	1990	1992	1994	1995	1996	1997	1998	1999[1]	2000	2001[2]
Calves, younger than $^1/_2$ year old	3012	2841	2477	2470	2416	2275	2190	2393	2331	2289
Young cattle, $^1/_2$ -1 year old	3701	2991	2861	2771	2729	2622	2562	2393	2295	2216
Cattle, 1-2 years old	4731	3791	3670	3652	3632	3492	3463	3452	3403	3436
Cattle more than 2 years old, female	7827	6791	6804	6848	6843	6702	6593	6498	6341	6419
Cattle more than 2 years old, male	218	153	150	149	140	136	134	155	167	175
Cattle, total	19 488	16 207	15 962	15 890	15 760	15 227	14 942	14 896	14 538	14 536
Pigs	30 819	26 514	24 698	23 737	24 283	24 795	26 294	26 101	25 633	25 893
Sheep	3239	2386	2340	2437	2324	2302	•	2724	2743	2675
Horses	491	531	599	•	652	•	•	476	•	•

Poultry	113 879	104 014	109 878	•	112 508	•	•	118 303	•	•

[1] As of 1999, reduced comparability with earlier counts, as a result of changes in counting methods – especially for sheep, horses and poultry.
[2] Provisional.
Source: Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL)

II.3.3 Forestry

Geobotanically, Germany's forests are located in the temperate zone, and in their natural make-up they consist primarily of mixed deciduous-tree populations. As a result of human impacts, the conifers spruce, fir and Douglas fir predominate, however. They are found on approximately 35 % of all forested areas, while pine and larch account for 31 %, and deciduous trees 34 %, of all forests. About 10.7 million hectares[1], or about 30 % of the country's total area, are forested. In recent years, Germany's forest area has increased by about 5,000 hectares annually, and further increases of about 5,000 hectares per year are expected over the next ten years. Numerous Länder and the Federal Government have launched forest-management programmes aimed at promoting cultivation of semi-natural forests and, thus, of increasing percentages of deciduous forest.

II.4 Climate

Germany's climate is shaped by the country's location within the temperate zone, where the weather changes frequently. Any given location's general climate is modified by its altitude and distance from the sea, however. The prevailing winds are westerly, and precipitation occurs in all seasons.

As one moves from the country's north-western areas to its eastern and south-eastern regions, the climate makes a gradual transition from more oceanic to more continental, i.e. temperature fluctuations between summer and winter, and between night and day, gradually increase. Germany's average annual temperature is +9° C. The average temperatures in January, the coldest month of the year, range from +1.5° C to –1.5° C in the lowlands; in mountain areas, they drop to –6.0°C and lower, depending on elevation. The mean July temperatures (July is the warmest month of the year) range from +17° C to +18° C in the north German lowlands; in the upper Rhine graben (Germany's warmest region), they reach +20° C.
In the course of the 20th century, a temperature increase of about 0.6^{o} C was observed in Germany, as is shown in Fig. II.4.1. Fig. II.4.2 provides another example

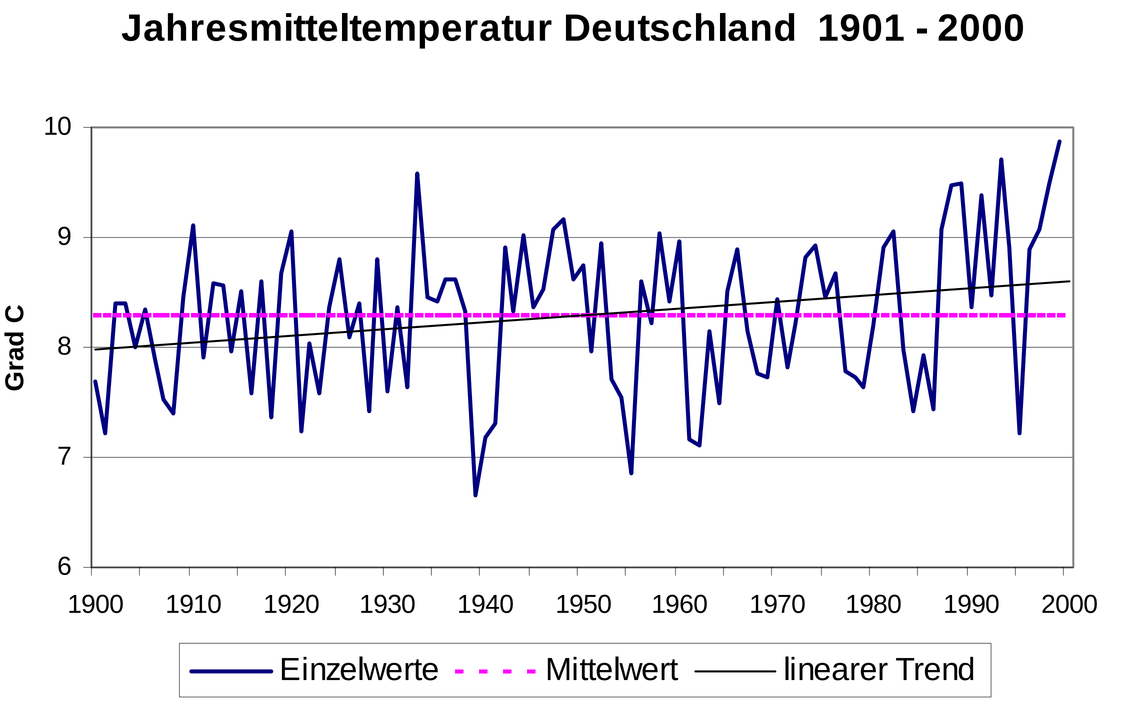
[1] Data from the Federal Forest Inventory (Bundeswaldinventur - BWI) and Datenspeicher Waldfonds. Any discrepancies with Table 3.1.1 result from differences in methods.

of long-term data – it shows mean annual temperatures recorded at the Hohenpeissenberg measuring station, which has a particularly long record of measurements (since 1781).

The last ten years of the 20^{th} century were the warmest decade of the century, both in Germany and worldwide. The temperature in nine of these years was higher than the long-term average mean (8.3^{o} C). Five of the century's 10 warmest years occurred during the same period. The year 2000 was the warmest year of the entire century.

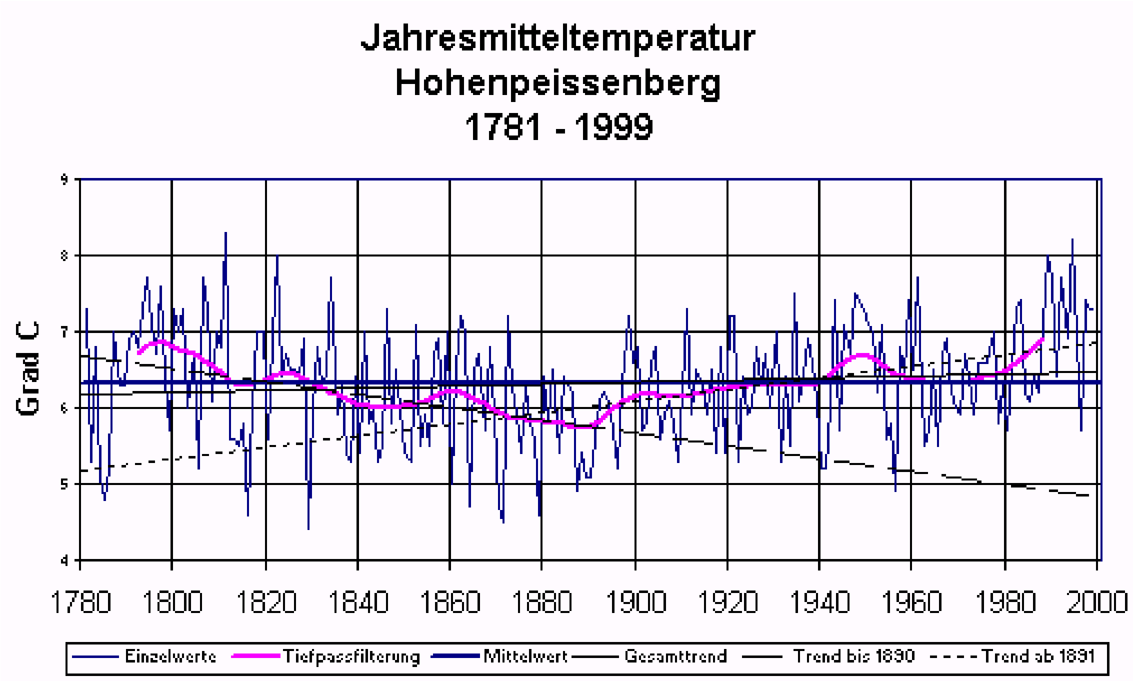
Overall, the mean annual temperatures in Germany for the 20^{th} century show an increasing trend, totalling 0.6° C (see Fig. II.4.1). This increase was not evenly distributed throughout the century, however. It was due largely to an increase occurring until 1911 and then to a very warm period in the 1980s and 1990s. Between these two periods, the mean annual temperatures remained at about the same level, and the third-warmest year (1934) occurred shortly before the coldest year (1940).

Fig. II.4.1 Annual mean temperature in Germany, 1901-2000



[Mean average temperature in Germany, 1901-2000; Degrees C; Individual measurements; Mean value; Linear trend]

Fig. II.4.2 Mean average temperature recorded at the Hohenpeissenberg measuring station, 1781-1999

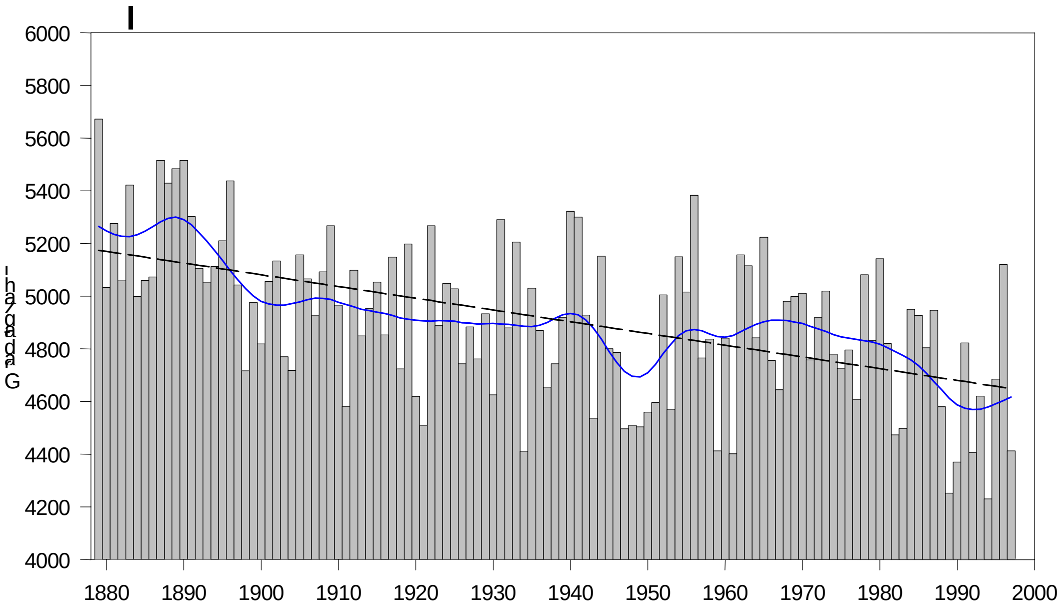


[Mean average temperature recorded at the Hohenpeissenberg measuring station, 1781-1999; Degrees C; Individual measurements; Low-pass filter; Mean value; Overall trend; Trend until 1890; Trend beginning in 1891]

The warming trend during the winter is also apparent in development of "degree day" figures.

The "degree day" is an indicator that is widely used by the energy sector to determine heating requirements. A degree-day number represents the sum of daily differences between mean temperature and 15° C (only days with an average temperature below 15° C count in the degree-day total). The long-term yearly average in Germany is 4,000. The winter half of the year (October to March) by itself registers a total of 3,000.

Fig. II.4.3 Annual degree-day figures for Hohenpeissenberg, 1879 - 1997



As the example of Hohenpeissenberg shows, degree-day numbers – and thus heating requirements – have clearly been decreasing.

Annual precipitation levels in the north German lowlands range from 500 to 700 mm. In upland areas, they range from 700 to over 1,500 mm, and in the Alps they reach over 2,000 mm. Daily rainfall levels surpass 10 mm on 10 to 20 days of the year in coastal areas and interior lowlands, on 20 to 30 days of year in upland areas and on 50 to 70 days of the year in high mountains (Zugspitze).

Records of mean annual rainfall levels in Germany show a slight, statistically insignificant increase that is due mainly to the lack of particularly wet years in the first 20 years of the century. In the 1990s, 4 years had rainfall below the average of 790 mm, and 6 years had rainfall above this average. On the other hand, 1993 and 1994 were among the 10 wettest years of the century. The wettest year, with 996 mm of rainfall, was 1981, while the driest, with only 552 mm, was 1959.

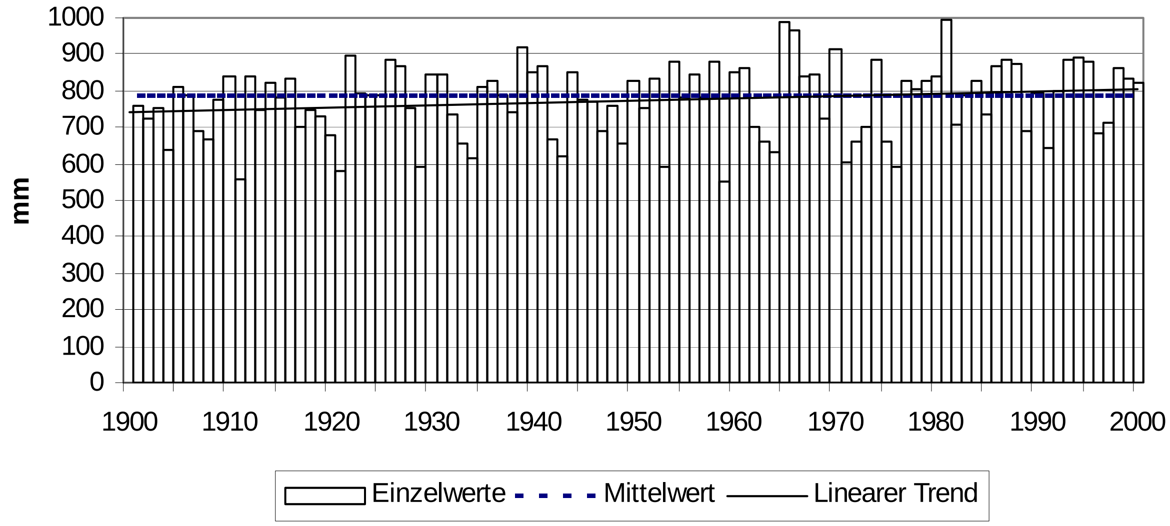
In low-lying inland areas, strong winds (over 8 on the Beaufort scale) occur on only 1 to 6 days of the year. In coastal areas, coastal islands and upland areas, they occur on 10 to 20 days of the year, while in the Alps they occur on about 50 days of the year.

Over the past 20 years, storm frequencies have been relatively high, and some storms, such as the ‘Lothar’ and ‘Martin’ storm systems of December 1999, were particularly strong.

Storm frequency can be correlated with prevailing westerly wind conditions when the North Atlantic Oscillation (NAO) is in a positive phase (i.e. with relatively well-developed high-pressure systems near the Azores/Portugal and low-pressure systems near Iceland). It is still unclear whether such positive NAO phases are linked to global climate change (a result provided by a number of model calculations).

Fig. II.4.4 Annual precipitation in Germany, 1901-2000

Abb. 4 Jahresniederschlag Deutschland 1901 - 2000



[Fig. 4 Annual precipitation in Germany, 1901-2000; Individual measurements; Mean value; linear trend]

II.5 Economy

From 1991 to 1999, Germany's gross domestic product (GDP) grew by an average of about 1.4% per year. Over the past few years, the country has also achieved an absolute reduction in its primary energy consumption. As a result, Germany has succeeded in severing the link between economic growth and energy consumption.

II.5.1 Overall economic indexes

A country's gross domestic product (GDP) is the monetary result of its production processes, i.e. the total value of all goods and services produced within its geographic boundaries, by both nationals and foreigners, minus the value of the goods consumed as part of the production process.

The gross domestic product is figured as the total gross value added (GVA) of all economic sectors, minus the theoretical cost of relevant banking services, plus non-deductible value-added tax and import duties. The GVA is the net result of production. As a rule, it is calculated as the difference between the various economic sectors' gross production values and advance payments. The GDP is the more suitable figure for establishing a relationship to the environmental stresses resulting from economic processes, since it describes a country's total economic activity.

Table II 5.1.1 shows the development of GVA for various aggregated economic sectors in DM, taking into account the relevant exchange rate in US $. The data for 1991 to 1999 is listed in 1995 prices. Germany's GVA in 1999 amounted to a total of 3,542.3 billion DM. This works out to 43,153 DM per capita.

Tab. II.5.1.1 Gross value added (GVA) from 1991 to 1999, by sectors, in 1995 prices (in billions)

Sector	1991		1992		1993		1994		1995		1996		1997		1998		1999		Sectors' percentage shares of GVA in 1999
	DM	US-$	DM	US-$	DM	US-$	DM	US-$	DM	US-$	DM	US-$	DM	US-$	DM	US-$	DM	US-$	%
Agriculture and forestry, fisheries	39.3	23.7	41.6	26.7	42.5	25.7	40.3	24.8	42.2	29.4	45.1	30.0	44.9	25.9	45.9	26.1	47.5		1.3
Manufacturing	1093.6	658.3	1088.4	697.9	1028.3	621.5	1061.7	654.6	1060.8	739.8	1033.4	687.2	1049.1	604.7	1058.2	601.5	1046.4		30.0
Trade, hotels and restaurants and transport	551.2	331.8	573.1	367.5	565.4	341.7	574.2	354.1	585.8	408.5	591.8	393.5	598.6	345.0	613.0	348.4	650.3		18.4
Financing, leasing and institutional services	779.6	469.3	807.5	517.8	834.3	504.3	849.9	524.0	893.1	622.8	935.3	622.0	970.9	559.6	1018.8	579.1	1058.2		29.9
Public and private services	653.2	393.2	677.8	434.6	686.8	415.1	700.7	432.1	713.6	497.7	726.5	483.1	731.2	421.5	736.9	418.9	739.9		20.9
Total GVA	3116.8	1876.3	3188.5	2044.5	3157.3	1908.3	3226.7	1989.6	3295.4	2298.2	3332.1	2215.8	3394.6	1956.6	3472.7	1973.9	3542.3		100
Exchange rate 1 DM = US-$*		0.6020		0.6412		0.6044		0.6166		0.6974		0.6650		0.5764		0.5684		-	

* Basis: DM exchange rates, Deutsche Bundesbank, monthly report, Jan. 2001
Source: Federal Statistical Office

Tab. II.5.1.2 Development of gross domestic product (GDP), in 1995 prices

	1991	1992	1993	1994	1995	1996	1997	1998	1999
GDP (in billions of DM)	3,346	3,421	3,384	3,463	3,523	3,550	3,600	3,670	3,738
Primary energy consumption (PJ)	14,467	14,150	14,179	14,078	14,269	14,746	14,574	14,454	14,200

Source: Federal Statistical Office, Umweltökonomische Gesamtrechnung 2000

II.5.2 Per-capita GDP

Tab. II.5.2.1 Development of per-capita gross domestic product, in 1995 prices, from 1991 to 1999 (in DM per capita)

	1991	1992	1993	1994	1995	1996	1997	1998	1999
Germany	41,833	42,444	41,683	42,534	43,142	43,348	43,870	44,740	45,535

Source: Federal Statistical Office, Umweltökonomische Gesamtrechnung 2000

Table II.5.2.1 shows development of per-capita GDP in Germany, from 1991 to 1999. Per-capita GDP grew by a total of 8.8 % during this period, and it has been increasing continually since 1994.

II.5.3 Employment by economic sectors

Table II.5.3.1 shows the development of employment in Germany's various economic sectors, from 1991 to 1999. Workforce levels decreased in agriculture and forestry, fisheries and manufacturing, while they grew in other sectors. Job growth in services sectors was unable to compensate for overall job losses, and thus the employment level in 1999 was lower than that for 1991.

Tab. II.5.3.1 Employment in Germany, by economic sectors, from 1991 – 1999 (in 1000s of persons)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	Percentage-share of employed persons in each sector in 1999
Agriculture and forestry, fisheries	1,555	1,325	1,224	1,172	1,115	1,008	991	994	973	2.6
Manufacturing	14,117	13,372	12,755	12,394	12,228	11,871	11,585	11,496	11,345	29.8
Trade, hotels and restaurants and transport	9,333	9,356	9,341	9,313	9,309	9,326	9,347	9,470	9,616	25.2
Financing, leasing and institutional services	3,707	3,909	4,054	4,248	4,404	4,566	4,738	5,015	5,347	14.0
Public and private services	9,742	9,916	9,991	10,177	10,326	10,499	10,547	10,636	10,800	28.4
Total number of employed persons	38,454	38,878	37,365	37,304	37,382	37,270	37,208	37,611	38,081	100

* Basis: DM exchange rates, Deutsche Bundesbank, monthly report, Jan. 2001
Source: Federal Statistical Office, Series (Fachserie) 18, Row (Reihe) 1.3 (2000)

II.6 Energy consumption

II.6.1 Primary energy consumption by sectors and by fuels

If measures for preventing a broad range of energy-related environmental impacts are to be effective, they must be based on a detailed understanding of where energy is used.

Final energy consumption – the energy available to end consumers – is divided into the sectors "industry", "residential", "institutional" (trade, commerce, services), "road transports" and "other transports". Two other categories, "non-energy-related consumption" (including, for example, use of oil in plastics production) and "energy conversion" (including consumption and losses, primarily as incurred in electricity generation and fuel production), are also listed. The total energy consumption and losses for all sectors make up the primary energy consumption, which is shown broken down by the various fuels involved.

In 2000, Germany used some 14,180 PJ of primary energy.

Tab. II.6.1.1 Primary energy consumption (in PJ) in Germany, by energy sectors, 1970-2000

Primary energy consumption by energy sectors, 1970–2000 (in PJ)															
Energy sector	Substitution method [d]				Efficiency method [e]										
	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999[*]	2000[*]
Final energy sectors:															
transport	1 371	1 589	1 891	1 924	2 379	2 428	2 522	2 596	2 554	2 614	2 625	2 643	2 692	2 779	2 745
residential	2 179	2 186	2 496	2 642	2 383	2 516	2 436	2 617	2 558	2 655	2 890	2 854	2 779	2 637	2 550
institutional [a]	1 526	1 669	1 803	1 862	1 702	1 678	1 556	1 529	1 468	1 614	1 749	1 603	1 576	1 514	1 472
industry [b]	3 600	3 527	3 609	3 312	2 977	2 694	2 560	2 432	2 463	2 474	2 424	2 440	2 397	2 380	2 430
Conversion sector:															
losses and own consumption [c]	3 411	3 654	4 241	4 407	4 513	4 404	4 329	4 243	4 175	3 950	4 105	4 019	3 925	3 832	3 886
Non-energy-related consumption [d]	834	859	963	888	958	891	911	887	964	963	953	1012	1 046	1 052	1 096
Total	12 920	13 484	15 002	15 036	14 912	14 610	14 314	14 305	14 182	14 270	14 746	14 614	14 521	14 193	14 180

a) Including military agencies
b) Other mining and processing sectors
c) Losses in energy conversion – for example, in power stations, refineries and briquetting plants, including line losses and statistical differences
d) For example, fuels used as raw materials in the chemical industry
e) In the interest of international comparability, as at 1990 primary energy consumption in Germany has been calculated using the efficiency method. In keeping with procedures used by relevant international organisations (IEA,EUROSTAT,ECE), the efficiency method is based on the following assumptions regarding percentages of relevant energy content actually converted to electricity: nuclear power – 33%; hydroelectric and wind power and photovoltaic power – 100%; and power imports – 100%. Under the substitution method, which was used in Germany until 1994, it was assumed that electric power from the aforementioned energy sources would replace (substitute for) corresponding amounts of power from conventional thermal-electric power stations and that thus the usage efficiency for the aforementioned energy sources would be the same as that for fuels in conventional thermal-electric stations. In comparison with the substitution method, the efficiency method produces higher primary energy percentages for nuclear power and lower primary energy percentages for other energy sources. (For example, in keeping with the "Erneuerbare Energien 2000" ("Renewable Energies 2000") yearbook of Baden-Württemberg's Stiftung Energieforschung (Energy Research Foundation), renewable energies' share of primary energy consumption in 1999 was nearly 2.4% under the substitution method and only 1.2% under the efficiency method, although it must be noted that the definition for renewable energies used here is narrower than that used in analysis of relevant data as carried out by the Energy Balances Working Group (AG Energiebilanzen).)
*) Tentative figures

Source: German Institute for Economic Research, Berlin (DIW), AG Energiebilanzen: Auswertungstabellen zur Energiebilanz (evaluation tables for energy balance sheet), Sept. 2001

In recent decades, the sector structure of final energy consumption has undergone considerable changes. The percentage share for industry has decreased considerably: its share of total final energy consumption decreased from a solid two-fifths in 1970 to a little over one-fourth (26.4%) in 2000. At the same time, the percentage for the private residential sector has increased (from 25 % in 1970 to 28 % in 2000), as has that for road transports (even more markedly: from about 10 % in 1970 to nearly 19 % in 2000). About two-thirds of all primary energy consumption wind up in the final energy sectors, while about 8 % goes to consumption for non-energy-related purposes. Some 27 % of primary energy consumption consists of losses and production-related (own) consumption in generation and provision of electricity and other secondary energy sources, such as fuels, in the energy-conversion sector itself.

In 2000, Germany relied on the following energy sources to meet its energy requirements (percentages of total energy use shown in parentheses): petroleum (about 39 %), natural gas (21 %), hard coal (14 %) and lignite (11 %). In addition, nuclear power contributed 13 % of primary energy requirements. Renewable energies – including hydroelectric power, wind power and solar energy – along with "other energies", such as waste, sewage sludge and biomass – contributed only a small percentage, some 3 %. Over the past decade, the largest changes in energy sources' percentage contributions occurred with lignite, use of which dropped by half, and natural gas, use of which increased by about one-third.

Tab. II.6.1.2 Primary energy consumption (in PJ) in Germany, by fuels, 1970 -2000

Primary energy consumption by fuels, 1970–2000 (in PJ)

Fuel	Substitution method [d)]			Efficiency method [d)]											
	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999 [*)]	2000 [*)]
Hard coal	3 142	2 191	2 497	2511	2 307	2 330	2195	2 139	2 139	2 060	2 090	2 065	2 059	1 890	1 920
Lignite	3 190	3 178	3 390	3 687	3 200	2 506	2178	1 984	1 861	1 735	1 688	1 595	1 514	1 468	1 547
Petroleum	5 652	5 927	6 059	5115	5 237	5 548	5 627	5 744	5 692	5 689	5 808	5 753	5 775	5 598	5 478
Natural gases [a)]	563	1 657	2 190	2 086	2 315	2 433	2 406	2 544	2 591	2 828	3 161	3 022	3 048	3 057	3 025
Hydroelectric, wind power [b)]	256	239	242	177	59	53	62	62	64	82	73	78	80	88	106
Foreign trade balance, electricity	0	0	0	0	3	–3	–21	3	9	18	-19	-9	-2	3	9
Nuclear power	67	240	563	1 354	1 665	1 609	1 732	1 673	1 650	1 682	1 764	1 859	1 764	1 852	1 849
Other energy sources [c)]	49	52	61	106	126	135	135	155	176	176	181	251	283	237	246
Total	12 920	13 484	15 002	15 036	14 912	14 610	14 314	14 305	14 182	14 270	14 746	14 614	14 521	14 193	14 180

[a)] Includes natural gas, gas from petroleum, pit gas, sewage gas
[b)] Until 1990, only foreign trade balance for electricity; wind power included as at 1995
[c)] Firewood and waste wood, peat, waste, sewage sludge, other gases and waste heat for electricity and district heat
[d)] Compare footnote e) in Table II.6.1.1
[*)] Tentative figures
Source: German Institute for Economic Research, Berlin (DIW), AG Energiebilanzen: Auswertungstabellen zur Energiebilanz (evaluation tables for energy balance sheet), Sept. 2001

II.6.2 Electricity generation and consumption

Consumption of electric power in Germany has increased by about 5% over the past decade. While use of lignite in power generation decreased by one-fourth, and use of heating oil in power generation dropped by over half, relevant consumption of hard coal and nuclear power increased slightly and gas-fired generation, hydroelectric generation and wind-power generation increased considerably. On the whole, coal still accounts for the largest share, about 50 %, of electricity generation. Thanks to efficiency increases via improved power-station technology, the total amount of energy represented by the energy sources used in power generation decreased by about 5 % between 1990 and 1999.

Tab. II.6.2.1 Electricity generation, energy losses and electricity consumption in Germany, from 1990 to 1999 (in PJ)

	1990	1991	1992	1993	1994	1995	1996	1997*	1998*	1999*
Fuel	Energy consumption in PJ									
Hard coal	1269	1354	1287	1322	1307	1334	1369	1284	1363	1272
Lignite	1797	1679	1618	1530	1504	1445	1433	1389	1345	1328
Other solid fuels	64	64	67	67	73	64	64	67	73	79
Heating oil	108	126	111	79	76	73	79	53	47	38
Gases	434	416	369	363	410	443	454	489	501	504
of these: natural gases	337	325	281	284	325	343	375	384	393	396
Hydroelectric/wind [1)]	76	70	79	82	82	94	94	85	88	94
Nuclear power	1665	1609	1732	1673	1650	1682	1764	1858	1764	1852
Primary energy cons. Total in electricity generation	**5413**	**5319**	**5264**	**5117**	**5103**	**5135**	**5258**	**5226**	**5182**	**5167**
Losses and prod.-related cons. in electricity generation and distribution	**3763**	**3705**	**3661**	**3535**	**3499**	**3488**	**3581**	**3543**	**3479**	**3467**
Total electricity consumption	**1650**	**1615**	**1603**	**1583**	**1603**	**1647**	**1676**	**1682**	**1703**	**1700**
Industry	747	698	683	648	665	686	677	700	715	724
Institutional	434	422	425	428	434	445	457	448	463	457
Residential	419	440	443	454	448	457	484	472	472	466
Transports	50	56	53	53	56	59	59	62	53	53

1) Wind power as at 1995

*) Tentative figures; Auswertungstabellen zur Energiebilanz, DIW, 31 July 2000

Source: DIW, AG Energiebilanzen

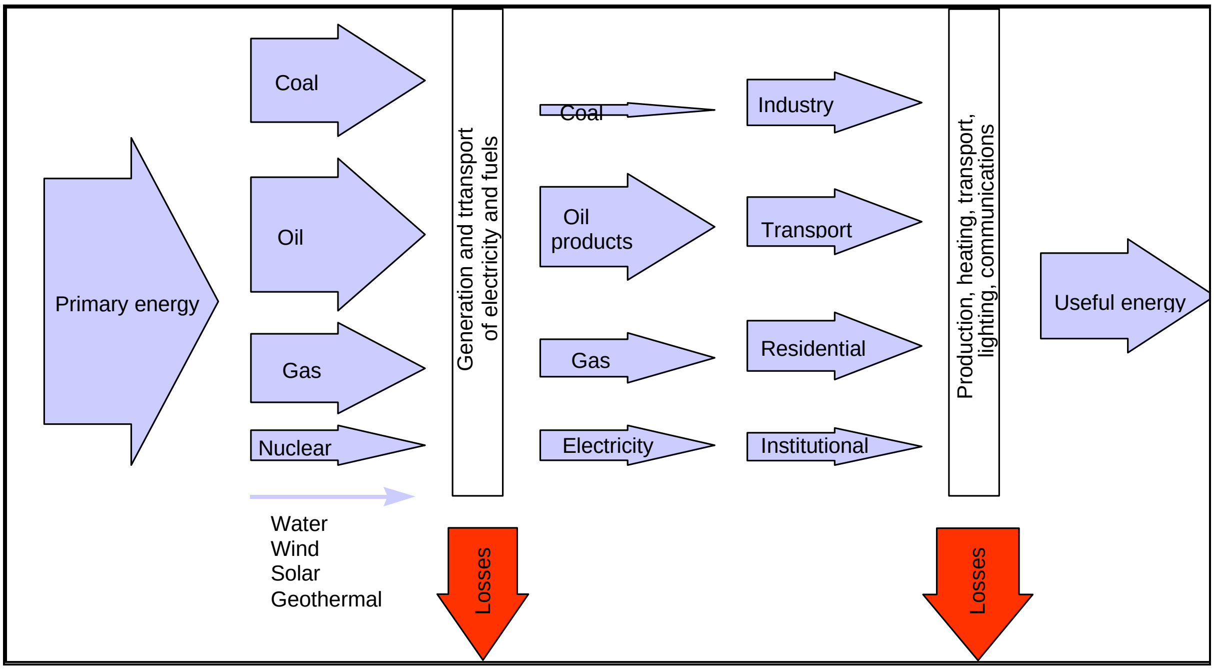
II.6.3 Efficiency in energy consumption

Considerations of efficiency in energy consumption generally focus on the relationship between primary energy consumption (PEC) and economic output (GDP). Significantly, Germany's energy efficiency in this area (units of GDP per unit of PEC) has continually improved since 1991. For example, Germany's energy intensity (i.e. units of PEC per unit of GDP) decreased by an average of 1.9 % annually from 1991 to 2000; in other words, primary energy consumption was decoupled from GDP growth.

In analysing energy efficiency and climate-protection progress, it could also be useful to consider not only the supply side (generation and conversion), but also the demand side – i.e. where and how (for what purposes) energy is used. The many different energy services are divided into the categories process heat, indoor heat, mechanical energy, lighting and information/communications. The relationship between the actual amount of energy consumed in using an energy service (useful energy such as brightness or heat for a room) and the final energy actually used to provide the service can provide an indication of energy efficiency (i.e. efficiency of energy use). On the other hand, the data required for such useful-energy analyses is not always available. As a result, the following consideration is based on evaluation of studies carried out by RWE Energie and VDI-Gesellschaft Energietechnik several years ago.

The following figure illustrates the relationship between primary energy and "useful energy".

Fig. II.6.3.1 Energy consumption in Germany



Tab. II.6.3.2 Energy efficiency in Germany

Application	Final energy in PJ			Useful energy in PJ			**Energy efficiency**			
	1995	1996	1997	1995	1996	1997	1995	1996	1997	1990 Old Federa Länder
Industry	**2474**	**2400**	**2456**	**1504**	**1475**	**1507**	**61%**	**61%**	**61%**	**56%**
Process heat, including hot water	1670	1594	1680	985	956	1008	59%	60%	60%	57%
Indoor heat	279	284	243	195	199	170	70%	70%	70%	65%
Mechanical energy	460	455	463	294	291	296	64%	64%	64%	} 46%
Lighting	35	38	38	3	3	4	9%	8%	11%	
Information/communications	30	29	32	27	26	29	90%	90%	91%	
Transport	**2614**	**2600**	**2638**	**481**	**480**	**489**	**18%**	**18%**	**19%**	**18%**
Process heat, including hot water	0	0	0	0	0	0				
Indoor heat	9	12	12	6	9	9	67%	75%	75%	65%
Mechanical energy	2587	2567	2602	466	462	468	18%	18%	18%	} 18%
Lighting	9	12	12	1	1	1	11%	8%	8%	
Information/communications	9	9	12	8	8	11	89%	89%	92%	
Residential	**2655**	**2934**	**2840**	**1759**	**1983**	**1912**	**66%**	**68%**	**67%**	**61%**
Process heat, including hot water	398	419	413	183	193	190	46%	46%	46%	40%
Indoor heat	2034	2298	2201	1485	1701	1629	73%	74%	74%	67%
Mechanical energy	133	123	132	53	49	53	40%	40%	40%	} 32%
Lighting	40	41	41	3	3	3	8%	7%	7%	
Information/communications	50	53	53	35	37	37	70%	70%	70%	
Institutional	**1579**	**1694**	**1536**	**936**	**1015**	**898**	**59%**	**60%**	**58%**	**51%**
Process heat, including hot water	347	393	375	149	169	161	43%	43%	43%	35%
Indoor heat	816	909	736	579	654	530	71%	72%	72%	67%
Mechanical energy	300	272	296	174	158	172	58%	58%	58%	} 31%
Lighting	81	85	94	6	6	7	7%	7%	7%	
Information/communications	35	35	35	28	28	28	80%	80%	80%	
Total for consumption sectors	**9322**	**9628**	**9470**	**4680**	**4953**	**4806**	**50%**	**51%**	**51%**	**47%**
Process heat, including hot water	2415	2406	2468	1317	1318	1359	55%	55%	55%	51%
Indoor heat	3138	3503	3192	2265	2563	2338	72%	73%	73%	67%
Mechanical energy	3480	3417	3493	987	960	989	28%	28%	28%	} 25%
Lighting	165	176	185	13	13	15	8%	7%	8%	
Information/communications	124	126	132	98	99	105	79%	79%	80%	

Sources: RWE Energie, VDI-Gesellschaft Energietechnik
Evaluation: UBA, I 2.5

On the average, only about half of the final energy provided to end consumers is actually converted to useful energy (Tab. II.6.3.2). In indoor heating in the residential sector, the largest category among energy services, about 75 % of final energy is converted to useful energy. In the transport sector, by contrast, the physical limitations of current technologies permit only about 18 % of final energy to be converted into useful energy.

Increases in useful-energy efficiency take place relatively slowly. A cautious comparison of figures for Germany as a whole in 1997 with 1990 figures for the old Federal Länder shows an increase of 4 % in this area (Tab. II.6.3.2). One reason why change is so slow is that devices needed to provide and use energy services tend to be quite durable; they are replaced only at long intervals, and only when they no longer function properly or become too expensive to use. This is why it is important to continue development of effective energy uses – and, especially, of the relevant underlying technologies. And instruments that affect cost-effectiveness can also help accelerate adoption of efficient energy applications.

II.7 Transport

II.7.1 Transport mileage

The key transport trends in the 1990s included moderate growth in passenger transports and considerable increases in goods transports. Between 1991 and 2000, passenger transports grew by 7.0 %. Private automobile transports increased by 3.7 % and retained their dominant position in this area. Their share of total passenger transports decreased slightly from 1991 (81.6 %) to 2000 (79.1 %). The fastest growth, by far, among all modes of passenger transportation took place in air transport. From 1991 to 2000, air transports over Germany increased by 88.9 %.

During the same period, transports in public road and rail transportation increased by 10.3 %. These relatively "clean" modes of transportation continue to account for a small share – about 16 % – of transports.

Even when non-motorised transports are taken into account, private automobile transports, then accounting for 75 % of transports, still have a much higher share of transports than environmentally friendly transports (walking, cycling, rail transports and public road transports), which account for a share of 21 %.

According to the Association of the German Petroleum Industry (Mineralölwirtschaftsverband), in 2000 fuel consumption in transports decreased by 2.2 % over the previous year; in 2001, it decreased still further, by –2.1%. This development has been due primarily to trends in petrol sales, which dropped by 4.8 % in 2000 and by 3.0 % in 2001 (1999: -0.1 %). Sales of diesel duel in 2001 were down 1.3 % (2000: +0.5 %; 1999: +6.2 %). These trends have brought about a corresponding reduction of CO_2 emissions from road traffic, and they have been made possible by optimization of engines and automotive technologies – for example, use of new materials that have lowered vehicle weights while enhancing passive safety characteristics. Furthermore, within a space of 4 years, the relative percentage of newly registered vehicles with normed fuel consumption of no more than 6.5 litres/100 km has increased from 13.5 % to nearly 40 %. The government's ecological tax reform has played a central role in this improvement, which itself shows that the automobile industry is making progress in meeting its voluntary commitment to reduce fuel consumption of new vehicles by 25 % by 2005, compared to corresponding levels in 1990, and will probably be able to fulfill it completely.

Nonetheless, in light of the traffic growth expected in future, additional efforts must be made to reduce CO_2 emissions.

Tab. II.7.1.1 Motorised passenger transports (1991-2000) in Germany

Year	Railway		Public transportation		Air transports[2]		Private automobiles		Total transports
	billions of pkm	%	billions of pkm	%	billions of pkm	%	billions of pkm	%	billions of pkm
1991	57.0	6.5	81.6	9.3	22.6	2.6	713.5	81.6	874.7
1992	57.2	6.4	80.4	9.0	25.6	2.9	731.5	81.8	894.8
1993	58.7	6.5	79.6	8.8	27.7	3.1	740.8	81.7	906.9
1994	66.4	7.3	77.5	8.6	30.0	3.3	732.4	80.8	906.2
1995	75.0	8.1	77.0	8.3	32.5	3.5	742.9	80.1	927.3
1996	76.0	8.2	76.7	8.2	33.6	3.6	744.3	80.0	930.6
1997	73.9	7.9	76.2	8.1	35.8	3.8	749.7	80.1	935.7
1998	72.4	7.7	75.7	8.1	37.5	4.0	754.2	80.3	939.8
1999	73.6	7.7	76.2	8.0	39.9	4.2	761.6	80.1	951.2
2000	75.1	8.0	77.8	8.3	42.7	4.6	740.1	79.1	935.7

Source: Verkehr in Zahlen 2001/2002, published by Ministry of Transport, Building and Housing (BMVBW)

Goods transports grew 27.0 % from 1991 to 2000. The largest growth, which began from a relatively low level, took place in air transports (+78.0%) and road transports (+41.3%). The percentage of total goods transports that moved on roads increased from 61.7 % (1991) to 68.7 % (2000). This growth came primarily at the expense of railways, which in 2000 moved only 15.0 % of all goods transports. The goods-transports share of railways and inland waterways, two relatively environmental friendly modes of transport whose share of goods transports in 1980 was about equal to that of road transports, has dropped to about 28 %.

Tab. II.7.1.2 Goods transports (1991-2000) in Germany

Year	Railways		Road transports		Inland waterways		Long-distance pipelines (*)		Air transports (**)		Total transports
	billions of	%	billions of	%	billions of	%	billions of	%	millions of	%	billions of tkm

[2] In keeping with current applicable international conventions, these figures do not include international air transports. The statistics include only air transports over Germany (including overflights).

	tkm		tkm		tkm		tkm		tkm		
1991	80.2	20.2	245.7	61.8	56.0	14.1	15.7	3.9	428.8	0.1	398.0
1992	69.8	17.7	252.3	63.9	57.2	14.5	15.7	4.0	435.9	0.1	395.5
1993	64.9	16.6	251.5	64.5	57.6	14.8	16.1	4.1	459.2	0.1	390.5
1994	69.9	16.6	272.5	64.7	61.8	14.7	16.8	4.0	503.3	0.1	421.5
1995	68.8	16.0	279.7	65.2	64.0	14.9	16.6	3.9	522.4	0.1	429.6
1996	67.7	16.0	280.7	66.2	61.3	14.4	14.5	3.4	544.5	0.1	424.8
1997	72.9	16.2	301.8	67.1	62.2	13.8	13.2	2.9	565.0	0.1	450.6
1998	73.6	15.7	315.9	67.4	64.3	13.7	14.8	3.2	657.7	0.1	469.2
1999	71.4	14.5	341.7	69.6	62.7	12.8	15.0	3.0	696.0	0.1	491.4
2000	76.0	15.0	347.2	68.7	66.5	13.2	15.0	3.0	763.3	0.2	505.5

(*) As at 1996 only crude oil
(**) As at 1998 new kilometrisation in air transports
Source: Verkehr in Zahlen 2001/2002, published by Ministry of Transport, Building and Housing (BMVBW)

II.7.2 Total numbers of motor vehicles

Table II.7.2.1 shows how numbers of motor vehicles in Germany have grown.

Tab. II.7.2.1 Growth of the motor-vehicle fleet, including low-emissions automobiles

Year (as of 1 July)	Automobiles and vans, etc.			Trucks and semi-towing vehicles	Motorbikes and motorcycles	Other motor vehicles
	total	of these, number of low-emissions vehicles				
	in millions	in millions	in %	in millions	in millions	in millions
1991	36.8			1.8	3.7	2.6
1992	37.9	17.8	47.0	2.0	4.0	2.5
1993	38.9	25.3	65.0	2.1	3.9	2.4
1994	39.8	28.0	70.5	2.2	3.8	2.4
1995	40.4	30.8	76.2	2.3	3.9	2.5
1996	41.0	33.0	80.6	2.4	4.2	2.5
1997	41.4	35.0	84.7	2.5	4.4	2.5
1998	41.7	37.0	88.8	2.5	4.6	2.5
1999	42.3	39.0	92.1	2.6	4.9	2.5
2000	42.8	40.5	94.6	2.7	5.1	2.5
2001	43.8	41.5	94.7	2.8	5.0	2.5

Source: Verkehr in Zahlen 2001/2002, publ.: Federal Ministry of Transport, Building and Housing (BMVBW)

Germany's motor-vehicle fleet has been growing continually. In 2001, Germany had some 43.8 million automobiles, 2.8 million trucks and 5.0 million motorbikes/motorcycles. Its automobile fleet grew by 19 % from 1991 to 2001. The rate of automobile ownership increased from 460 automobiles per 1000 inhabitants to 533 automobiles per 1000 inhabitants – one of the world's highest rates. A total of 14.5 % of all automobiles in Germany have diesel engines. The size of the country's diesel-automobile fleet, expressed as a percentage of the entire automobile fleet, is expected to grow rapidly over the next few years, since diesel automobiles account for a growing share of new registrations (1998: 18 %; 2001: 35 %).
The total percentage share of low-emissions automobiles grew sharply from 1992 (47 %) to 2001 (95 %).

During the same period, the total number of trucks in Germany grew by 40 %. With their powerful engines, trucks are responsible for a disproportionately large share of all motor-vehicle emissions. The numbers of motorbikes and motorcycles also increased considerably from 1991 to 2001 (+35 %).

II.7.3 Forecast for the transport sector

Three scenarios for transport-sector trends have been compared within the context of the Federal Traffic Infrastructure Plan (Bundesverkehrswegeplanung - BVWP). These scenarios reflect different transport-policy assumptions (Federal Ministry of Transport, Building and Housing (BMVBW): "Integrated transport policy: our concept for a mobile future" – Transport Report 2000). Trends in total transport mileage and in the modal split are shown in Tables II.7.3.1 and II.7.3.2.

Tab. II.7.3.1 Transport mileage and modal split in passenger transports (comparison between 1997 and 2015)

	1997		"Laisser-faire"		"Integration"		"Restrictive"	
	billions of p-km	share	billions of p-km	share	billions of p-km	share	billions of p-km	share
Road	750	79.6 %	915	79.2 %	873	77.3 %	768	72.8 %
Rail	74	7.8 %	87	7.5 %	98	8.7 %	123	11.7 %
Public transportation*)	83	8.8 %	76	6.6 %	86	7.6 %	93	8.8 %
Air	36	3.8 %	78	6.7 %	73	6.5 %	71	6.7 %
Total	943	100 %	1156	100 %	1130	100 %	1055	100 %

*) Public transportation includes municipal railways, subways, tramways and bus transportation operated by municipal, mixed-form or private companies.

Tab. II.7.3.2 Transport mileage and modal split in goods transports (comparison between 1997 and 2015)

	1997		"Laisser-faire"		"Integration"		"Restrictive"	
	billions of t-km	share	billions of t-km	share	billions of t-km	share	billions of t-km	share
Road	236	63.6 %	422	69.5 %	374	61.5 %	353	58.1 %
Rail	73	19.6 %	99	16.3 %	148	24.3 %	169	27.8 %
Waterways	62	16.8 %	87	14.3 %	86	14.1 %	86	14.1 %
Total	371	100 %	608	100 %	608	100 %	608	100 %

Total goods transports are expected to reach a level of 608 billion tkm (not including local transports, pipelines and air transports) by 2015, a level that will represent 64 % growth between 1997 and 2015. The key factors driving this growth include the European Single Market, the opening-up of eastern European markets and increasing division of labour in production. If no transport-policy measures are taken to change the 1997/1998 status quo, road transports' percentage share of all goods transports will grow by about six percentage points by 2015. At the same time, railways' share of the modal split will decrease by over three percentage points. Measures under the "integration scenario", which is to provide the basis for further revision of the Federal Traffic Infrastructure Plan, along with elimination of current and expected bottlenecks in the railway network, would increase railways' share – compared not only to the trend but also to the current actual situation.

Total volumes and mileage in passenger transports are also expected to grow until 2015. At nearly 20 %, this growth will be considerably less than that in goods transports, however. Growth in this sector will be driven primarily by disproportionately increasing recreational and holiday traffic. As in the past few years, much of the growth will occur in the areas of private automobile transports and air transports. Private automobile transports will about maintain their large share of all transports, while air transports' share of the modal split will increase to 6.5 %.

II.8 Housing

Average residence size (in terms of floor space), and average per-capita living space, increased further over their levels in 1990 and 1994 (Tab. III.8.1). These increases represent a continuation of trends described in the last national report: the numbers of single-person households are increasing, the average number of children per household is decreasing, the divorce rate is increasing, children are moving out of their parents' homes at younger and younger average ages and the difference between the average life expectancies of men and women is growing.

Tab. II.8.1 Housing in Germany

	1990	**1994**	**1998**
Living space in m^2			
- per residence	81.9	83.5	84.0
- per resident	34.8	36.0	38.4
Number of rooms			
- per residence	4.3	4.4	4.4
- per resident	1.8	1.9	2.0
Residences with (in %):			
- 1 room	2.2	2.3	2.2
- 2 rooms	6.5	6.5	6.2
- 3 rooms	22.3	22.3	22.1
- 4 rooms	30.9	30.7	30.3
- 5 rooms	18.9	19.0	19.2
- 6 and more rooms	19.2	19.3	20.0

Source: 2000 Statistical Yearbook

Table II.8.2 shows total amounts of living space, in various building types, in 1997. As the table indicates, over 75 % of all living space is found in buildings that are over 20 years old.

Tab. II.8.2 Total amounts of living space, by building types, at the end of 1997

	millions of m^2	**%**
One-/two-family homes	1790.2	56.5
Multi-family homes	1315.0	41.5
Non-residential buildings	62.8	2.0
Total, by year built:		
before 1918	556.4	17.6
1919-1948	368.5	11.6
1949-1968	903.1	28.5
1969-1978	565.6	17.9
1979-1987	341.2	10.8
1988-1991	143.8	4.5
1992-1995	185.6	5.9
1996-1997	103.7	3.3
Total	**3167.9**	**100.0**

Source: Prognos 1999

A key part of any assessment of future heating requirements for buildings is to analyse and extrapolate statistics for types of heating systems found in existing buildings and residences. Over 75 % of all existing buildings are now heated with either natural gas or heating oil. The corresponding percentage for new buildings is even higher – over 90 %. Development of overall heating-system structures will be affected most strongly by trends for existing buildings, since numbers of replacements of old heating systems in the next few years will far outstrip numbers of heating systems added through construction of new buildings. The predominance of systems fired with heating oil and gas will remain largely unchanged in the future, since homeowners tend not to change fuels when they replace old central heating systems. By avoiding fuel changes, homeowners can normally continue using installed building systems and facilities, such as oil tanks and heat-distribution networks, or can modernise such systems at relatively low expense. Homeowners tend to change fuels only when they can save significantly by doing so.

Table II.8.3 shows the expected development in the overall heating-system structure for residential buildings.

Tab. II.8.3 Current situation (1997) and expected future development in the overall heating-system structure for residential buildings, expressed as percentage of living space for the various types of heating systems

	1997	**2005**	**2010**	**2015**	**2020**
Oil	34.2	32.5	31.5	30.6	29.8
Gas	41.2	46.6	48.9	50.6	51.8
District heat	12.2	12.0	11.7	11.3	11.0
Electricity	6.2	5.7	5.6	5.6	5.8
Coal	4.8	2.0	1.2	0.8	0.6
Other	1.4	1.2	1.1	1.0	1.0
Total	**100**	**100**	**100**	**100**	**100**

Source: Prognos 1999

II.9 Waste management

II.9.1 Amounts of waste

In 1998, some 45 million tonnes of municipal waste were produced in Germany. Municipal waste includes household waste, commercial waste that is similar to household waste and bulky waste. Table II.9.1.1 provides an overview of municipal waste production and waste composition. Of the some 45 million tonnes of municipal waste produced, about 23.7 million tonnes were disposed of, while the remaining amount was recycled. Of the 23.7 million tonnes of waste that were disposed, a total of 9.6 million tonnes were incinerated, and about 14.1 million tonnes were stored in landfills.

In 1997, the following amounts of waste other than municipal waste were produced: about 62 million tonnes of waste from manufacturing, about 58 million tonnes of excavated material from mining and about 222 million tonnes of building rubble, excavated soil, road-surface rubble and construction-site waste (Federal Statistical Office, internal memorandum to the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)).

Tab. II.9.1.1 Municipal waste in 1996 and 1997

Waste type	**Waste production** (in thousands of tonnes)		
Year	**1996**	**1997**	**1998**
Total	**44 390**	**45 758**	**44 995**
of this:			
Household waste; commercial waste similar to household waste, and collected via public waste collection	19 953	18 495	17 188
Commercial waste similar to household waste, but not collected via public waste collection (not including household waste and bulky waste)	5 238	5 307	5 194
Bulky waste	3 003	3 175	3 195
Road sweepings (including waste from public trash bins) and market waste	876	869	742
Garden and park waste (including cemetary waste)	3 069	3 268	3 168
Compostable waste from household receptacles for such waste ("Biotonnen")	2 413	2 936	3 321
Other waste separately collected (glass, paper, plastics, electronic parts)	9 838	11 708	12 187

Source: Federal Statistical Office 2002 (www.destatis.de/basis/d/umw/umwtab1.htm)

II.9.2 Laws

The basic law governing waste management is the Closed Substance Cycle and Waste Management Act (Kreislaufwirtschafts- und Abfallgesetz – KrW-/AbfG) of 7 October 1996. A number of ordinances have been enacted to specify how this Act is to be executed (cf. Chap. IV.2.7). In addition, the Federal Länder have their own Länder laws on waste.

II.9.3 Thermal treatment

Germany has a total of 61 incineration facilities for municipal waste, with a total capacity of 14 million tonnes ("thermal, mechanical-biological treatment facilities and landfills for left-over municipal waste in the Federal Republic of Germany", Federal Environmental Agency (UBA), Series (Fg.) III.3.3, 5th edition, 01/2001). In some 10 to 15 facilities, municipal sewage sludge is managed together with left-over (i.e. not recycled) municipal waste. The capacities of the relevant facilities range between 16 000 t/a and 750 000 t/a, and the individual incineration units involved can process waste at rates varying from 3-40 t/h. Development of the total number of incineration facilities for municipal waste is shown in Table II.9.3.1.

Tab. II.9.3.1 Germany's incineration facilities for municipal waste, and their capacities

Year	Number of facilities	Total waste throughput (in 1000 t/a)	Average throughput per facility (in 1000 t/a)
1965	7	718	103
1970	24	2,829	118
1975	33	4,582	139
1980	42	6,343	151
1985	46	7,877	171
1990	48	9,200	191
1992	50	9,500	190
1993	49	9,420	192
1995	52	10,870	202
1998	53	11,900	225
2000	61	13,999	230
2005*	75	17,600	234

Source: Federal Environmental Agency (UBA) 01/ 2001
*including planned facilities and facilities at an advanced stage of planning

Germany also has a total of 30 incineration facilities for hazardous waste, with total capacity of about 1 million t/a. Waste is also used for energy generation (such as old tyres, sewage sludge) in co-incineration facilities (in plants such as power stations, cement plants).

All waste-incineration facilities must comply with the 17th Ordinance on Execution of the Federal Immission Control Act (Ordinance on incineration facilities for waste and similar combustible materials), which establishes strict standards for emissions into the air. For this reason, waste-incineration facilities are equipped with highly effective flue-gas scrubbing systems. Most of the facilities produce no wastewater.

All waste-incineration facilities in Germany use the energy released from incinerated waste. Most facilities generate both electricity and heat or provide their generated steam to power stations or industrial companies. The amount of electric power they produce represents about 0.7 percent of Germany's gross electricity generation.

II.9.4 Mechanical-biological treatment

Germany currently has 29 facilities for mechanical and biological treatment of waste. New facilities must comply with the strict provisions, especially emissions standards, set forth by the 30th Ordinance on Execution of the Federal Immission Control Act (Ordinance on facilities for biological treatment of waste), which has been in force since 1 March 2001.

II.9.5 Waste storage in landfills

Over half of all left-over (unrecycled) municipal waste produced in Germany is stored in landfills.

Germany currently has a total of over 300 landfills for municipal waste. This figure is expected to decrease over time. Not all of the country's landfills are in keeping with criteria for best available technology (state of the art). Table II.9.5.1 provides an overview of changes in the number of landfills. Germany also has 14 above-ground landfills and 3 subterranean landfills for storage of waste requiring special supervision.

As of 2005, under regulations designed to prevent harmful emissions (landfill gas; contaminated leachage) from landfills, only pre-treated municipal waste may be placed in landfills. In addition, waste-treatment techniques are to be refined in such a manner that as of 2020 all municipal waste is completely recycled and landfill storage is no longer required for any such waste. Storage would then be required only (if at all) for filter dusts and other polluted residues.

Tab. II.9.5.1 Numbers of household-waste landfills operated in Germany, 1990 to 1999

	1990	**1991**	**1993**	**1995**	**1999**
New Länder	7 983	1 590	292	202	137
Old Länder	290	NE	270	270	239
Germany (Total)	**8 273**	**NE**	**562**	**472**	**376**

Federal Environmental Agency, 1999

III Inventories of anthropogenic emissions of greenhouse gases

The following section presents an overview of data for the directly acting greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (laughing gas, N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). While ozone is also an important greenhouse gas, it is not emitted as such; instead, it is formed from precursors via photochemical reactions in the atmosphere. For this reason, emissions of the precursors nitrogen oxides (NOx), carbon monoxide (CO) and non-methane volatile organic compounds (NMVOC) have been included in the data as emissions of indirectly acting greenhouse gases.

Data is also presented on emissions of sulphur dioxide (SO_2), which forms aerosols.

III.1 Presentation, determination and structure of emissions data

The emissions data is presented in annual summary tables, as prescribed by the UNFCCC reporting guidelines[3] (summary tables 1A and as CO_2 equivalents in summary table 2). In addition, to highlight emissions trends, substance-specific trend tables are also presented for Germany, for the years 1990 to 1999/2000. As an additional aid for the reader, the trends are also presented in graphic form.
The emissions data for years since 1996 is somewhat provisional, since no comprehensive reference data (energy balances, in particular) is yet available for these years.

III.2 Accuracy of emissions data

Some of the emissions data is subject to considerable uncertainty. To some extent, this may well be due to a lack of data relative to certain emissions-producing processes. Another, more significant reason, however, is that the emissions contributions of individual relevant activities are poorly understood. This shortcoming affects the socio-economic reference data as well as the emissions factors.

With the exception of the CO_2 data, the emissions factors are based largely on measurements made under defined conditions, although the numbers of such measurements, in many cases, must be considered inadequate. This problem exists especially in the area of non-energy-related emissions.

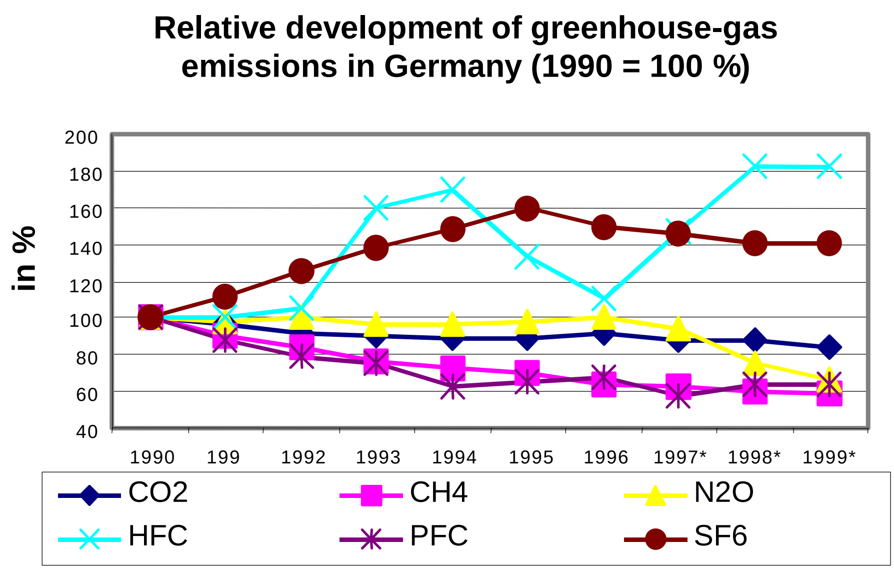
In general, data for combustion-related emissions is significantly more reliable than that for emissions from other processes, some of which begin with extremely complex initial processes. A qualitative assessment of the accuracies of emissions calculations is provided in the Annex, in the Summary 3 and Table 7 compilations. The data for years after 1996, because of its provisional quality, is likely to be less accurate than other data.

[3] See document FCCC/CP/1999/7

III.3 Emissions of greenhouse gases

The Tables in the Annex show emissions of greenhouse gases – broken down by source groups – for the years 1990 to 1999. They also show carbon storage in forests, although this was not included in the overall emissions balance. In addition, they show emissions trends for the individual relevant components.

Fig. III.3.1 Development of GHG emissions in Germany



The following table presents a compilation of total emissions of various relevant components and substance groups, for the years 1990 to 2000.

The figure shows the relevant emissions trends with respect to the year 1990. In the period under consideration, considerable reductions were achieved in emissions of important (in terms of amounts) directly acting greenhouse gases.

Tab. III.3.2 GHG and SO_2 in Germany

Table 1: Emissions of Greenhouse gases and SO2 in Germany 1990 - 2000

Figures in Gg (HFC, CF4, C2F6 and SF6 in Mg)

	1990	1991	1992	1993	1994	1995	1996 *	1997 *	1998 *	1999 *	2000 *
Directly acting greenhouse gases											
CO_2	1.014.500	975.951	928.307	918.268	904.111	903.665	923.085	892.649	885.963	859.246	857.908
CH_4	5.273	4.743	4.400	4.017	3.772	3.616	3.285	3.208	3.107	3.041	2.885
N_2O	286	272	277	265	256	259	265	250	206	194	194
HFC	200	200	302	1.665	1.942	2.135	2.435	2.901	3.284	4.200	5.000
CF_4	355	308	278	260	214	224	221	171	186	186	186
C_2F_6	42	38	36	35	31	32	39	42	46	46	46
C_3F_8	0	0	0	0	0	2	5	8	11	11	11
SF_6	163	182	204	226	242	261	243	238	229	148	144
CO_2-equivalent emission	1.222.765	1.169.013	1.116.027	1.095.819	1.074.128	1.071.177	1.084.343	1.048.155	1.026.475	993.819	991.421
Iindirectly acting greenhouse gases											
NOx (as NO_2)	2.729	2.514	2.323	2.208	2.055	1.984	1.897	1.800	1.724	1.676	1.600
NMVOC	3.221	2.796	2.539	2.326	2.158	2.020	1.892	1.823	1.739	1.675	1.602
CO	11.213	9.515	8.351	7.704	7.065	6.532	6.109	5.955	5.424	5.143	4.768
aerosol precursor											
SO_2	5.321	3.996	3.307	2.945	2.473	1.939	1.340	1.087	874	804	795

* preliminary data

Pursuant to Art. 3 VIII of the Kyoto Protocol, the parties may choose either 1990 or 1995 as their base year for commitments to reduce emissions of the three fluorated greenhouse gases HFC, FC and SF_6. Germany has not yet made its final decision regarding its choice of base year for the so-called "F gases". Selection of 1995 as the year would mean that emissions in the base year would actually be virtual (directly acting greenhouse gases in 1990 and indirectly acting gases in 1995). With respect to this base year, Germany's emissions of nearly all directly acting and indirectly acting greenhouse gases considered here have been considerably reduced (see the following overview). A contrasting picture is seen for trends in emissions of HFC and C_3F_8. As a result of growing use of HFCs as substitutes for fully and partly halogenated chloroflurocarbons, which deplete the earth's ozone layer and also have a greenhouse impact, HFC emissions more than quadrupled between 1995 and 1999.

Relative emissions trends (in %) in Germany for 2000, with regard to a mixed base year, 1990/95, are shown in the following table.

Tab. III.3.3 Emissions trends in Germany since 1990

Table 2			**Emission Trends in Germany since 1990**						(% change in relation to the base year)				
				1991	1992	1993	1994	1995	1996 *	1997 *	1998 *	1999 *	2000 *
Directly acting greenhouse gases	base year	absolute	%	+/- %	+/- %	+/- %	+/- %	+/- %	+/- %	+/- %	+/- %	+/- %	+/- %
CO_2	1990	1.014.500	100,0	-3,8	-8,5	-9,5	-10,9	-10,9	-9,0	-12,0	-12,7	-15,3	-15,4
CH_4	1990	5.273	100,0	-10,1	-16,6	-23,8	-28,5	-31,4	-37,7	-39,2	-41,1	-42,3	-45,3
N_2O	1990	286	100,0	-4,7	-3,1	-7,4	-10,4	-9,2	-7,4	-12,6	-28,0	-32,0	-32,2
HFC	1995	2.135	100,0					0,0	14,1	35,9	53,8	96,7	134,2
CF_4	1995	224	100,0					0,0	-1,3	-23,7	-17,0	-17,0	-17,0
C_2F_6	1995	32	100,0					0,0	21,9	31,3	43,8	43,8	43,8
C_3F_8	1995	2	100,0					0,0	150,0	300,0	450,0	450,0	450,0
SF_6	1995	261	100,0					0,0	-6,9	-8,8	-12,3	-43,3	-44,8
CO_2-equivalent emission		1.224.976	100,0	-4,6	-8,9	-10,5	-12,3	-12,6	-11,5	-14,4	-16,2	-18,9	-19,1
Indirectly acting greenhouse gases													
NOx (as NO_2)		2.729	100,0	-7,9	-14,9	-19,1	-24,7	-27,3	-30,5	-34,0	-36,8	-38,6	-41,4
NMVOC		3.221	100,0	-13,2	-21,2	-27,8	-33,0	-37,3	-41,3	-43,4	-46,0	-48,0	-50,2
CO		11.213	100,0	-15,1	-25,5	-31,3	-37,0	-41,7	-45,5	-46,9	-51,6	-54,1	-57,5
aerosol precursor													
SO_2		5.321	100,0	-24,9	-37,9	-44,7	-53,5	-63,6	-74,8	-79,6	-83,6	-84,9	-85,1

* preliminary data

The following compilation shows emissions data converted to equivalent emissions in order to highlight the main emissions sources. As this compilation shows, CO_2 is the predominant component, and the vast majority of emissions are caused by energy-related processes (stationary and mobile combustion, fuel transports and distribution).

Tab. III.3.4 Greenhouse-gas emissions in CO_2-equivalents, 1990 - 2000

GREENHOUSE GAS EMISSIONS	Base year[(1)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	CO2 equivalent (Gg)											
Net CO_2 emissions/removals	980781	980781	942232	894588	884549	870392	870235	889655	859219	852533	825816	841082
CO_2 emissions (without LUCF) [(6)]	1014500	1014500	975951	928307	918268	904111	903665	923085	892649	885963	859246	857908
CH_4	110741	110741	99606	92401	84365	79208	75934	68994	67359	65243	63868	60583
N_2O	88593	88593	84415	85835	82023	79369	80445	82047	77455	63808	60209	60080
HFCs	3130	2340	2340	2470	3750	3980	3130	2580	3450	4278	5250	7700
PFCs	1764	2694	2352	2138	2012	1676	1764	1830	1554	1709	1709	1709
SF_6	6238	3896	4350	4876	5401	5784	6238	5808	5688	5473	3537	3442
Total (with net CO_2 emissions/removals)	**1191248**	**1189046**	**1135294**	**1082308**	**1062100**	**1040409**	**1037747**	**1050913**	**1014725**	**993045**	**960389**	**974595**
Total (without CO_2 from LUCF) [(6)]	**1224967**	**1222765**	**1169013**	**1116027**	**1095819**	**1074128**	**1071177**	**1084343**	**1048155**	**1026475**	**993819**	**991421**

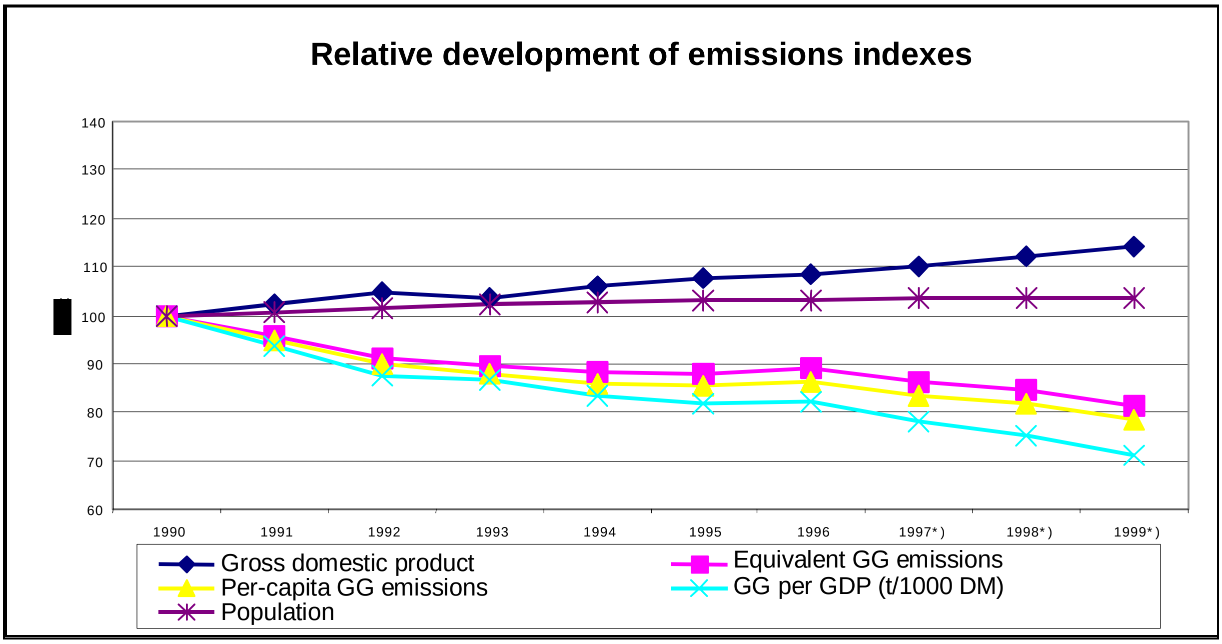
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	Base year[(1)]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
	CO2 equivalent (Gg)											
1. Energy	1035481	1035481	997241	948246	936060	917251	915580	935140	902733	893989	865432	861055
2. Industrial Processes	64225	62018	59586	63703	62465	63504	62965	61754	58817	46379	41658	44089
3. Other Product Use	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860	1860
4. Agriculture	82398	82398	73492	70466	68657	66880	67927	67731	66831	66333	66955	66503
5. Land-Use Change and Forestry [(7)]	-33719	-33719	-33719	-33719	-33719	-33719	-33430	-33430	-33430	-33430	-33430	-16826
6. Waste	41008	41008	36835	31753	26776	24634	22849	17872	17914	17914	17914	17914
7. Other	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE

For example, in 2000 about 87% of all greenhouse-gas emissions were CO_2, 7% were CH_4, over 4% were N_2O and slightly over 1% were so-called "F gases". The relevant sectoral breakdown shows that 88% were caused by energy-related processes, 4% were caused by industrial processes, 6% were caused by agriculture and 2% were caused by the waste-management sector. Solvents and other product use made only negligible contributions to total greenhouse-gas emissions.

III.3.1 Individual emissions trends

As the following figure shows, from 1990 to 1999 economic growth (14.3%) and population growth (+3.5 %) were clearly separate from trends in greenhouse-gas emissions (-18.6 %). This progress is even more pronounced when seen in terms of development of "per-capita emissions" (-21.4 %) and emissions changes with respect to economic growth (-28.8 %).

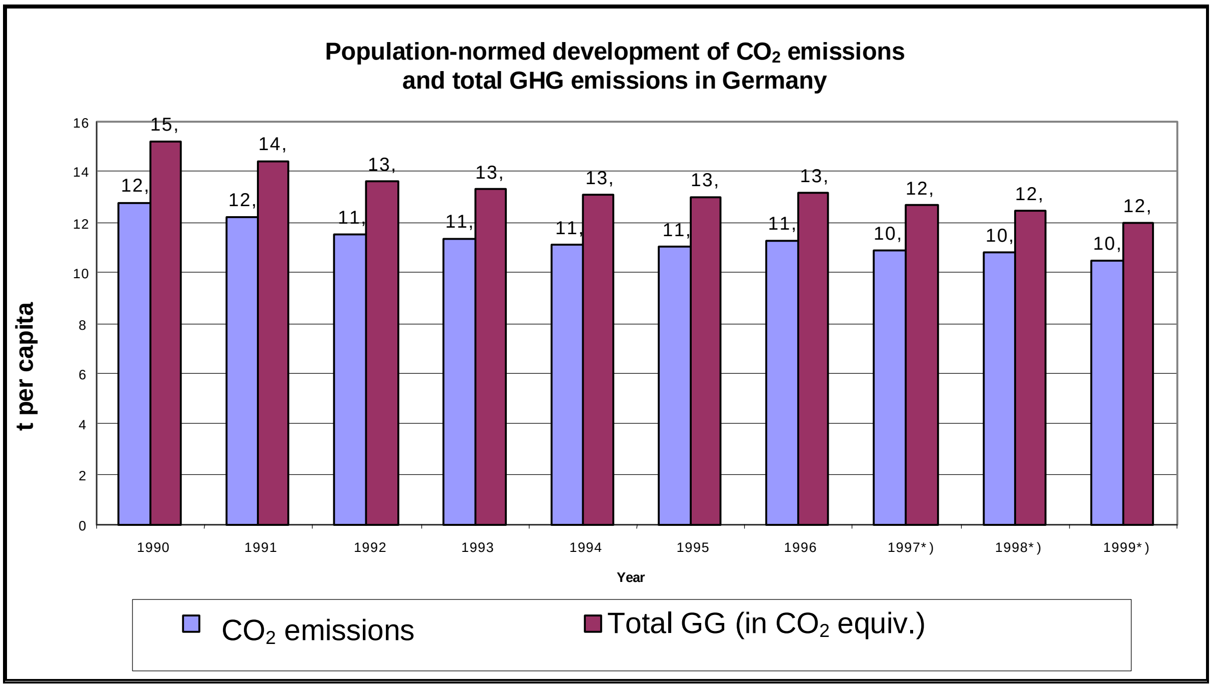
Fig. III.3.1.1 Relative development of emissions indexes



Since annual inventories and substance-based emissions trends are shown in detail in the Annex, in the following figures such data for individual greenhouse gases is graphed simply as development of "per-capita emissions".

The emissions reductions of recent years are due primarily to economic restructuring and to reduced use of lignite, especially in eastern Germany. CO_2 emissions were reduced in all source groups, with the exception of the transport sector.

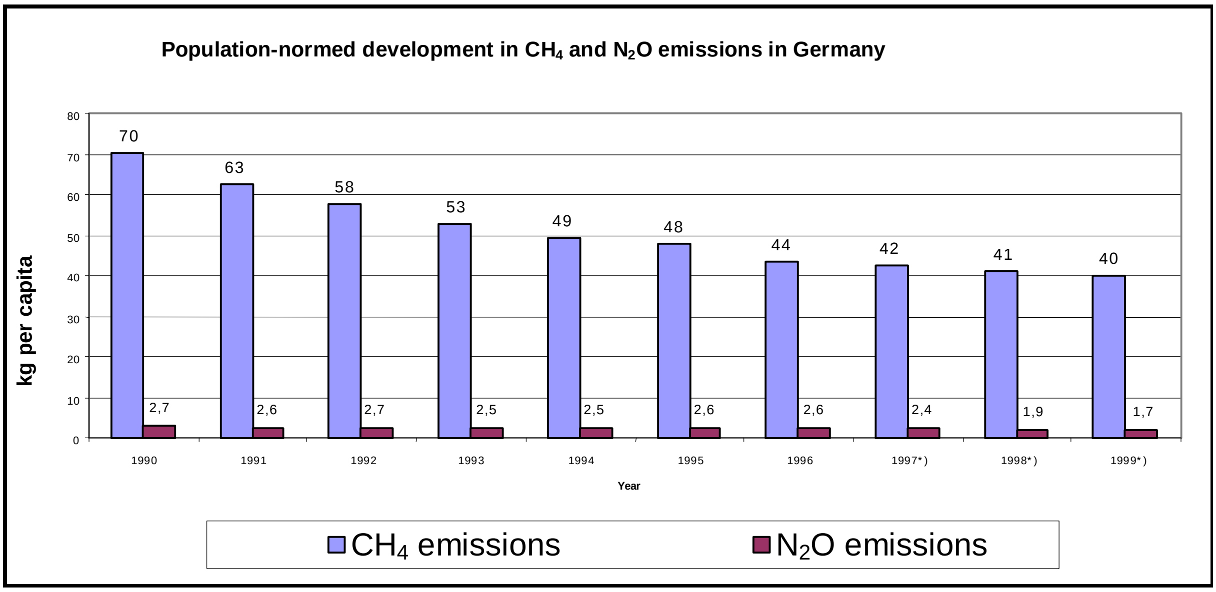
Fig. III.3.1.2 Population-normed CO_2 and GHG emissions in Germany



Between 1990 and 1999, emissions of methane were reduced by about 2.3 million t. This represents a per-capita reduction from over 70 kg to 40 kg. This reduction, amounting to over 40%, was achieved by lowering levels of coal production, reducing sizes of livestock herds and carrying out waste-management measures such as reducing landfill storage of untreated household waste (via intensified recycling of biological waste and increased thermal treatment of unrecycled waste) and intensified collection and use of landfill gas. Modernisation of gas-distribution networks and conversions from liquid to gas fuels, in smaller combustion systems, also contributed to emissions reductions.

Emissions of nitrous oxide in 1999 were about 34 % below their level in 1990. This represents a "per-capita emissions" reduction from a level of 2.7 kg to one of 1.7 kg. These reductions were achieved even though emissions reductions in agriculture (shrinkage of livestock herds) were counterbalanced by growth in emissions from road transports. As at 1997, technologically based reductions in the area of adipic acid production brought about major reductions of total emissions.

Fig. III.3.1.3 Population-normed CH_4 and N_2O emissions in Germany



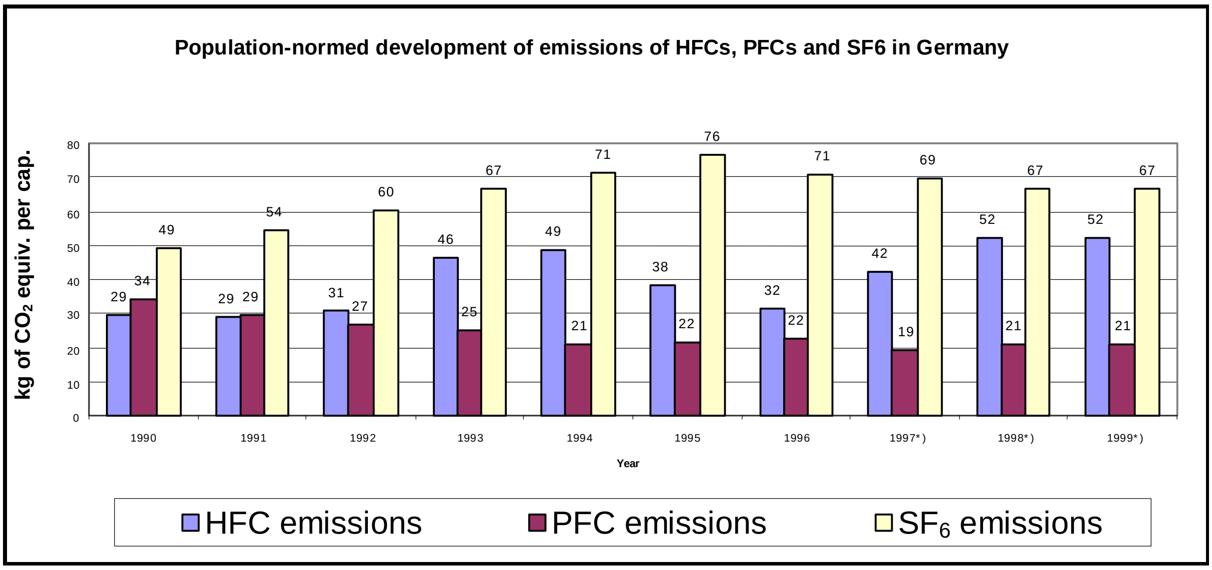
A number of different trends emerged in emissions of so-called "F gases" between 1990 and 1999.

As a result of increased use of HFCs as substitutes for CFCs, HFC emissions during this period grew by about 80 %, to a "per-capita-emissions" level of about 52 kg. Growth since the base year, 1995, has been about 40 %.

SF_6 emissions increased from 49 kg to 67 kg per capita. On the other hand, emissions have decreased by over 12 % since 1995, as result of reductions measures.

In the area of PFC compounds, emissions have been considerably reduced since 1990: they dropped from 34 kg per capita to 21 kg per capita. This reduction of over 35 % has been brought about mainly through reduction of CF_4 emissions in the aluminium industry.

Fig. III.3.1.4 Population-normed emissions of HFCs, PFCs and SF_6 in Germany



III.4 Emissions of fluorated gases

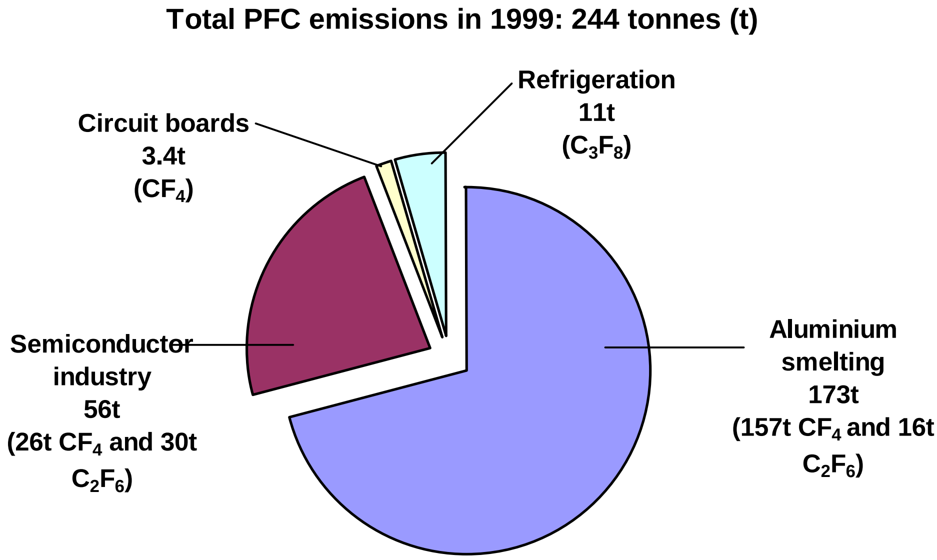
III.4.1 Perfluorocarbons (PFCs)

As in 1995, aluminium smelting is the largest source of CF_4 emissions. On the other hand, its share of total CF_4 emissions dropped from 95% to about 85% between 1995 and 1999. The remaining 5% and 15%, respectively, are generated by use of these substances in plasma etching in the electronics industry. Until 1994, CF_4 was also emitted as a by-product of CFC production. C_2F_6 represents a second important group of PFCs. A total of about 35% of emissions of this substance originate in aluminium smelting, and about 65% result from its use as an etching gas in semiconductor production.

All in all, PFC emissions, including those resulting from use of C_3F_8 in refrigeration, decreased by 39% from 1990 to 1999. In 1999, a total of 244 t of PFCs, corresponding to 1.7 million t of CO_2 equivalents, were emitted. Of this amount, a total of 186 t was in the form of CF_4 and 45.8 t was C_2F_6.

Further reductions in PFC emissions are expected to result from the primary aluminium industry's voluntary commitment to reduce these emissions (see the Table "Measures in the area of industry and commerce", Chapter IV.2.5). At the same time, a sharp increase in PFC emissions from the semiconductor industry is expected, although this increase can be reduced via suitable measures (see the Table "Measures in the area of industry and commerce", IV.2.5).

Fig. III.4.1.1 Sources of PFC emissions in Germany



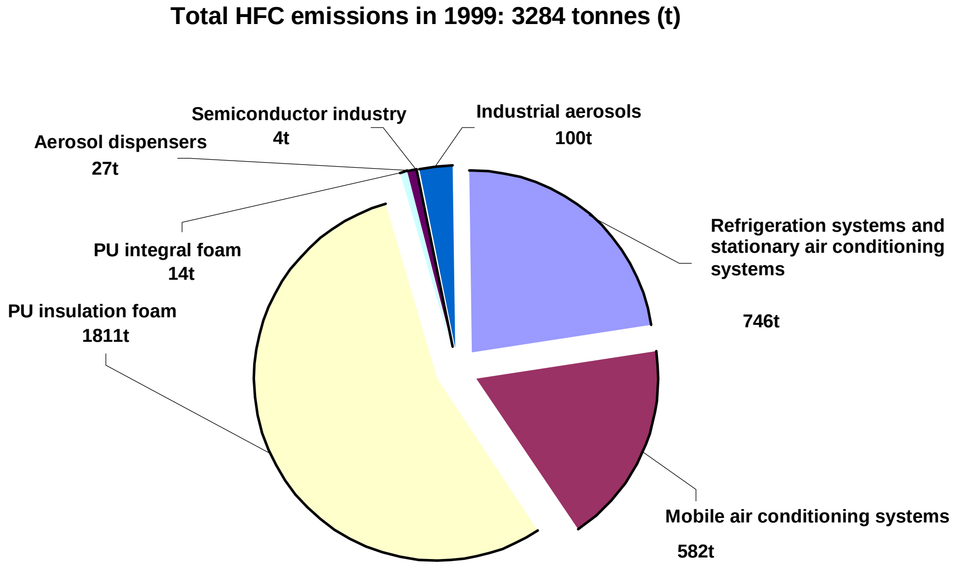
III.4.2 Hydrofluorocarbons (HFCs)

Since the early 1990s, use of hydrofluorocarbons as substitutes for fully or partly halogenated chlorofluorocarbons (CFCs or HCFCs), which deplete the ozone layer and contribute to the greenhouse effect, has been increasing. Currently, the main sources of HFC emissions are polyurethane (PU) insulation foam sprays (55%) and refrigeration and air conditioning systems (20%). A number of relevant compounds and mixtures of compounds are used in refrigeration and air conditioning systems. In contrast to the situation in other sectors, large amounts of HFCs are bunkered in refrigeration and air conditioning systems. In 1997, consumption of HFCs alone amounted to about 4500 t. The most important propellant for PU insulation foam sprays is HFC-134a (CH_2FCF_3); increasingly, HFC-152a ($C_2H_4F_2$) is also being used. Other emissions sources include PU foams (CH_2FCF_3), medical aerosol dispensers (CH_2FCF_3), industrial refrigeration and compressed-air sprays (CH_2FCF_3) and semiconductor production (CHF_3). HFC-23 (CHF_3), a by-product of HFC-22 (CF_2HCl) production, has not been emitted since 1996.

Since 1998, XPS insulation plates must also be considered an HFC emissions source (CH_2FCF_3 and $C_2H_4F_2$). Until that year, XPS insulation materials were foamed with HCFCs, which served as substitutes for CFCs. As discontinuation of use of ozone-depleting substances progresses, some manufacturers are now using HFCs.

Disproportionately large growth in HFC emissions has been expected as a result of discontinuation of use of CFCs and HCFCs. Between 1990 and 1999, emissions were determined to have increased by a factor of about 16. In 1999, some 3,284t of HFCs, corresponding to 4.3 million t of CO_2 equivalents, were emitted.

Fig. III.4.2.1 Sources of HFC emissions in Germany



Database: Schwarz, W., Leisewitz, A.: Emissionen und Minderungspotential von H-FKW, FKW und SF_6 in Deutschland.

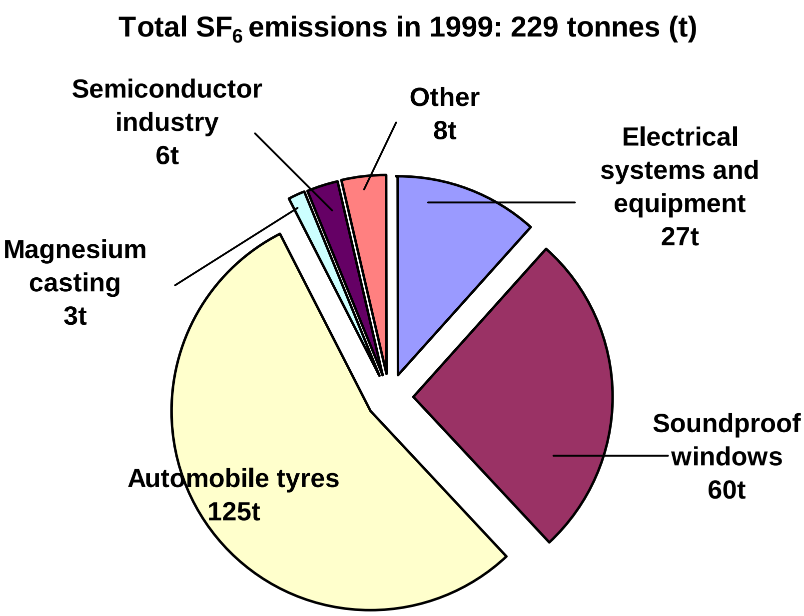
III.4.3 Sulphur hexafluoride (SF_6)

Currently, automobile tyres filled with SF_6 are the largest source of emissions of SF_6 (55%). Some 26% of total emissions are released from soundproof windows, which are filled with SF_6 because it slightly improves soundproofing performance. In spite of the large amounts of SF_6 used in the electrical power sector (currently about 350 - 400 t/ a), electrical systems contribute only about 12% to total emissions. This has to do with the low rates of leakage from systems and the small amounts of emissions generated through maintenance (see Table "Measures in the area of industry and commerce", Chapter IV.2.5). On the other hand, very large amounts are bunkered in this sector (currently about 1300 t). Marginal amounts of emissions were produced through use of SF_6 as a protective gas in magnesium casting, through its use as an etching gas in semiconductor manufacturing and through its use in other areas.

Due to a drastic reduction of emissions from the area of soundproof windows – due, in part, to setting of priorities on thermal insulation – emissions trends, which pointed sharply upward in the early 1990s, have reversed. This development has compensated to a certain extent for the disproportional increases in emissions from automobile tyres. Overall, however, SF_6 emissions increased by about 40 %, to 229 t, between 1990 and 1999.

Discontinuation of use of SF_6 for filling automobile tyres and windows, made possible through use of substitute fill gases and, in the latter case, by alternative window technologies (see Table "Measures in the area of industry and commerce", Chapter IV.2.5), can be expected to reduce SF_6 emissions from these sources.

Fig. III.4.3.1 Sources of SF_6 emissions in Germany



III.5 Inventory of carbon-dioxide storage in sinks – forests

The net sink resulting from forest management is determined from the difference between wood growth and the wood harvest. Wood growth, broken down for the main tree species, is determined on the basis of existing inventory data (Federal Forest Inventory (Bundeswaldinventur), 1986-1990, and Datenspeicher Waldfonds for the new Federal Länder) and of yield tables that reflect the different area shares for different types of tree species as well as the relevant age-class distributions. It does not include areas newly afforested since 1990.

Wood-harvest data is taken from logging statistics. Wood growth and wood harvest are converted into biomass figures, using specific conversion factors. The net sinks shown in the tables represent five-year-average values. This procedure ensures that data is properly adjusted in spite of any unusual maxima due to unusual circumstances, such as the major storm damage in February/March 1990.

No figures are available for land-use changes, since the data for this area is incomplete. It may be assumed that changes from forest to other types of uses are more than compensated for by initial afforestation, and that thus the total forest area is increasing. Furthermore, it may be assumed that logging statistics include at least part of the wood harvest resulting from conversion of forest. Separate listing under "conversion from forest" could thus lead to double counting.

Any overall assessment should also take account of amounts of carbon released from the soil – amounts which can be considerable for land converted from forest to farmland. No data is currently available that would permit any precise assessment of this overall effect. The Federal Government plans to determine how such statistics could be estimated or obtained in future. In order to clarify issues arising in the area of emissions determination, the Federal Government, in its resolution of 18 October 2000 on the "National climate-protection programme, 5th report of the CO_2-Reduction Interministerial Working Group", established a new Working Party 6, "Emissions Inventories", under the direction of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

IV Policies and measures

IV.1 General and political framework and greenhouse-gas reduction targets

The Federal Government was early in developing a comprehensive climate-protection strategy. The Federal Government's climate-protection programme includes measures for reducing emissions of CO_2 and other greenhouse gases such as CH_4, N_2O, HFCs, PFCs and SF_6, as well as measures for maintaining and expanding CO_2 storage in forests and wood products. The Federal Government's climate-protection programme is also being refined at regular intervals and implemented on an ongoing basis.

The 5th report on climate-protection strategy, which was published in October 2000, again emphasises that the Federal Government's national climate-protection policy is oriented to the following aims:

IV.1.1 Reduction of carbon-dioxide emissions

The Federal Government continues to uphold its aim of reducing CO_2 emissions by 25 %, by 2005, with respect to their level in 1990. The aim formulated for 2005 is an important intermediate step within the meaning of the "demonstrable progress" called for by the Kyoto Protocol.

IV.1.2 Reduction of emissions of so-called "Kyoto gases" (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6)

Within the framework of the burden-sharing agreed on in 1998 by the Member States of the European Union, the Federal Government has committed itself to reducing, during the period 2008 to 2012, emissions of the six so-called "Kyoto gases" (calculated as CO_2 equivalents pursuant to IPCC) by 21 % with respect to their levels in 1990/95. With this commitment, Germany is contributing very significantly to fulfillment of the European Union's commitment, as entered into in Kyoto, to reduce the European Union's greenhouse-gas emissions by a total of 8 %, with respect to the relevant level in 1990, during the first commitment period, 2008/ 2012.

Medium-to-long-term aims

National and international climate-protection policy must not end in 2005 or 2012. The Federal Government considers it absolutely necessary to give all players a long-term perspective – and, thus, a reliable framework for investment decisions. Both nationally and internationally, further drastic reductions of greenhouse-gas emissions will be required after the Kyoto 2008/2012 target zone. The Federal Government plans to discuss long-term aims with the relevant groups, and it expects other industrialised countries to commit themselves to similarly ambitious aims, so that the German economy does not suffer any disadvantage in international competition.

The Federal Government maintains that the industrialised countries' commitments, as set forth by the Kyoto Protocol for the first commitment period, 2008 – 2012, will have to be significantly expanded in subsequent commitment periods, and that developing countries (non-Annex B countries), in addition to the industrialised countries (Annex B countries), will have to assume reduction commitments. Within this framework, the Federal Government also plans to continue developing – ambitiously – the commitments it has made to date.

IV.2 Measures and instruments for climate protection since 1990

Since 1990, the Federal Government has been implementing a comprehensive and co-ordinated package of measures within the framework of its climate-protection strategy. This package comprises a broad spectrum of regulatory provisions, economic instruments and supporting measures (such as research, training and education, provision of information and advising).

The following sections describe the measures that the Federal Government has taken, or will take, in order to achieve its greenhouse-gas-reduction targets. The measures are arranged in accordance with the following sectors: energy, transport, industry, private households, agriculture, waste-management and intersectoral measures.

This section does not include measures to reduce emissions of gases regulated by the Montreal Protocol.

The section also describes additional specific measures of the Federal Länder and of municipalities in order to reduce emissions of CO_2 and other greenhouse gases.

The abbreviations in the tables have the following meanings:

Type of measure:

E Economic instrument

R Regulation, law, guideline

V Voluntary agreement

I Information

ET Education and training

D Research and development

The following is important to note with regard to the column "expected effect":

The "expected effect" refers to the forecast reductions in millions of tonnes of CO_2 equivalents pursuant to IPCC, with respect to the relevant forecast year. The forecast years selected are 2005 and 2008/2012, which are important for Germany.

In assessing the effects, it must be remembered that political action normally consists not of structural changes – for example, "expansion of heat/power cogeneration" – but of measures to promote such changes. Such measures create extremely demanding requirements in the area of effects analysis, since the reactions of the parties directly affected, and the secondary effects of such reactions, are very difficult to predict. The less that political instruments restrict the relevant freedoms of the concerned parties, the more difficult it is to predict the effects of such measures. An added difficulty is that political instruments often function in combination, with the result that effects of individual instruments cannot be precisely stated. Finally, numerous measures (information, advising, even certain regulatiory measures) are qualitative in nature.

The effects analysis integrates purely qualitative information, individual predictions of experts and integrated model analyses. Qualitative estimates are unavoidable especially when measures cannot be sufficiently well quantified, when little empirical data is available regarding the paths by which measures function or when significant interactions occur that preclude clear allocation of effects. Quantitative assessments by experts take account of primary effects (effects on parties directly concerned), secondary effects (influences, "wake" effects, etc.), assessments of catalysed technical measures (for example, construction of facilities), calculations of impacts on the energy sector (for example, substitution effects) and calculations of impacts on emissions. Integrated global analyses must be carried out to illuminate interdependencies between measures and developments within the energy system.

IV.2.1 Intersectoral measures

The following section lists measures that cannot be assigned to specific sectors, since they function intersectorally.

The Ecological Tax Reform is part of the Federal Government's climate-protection policy. Applicable relevant laws call for energy prices to increase, in a total of five phases, from 1999 to 2003. The basic concept calls for energy to become more expensive, through taxation, and for "work" to become less expensive. In particular, ecologically oriented trends are to be encouraged by providing incentives for energy efficiency, for use of advanced technologies and, thus, for avoidance of greenhouse-gas emissions. The Federal Government plans to review the possibility of exempting renewable energies from taxation and of enhancing the ecological precision of the Ecological Tax Reform.

The Federal Government considers contracting and operator models to be an important, yet still insufficiently used, way of optimising energy use in the industrial, residential and institutional areas. In the main, it is up to the commercial sector to introduce such financing and operator concepts to the market. Nonetheless, the Federal Government plans to review options for supporting current developments in this area.

In order to provide a clear signal, the Federal Government has committed itself to reducing CO_2 emissions in its sphere of responsibility by 25 % by 2005 and by 30 % by 2010, with respect to their 1990 level. As part of this commitment, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has made a commitment to reduce its own energy-related CO_2 emissions by 30 % by 2005 (base year 1990). The BMU has been commissioned to develop a coordinated concept that government ministries can use as a guide in reaching relevant targets, under their own responsibility in each case. The concept is expected to emphasise measures involving little or no cost. One relevant example consists of "fuel-saving training" events for motorists – events in which motorists learn effective techniques, especially changes in driving habits, that can very quickly reduce fuel consumption and generate significant savings. It is being left up to the ministries themselves to select measures for achieving the main aims within their own spheres of responsibility.

Name	Description / aim	GHG	Type	Implementation status	Institution carrying out measure	Expected effect in millions of t of CO_2 equivalents	
Intersectoral measures						2005	2008 to 2012
Ecological Tax Reform	Integration of ecological steering mechanisms within the tax system Aim: to change production and consumption patterns that have negative ecological effects	**CO_2**	R	In force; several phases through 2003	Federal Government	-10	-20
Promotion of contracting	Support for development of financing and operator concepts Aim: to enhance energy efficiency	**CO_2**	D	Review	Federal Government; commercial sector	NE	NE
Voluntary commitment by the Federal Government	In order to provide a clear signal for the public, the Federal Government plans to reduce CO_2 emissions, within its sphere of responsibility, by 25% by 2005 and by 30% by 2010. Aim: to enhance energy efficiency in buildings and structures, in equipment and devices and in transports	**CO_2**	V	Resolution of the Federal Government	Federal Government	NE	NE

IV.2.2. Measures in the energy sector

Germany's energy supply

A suitable energy supply represents a key basis for prosperity – and, thus, for a high standard of living. Whether in production processes, in the transport sector in or in heating buildings – energy is required virtually everywhere.

The Federal Government has made key decisions relative to its future energy-supply structures. These include decisions on an orderly termination of use of nuclear power, expansion of use of renewable energies, development of new energy technologies (such as fuel cells), and careful use of price signals, via the Ecological Tax Reform, aimed at conserving resources via increasing internalisation of previously external costs. At the same time, it is aware that the energy supply, throughout the foreseeable future, must be based on a balanced mix of energy sources in which fossil fuels continue to play a significant role.

Germany has completely liberalised its electricity and gas markets, in a single step. This has led to lower electricity prices, especially for the industrial sector, as well as to the development and provision of new energy products (for example, "green electricity"), efficiency improvements on the part of energy suppliers – to protect competitiveness – and to market-oriented trading arrangements such as electricity bourses and purchasing associations.

A reliable energy supply is a central concern of modern societies. To function properly, and to maintain a high standard of living – such as that attained in Germany – societies require adequate energy services (heating, cooling, lighting, power, communications, mobility). In addition to emphasising environmental compatibility (including both resources conservation and climate protection), sustainable energy policy thus focuses on ensuring that the energy supply is cost-effective and reliable.

One way of ensuring a reliable energy supply is to avoid strong dependencies on certain energy sources or supplier countries. Efficient, careful use of energy can help avoid such dependencies. Another key way of protecting reliabily is to structure the energy supply properly. For example, Germany would be ill-advised to limit its energy supply to a very few imported fuels and energy sources. Similar principles apply in the electricity market.

For this reason, Germany's energy policy will continue to emphasise a balanced energy mix comprising petroleum, natural gas, hard coal and lignite and renewable energies. Such an energy mix, including use of Germany's own coal reserves, can keep additional supply and price risks within acceptable limits.

In a competition-based energy sector, individual energy sources' various shares of the overall energy supply cannot, and should not, be permanently fixed. On the other hand, the country's energy-source mix is influenced by the prevailing political framework – for example, in the areas of climate protection, industry, the energy sector and tax policy. It is also affected by external circumstances such as developments in world energy markets and energy shortages (whether real or politically induced).

Cost-effectiveness

Along with its reliability, the energy supply's cost-effectiveness is centrally important. For both economic and social reasons, a sustainable energy policy must aim to keep energy as affordable as possible. For example, energy prices are an important competitive factor – at least for energy-intensive industries that face international competition; investments in energy-supply facilities must remain attractive.

Structure of the energy supply

Germany depends on fossil and nuclear energy sources to meet over 97 % of its energy requirements. With a primary energy consumption totalling about 14,500 PJ, Germany's per-capita consumption in 2001 was about 176 GJ (equivalent to about 6 t of hard coal per year). With respect to its gross domestic product, Germany's consumption amounted to 7.3 GJ/1000 €.

Within the foreseeable future, the market shares of Germany's various energy sources will change in Germany. The importance of nuclear power will gradually decline, as a result of an agreement reached with the energy sector, and legally enshrined, to phase out use of nuclear power. The "winners" of this agreement will include natural gas, which is increasingly having to be imported from outside the EU and transported over large distances.

The German economy is less sensitive now to energy-price fluctuations than it was in the 1970s and early 1980s. This development is due to a diversified energy mix that has reduced the country's strong dependence on oil. In electricity generation, use of Germany's own coal reserves has contributed to this result. In addition, use of renewable energies, which has increased sharply in recent years, and continual improvements in energy efficiency, have helped slow growth in dependence on imports and in relevant risks.

Final energy consumption

In the 1990s, final energy consumption developed in a number of very different ways, in the various consumption sectors: whereas consumption in the energy sector and in industry continually decreased, thanks to continuing efficiency improvements and structural changes away from energy-intensive products and toward services, the respective energy-consumption shares of private households and the transport sectors increased considerably, until recently. In the transport sector, this development was due to growth in numbers of vehicles and in transport mileage.

Tab. IV.2.2.1 Energy-consumption indexes

Energy-consumption indexes	**1991**	**2000***)
Primary energy consumption per capita (GJ)	183	173
Gross electricity consumption per capita (kWh)	6,736	6,758
Primary energy consumption per 1,000 € of gross domestic product (MJ)	8,540	7,253
Gross electricity consumption per 1,000 € of gross domestic product (kWh)	315	283
Final energy consumption in industry per 1,000 € gross value added (MJ)	5902	5.363
Electricity consumption in industry per 1,000 € gross value added (kWh)	509	529**)
Average automobile fuel consumption (l per 100 km)	9.4	8.5

Sources: Federal Statistical Office, AG Energiebilanzen, VDEW, Calculations of Federal Ministry of Economics and Technology (BMWi):

*) In part, provisional data, **) Figure for 1999

Electricity and gas market

The prices commanded by German electricity and gas suppliers are within the EU's middle range. This statement must be seen in light of the fact that such comparisons depend strongly on what specific types of sales are being considered, however. For manufacturing companies, market liberalisation has brought electricity-price reductions of 30 % and more, providing palpable cost reductions and enhancing companies' competitiveness. On the other hand, the importance of energy costs for German industry has declined considerably over the past two decades: whereas in the 1980s energy costs accounted for an average of 3 % of production costs, their share today is only 1.7 %. Nonetheless, for energy-intensive industries such as basic chemicals, iron and steel and non-ferrous metals, energy costs remain an important factor in location selection.

In the electricity sector, liberalisation has also prompted utilities to improve their own efficiency, and it has led to decreases in electricity prices – especially for the industrial sector. Furthermore, new energy products (such as "green electricity") and market-oriented trading arrangements, such as electricity bourses and purchasing associations, have emerged.

Development of CO_2 emissions

CO_2 emissions developed in very different ways in different energy-consuming sectors, including industry, the energy sector, transports, residential consumers, institutional consumers (trade, commerce, services). Whereas in the 1990s emissions decreased considerably in industry and the energy sector, they increased in the residential and transport sectors. Very recently, however, this trend has reversed: in 2000, CO_2 emissions in industry and the energy sector increased by about 2 %, while the transport sector showed a decrease for the first time. The residential sector is also now among the sectors that have considerably reduced their emissions from 1990 levels.

Tab. IV.2.2.2 Total CO_2 emissions, by emitter groups

Sectors	Share of CO_2 emissions in 2000, in %	Sectoral change, 1990-2000, in %	Sectoral change, 1999-2000, in %
Energy sector	42.2	-17.7	2.4
Industry [1)]	16.8	-26.8	1.8
Transport	20.8	12.8	-1.9
Residential	13.2	-11.5	-4.9
Institutional [2)]	7,0	-33.8	-3.7

[1)] Including industrial processes
[2)] Trade, commerce, services; includes military agencies
Source: Federal Environmental Agency, Arbeitsgemeinschaft Energiebilanzen, Calculations of the DIW

Phasing out of nuclear power

On 14 June 2000, the Federal Government and electric power utilities reached an agreement to phase out nuclear-based electricity generation in an orderly manner. Existing nuclear power stations are to be decommissioned as soon as they have generated a specified amount of electricity (amounts has been specified for all stations; the remaining electricity-generation allowance is calculated as of 1 January 2000). Transfer of remaining electricity-generation allowances to other stations is permitted. Operation of nuclear power stations is subject to high safety standards as required by law. Safety reviews are to be carried out at specified dates, for all nuclear power stations, and are to be repeated every 10 years.

The orderly phase-out of nuclear power presents new challenges for climate-protection and energy policy. On the other hand, it offers the opportunity for a completely new approach to energy policy and for the introduction of a viable energy supply oriented to the concept of sustainability and to reliability, cost-effectiveness and environmental compatibility (including such aspects as resources conservation and climate protection).

By 2005, nuclear power stations now generating some 8 billion kWh/a of electricity must be replaced. Depending on what types of power stations replace these nuclear power stations – natural-gas-fired gas-and-steam power stations, hard-coal-fired stations or lignite-fired stations – an additional 3 to 7 million t of CO_2 will be generated. From 2006 to 2010, nuclear power stations now generating some 19 billion kWh/a (an additional 7 to 17 million t of CO_2) must be replaced; from 2011 to 2020, an additional 87 billion kWh/a (an additional 33 to 74 million t of CO_2) of capacity must be replaced.

Considerable efficiency improvements in energy conversion – for example, through expansion of heat-power cogeneration, highly efficient gas-and-steam power stations and state-of-the-art coal-fired power stations – and in energy use (including careful use of energy in all relevant sectors), and expansion of use of renewable energies, will all play important roles in meeting this challenge. With its climate-protection programme of 18 October 2000, the Federal Government has taken the necessary decisions for making use of these options.

Energy efficiency

Enhancement of energy efficiency plays a key role in any modernisation strategy aimed at achieving a sustainable energy supply. By helping to protect the climate and the environment, and to conserve finite energy resources, energy efficiency thus promotes equitability between generations. In addition, it is an industry-policy and energy-policy key to sustainable, viable development. Improvements in energy efficiency reduce dependence on energy imports and reduce pertinent price risks. They also reduce companies' energy costs, thereby potentially helping to enhance companies' competitiveness. Significantly, consumers are paying more and more attention to their energy consumption.

Germany already leads all industrialised countries in energy efficiency. In areas such as electricity generation, industrial processes, motor-vehicle engines, household appliances and buildings and structures, Germany has continually enhanced its energy efficiency over the past ten years. Overall, Germany's per-capita energy consumption has decreased by 5.5% since the early 1990s. Energy input per unit of value added – i.e. energy intensity – decreased a full 15.5% between 1991 and 2000. Whereas annual energy efficiency improvements in Germany amounted to some 1.9% between 1991 and 2000, for the EU overall they were only 1.1% p.a. (1991 - 1998). As these figures show, Germany has been severing the links between energy consumption and economic growth – a process that must be continued.

Electricity generation plays an important role in this area, and significant progress has been made in recent years. For example, while state-of-the-art lignite-fired power stations have efficiencies of 41 %, older lignite-fired power stations have efficiencies below 35 %. Modern gas-and-steam power stations fired with natural gas, which can reach efficiencies of over 57 %, also hold great promise.

Cogeneration systems (heat-power cogeneration), which can reach efficiencies over 90 %, make especially efficient use of fuels. Above and beyond its existing, successful agreement on climate protection, German industry has committed itself to retaining, modernising and expanding the cogeneration sector. This effort is expected to prevent up to 23 million t of CO_2 emissions through 2010. Germany's new Act on maintaining, modernising and expanding heat-power cogeneration (Kraft-Wärme-Kopplungsgesetz), which came into force on 1 April 2002, will support this commitment.

Further significant improvements can be made in energy efficiency. Household applicances are an important area in this regard, for example. After energy efficiency classes were introduced for such appliances and relevant labeling requirements were imposed, sales of appliances in the higher "A" and "B" efficiency classes rapidly increased. Appliances in the lower efficiency classes largely disappeared from the market. And yet persisting discrepancies in energy consumption show that the potential for further improvements is far from exhausted. A recent study reached the conclusion, for example, that (highly cost-effective) optimization of electric motors in household appliances could, by itself, save 8 billion kWh of electricity annually.

The potential for efficiency improvements in the buildings and structures sector is especially great. The Ordinance on Energy Saving (Energieeinsparverordnung) will considerably decrease energy consumption in new buildings. While "zero energy" and "passive" houses are still the exceptions, they provide an idea of the possibilities in energy efficiency. The key, however, is to improve efficiency of existing buildings. Optimised insulation and modernised heating systems can drastically reduce energy consumption. And in many cases, such measures amortise themselves within reasonable periods of time, via reduced energy bills. Progress in this area will depend centrally on proper enforcement, by Federal Länder, of legal provisions on energy efficiency.

CO_2-oriented building-modernisation programme:

Experts agree that enormous reductions in CO_2 emissions can be made via technical improvements in existing buildings. A CO_2-oriented building-modernisation programme has been established with the aim of reducing CO_2 emissions by at least 40 kg per square metre and year. The programme comprises a number of measures packages and provides economic incentives to modernise heating systems in combination with insulation improvements or window replacements in buildings built in 1978 or earlier. This programme is expected to spark modernisation in some 330,000 residences in the next few years.

Campaign for "climate protection in the residential and institutional sectors"

One important element of the Federal Government's new climate-protection programme, in the buildings and structures sector, is a multi-year campaign – being carried out via a public-private partnership – aimed at tapping potential for reducing CO_2 emissions in the residential and institutional sectors. Within the framework of the relevant public-private partnership, the BMU is working with German industry – especially with manufacturers and providers of energy-saving systems and devices for buildings and structures. The campaign is aimed especially at providing effective information and advising in all relevant areas of action.

Expansion of use of renewable energies

One important way of achieving a sustainable energy supply in Germany is to considerably expand renewable energy systems' role in meeting Germany's energy needs. The Federal Government has thus established a comprehensive range of measures aimed at supporting expansion of renewable-energy use. The aim behind Germany's Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz) is to at least double renewable energies' share in meeting Germany's energy requirements. Specifically, renewable energies' share in meeting electricity needs is to be increased from 6.25% in 2000 (about 7% in 2001) to 12.5% by 2010. For comparison: in 1990, it was only 3.8%. And the expansion is to continue vigourously after 2010. Plans call for renewable energies to meet about half of the country's energy requirements by the middle of the century. This aim yields additional orientational levels for the period between 2010 and 2050.

The Federal Government's efforts in this area are proving successful: growth of renewable energies has accelerated considerably, and annual growth rates in some sub-sectors have reached two-place percentages. The aim is to make renewable energies competitive within the single market for electricity, in the medium-to-long term. This is necessary, since renewable energies will be able to play a lasting, major role in the energy market only if they can thrive without subsidies. A continuing aim in this context is for prices of conventional and renewable energies to reflect their different external costs (especially long-term environmental and climate damage), although this must develop in an economically compatible way.

Breakthrough for renewable energies: the EEG

The Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz - EEG)* of 29 March 2000 represents a decisive step toward a sustainable energy supply. It obligates operators of electrical power networks to accept electricity generated with solar-power, hydroelectric, wind-energy, geothermal and biomass systems and to pay certain minimum rates. The EEG has proven to be a highly effective instrument for promoting expansion of renewable energies.

According to the electric power industry, in 2001 some 16 TWh of electricity were fed into the grid on the basis of the EEG, with network operators paying some 1.4 billion euros for this power. For the first time, the EEG now divides relevant burdens evenly among the nation's electricity consumers, and thus end consumers' resulting average additional costs per kilowatt-hour remain within reasonable limits.

The EEG will promote further expansion of Germany's already booming wind-energy sector and, in combination with the Biomass Ordinance, is likely to spark similarly dynamic development in biomass use. In addition, it has provided impetus for use of photovoltaic systems, and it is expected to help launch use of geothermal energy.

In 2001, Germany's wind-energy systems alone contributed some 12 TWh, or over 2 %, of Germany's electric power production – a figure equivalent to over one-third of all wind-based electricity generated worldwide. As of the end of 2001, over 8,700 megawatts of wind-energy capacity were installed. In 2002, wind-energy systems are expected to meet some 3 % of Germany's electricity requirements.

Since the limits to land-based wind-energy use are now being reached in Germany, the Federal Government, within the framework of Germany's National Sustainability Strategy, has developed a strategy for sea-based wind-energy systems. In an initial phase through 2006, and under current conditions in areas now expected to be available, the strategy would enable installation of a total of at least 500 megawatts (MW) of wind-energy systems; in the medium term – through 2010 – it would enable installation of 2,000 to 3,000 MW of generating capacity. In the long term – i.e. by 2025 or 2030 – and once true cost-effectiveness is achieved, some 20,000 to 25,000 MW of generating capacity could be installed.

Investments in the future – support programmes for renewable energies

The Federal Government's support programmes for energy generation with wind-energy, solar-energy, biomass and geothermal systems have sparked an unprecedented boom in renewable energies. From 1998 through 2002, the Federal Government, via various programmes, is making well over a billion euros available for such programmes. These programmes include:

- *100,000-roofs photovoltaic programme** (provision of low-interest loans for installation and expansion of photovoltaic systems with installed peak capacities of at least one kilowatt peak (kWp). Aim: by 2003, installation of about 300 megawatt-peak (MWp) of photovoltaic generating capacity)
- *Market-incentives programme for renewable energy sources** (promotion of greater use of solar-collecting systems, photovoltaic systems for schools, systems for burning solid biomass, small biogas systems, small hydroelectric systems and systems for using deep-subterranean geothermal energy)
- *Programme for Investment in the Future (Zukunfts-Investitions-Programm - ZIP)** (Runs from 2001 to 2003; promotes research into sustainable forms of energy, with funding from UMTS interest income; emphasis: renewable energies and fuel-cell technology)
- *Eco-subsidy for homeowners* (for example, incentives for installing solar systems, as part of energy-saving measures completed in 2002 or for energy-saving homes (Niedrigenergiehaus) completed in 2002, and where the

relevant application for, or notification of, construction was submitted before 1 February 2002)

In 2000, use of renewable energies in Germany prevented some 35 million t of CO_2 emissions. Doubling renewable energies' share in Germany's energy supply by the year 2010 will thus mean CO_2-emissions reductions of about 70 million t in 2010. What is more, it will also prevent emissions of other greenhouse gases – especially methane – on a scale of about 10 million t of CO_2 equivalents.

Resources conservation and climate protection

The world's current energy-consumption patterns are not in keeping with sustainable development principles. In particular, rapid exploitation of scarce fossil energy reserves, along with the greenhouse-gas emissions their use generates, are limiting options for future generations and violating the principle of equitability between generations. What is more, many people are forced to use renewable resources unsustainably in order to meet their basic needs. For example, overly rapid consumption of firewood degrades and destroys forests, especially in the tropics, thereby contributing to greenhouse-gas emissions and exacerbating other problems such as poverty, erosion and desertification. The possible consequences of climate change, which is caused primarily by industrialised countries' greenhouse-gas emissions, will have to be borne by future generations. Such consequences include shifting of climate zones and rainfall regions, extinction of many animal and plant species, increased hurricane and storm frequency and spreading of tropical diseases.

This means that industrialised countries, with their large share of worldwide energy consumption, are not meeting their international responsibility. Energy policies oriented to sustainability must seek to reduce consumption of fossil fuels, especially in industrialised countries. This is the only way to provide latitude for the standard-of-living improvements that developing countries need, without overtaxing the environment in the long run. Apart from the CO_2 reductions required in industrialised countries, the necessary ingredients for global climate protection include greater energy efficiency and greater use of renewable energies in developing countries and countries undergoing economic transition.

The central aim is that established by the Framework Convention on Climate Change (which has been ratified by over 180 countries): to stablise greenhouse-gas concentrations in the atmosphere at a level that will prevent dangerous disruption of the climate system. This can be achieved only via a drastic reduction of current emissions.

Furthermore, if it is to be achieved, the world cannot continue to depend almost exclusively on fossil and nuclear energy sources. In keeping with the principle of equitability between generations, a system must be developed and implemented that in the long run does not deplete the environment's resources faster than they can be restored to the environment, externally, and that does not overtax the earth's ecological carrying capacity.

Achieving this aim is an ongoing, long-term task. Within the framework of EU-burden-sharing under the Kyoto Protocol, Germany has committed itself to reducing its greenhouse-gas emissions by 21 %, by 2012, compared to their 1990 levels. Furthermore, the Federal Government has set itself the aim of reducing Germany's CO_2 emissions by 25 % by 2005, compared to their 1990 level. And yet national and international climate-protection policy cannot end in 2012 – it must continue long after that year: additional national and international efforts must be made if the consequences of climate change are to be effectively limited. Clear long-term perspectives are needed, to give all players a reliable long-term framework for investment decisions. This applies especially to the energy sector, which characteristically has long investment cycles.

In this context, the Federal Government reiterates its intention to continue to provide leadership in developing and implementing ambitious climate-protection policies. At the same time, the Federal Government is aware that this problem, in light of its global dimension, cannot be solved by one country acting alone. An EU-wide strategy, co-ordinated internationally as effectively as possible, is required.

From the Federal Government's perspective, industrialised countries' commitments, as mandated in the Kyoto Protocol for the first commitment period, 2008 to 2012, must be considerably enlarged in subsequent commitment periods. Other key aims include bringing the U.S. back into the Kyoto process and reaching agreements with developing countries on limiting their emissions.

In this framework, the Federal Government plans to upgrade its existing commitments ambitiously and to continue to discuss necessary long-term aims with the relevant groups. The Federal Government also expects other industrialised countries to commit themselves to similarly ambitious aims, so that German industry will not be at a disadvantage in international competition.

Name	Description/aim	GHG	Type	Implementation status	Institution carrying out	Expected effect in millions of t of CO_2 equivalents	
Energy sector						2005	2008 to 2012
Renewable-Energies Act, Biomass Ordinance, market-incentives programmes to promote renewable energies, R&D, demonstration	Promotion of use of renewable energies in generation of electricity and heat Aim: substitution of fossil fuels	**CO_2**	R	In force	Federal Government	- - 20	- 40
Renewable-Energies Act, Biomass Ordinance, market-incentives programmes to promote renewable energies	Promotion of use of renewable energies; substitution of fossil fuels and prevention of methane emissions, especially via use of biomass, landfill gas, sewage gas and pit gas pursuant to Renewable Energy Sources Act	**CH_4**	R	In force	Federal Government	-5	-10

Maintenance, modernisation and expansion of heat-power cogeneration (including small cogeneration systems), and introduction of fuel cells on the market	Agreement between the Federal Government and German industry on reduction of CO_2 emissions and promotion of heat-power cogeneration, as a supplement to the climate-protection agreement of 9 November 2000 and the Act on heat-power cogeneration (Kraft-Wärme-Kopplungsgesetz)	**CO_2**	R	In force since 1 April 2002	Federal Government	-10	-23
Use of pit gas	Intensified use of pit gas, an unavoidable by-product of hard-coal mining; this will involve increasing percentages of pit-gas methane used for energy generation: from 70% to 78% Aim: avoidance of CH_4 emissions, substitution of fossil fuels	**CH_4**	V	Effective since 1993	Industry	-8.0	-8.0

Biomass Ordinance	Provisions on biomass specifications within the meaning of the Renewable Energy Sources Act (EEG), on technical processes for generating electricity from biomass, within the meaning of the EEG, and on environmental requirements in generation of electricity from biomass Aim: to use clean fuels as substitutes for fossil fuels	**CH_4**	E	In force since 2001	Federal Government		
Construction of additional natural-gas-fired gas-and-steam power stations	Modernisation of power stations Aim: to increase efficiency of power stations; to use fuels with lower carbon content as substitutes for carbon-intensive fuels	**CO_2**	V	Ongoing project	Industry	-8	-15 to -20
Reduction of methane losses in production and transport of natural gas	Optimisation of technical processes in production and transport of natural gas	**CH_4**	D	Ongoing project	Industry	NE	NE

IV.2.3 Measures in the transport sector

In comparison with other sectors, the transport sector exhibits the most unfavourable trends in energy consumption, in terms of climate protection. Because total mileage figures for all modes of transport increased between 1990 and 1999, CO_2 emissions the transport sector as a whole grew by 11 %[4]. Nonetheless, transport-related CO_2 emissions in recent years have not increased to the extent predicted by various studies. And recently the tide seems to be turning also in the transport sector. In 2000, carbon-dioxide emissions in the transport sector decreased for the first time. This positive development continued in 2001.

In light of the settlement, industry and transport structures that have grown over the past decades – and in light of these structures' ecological consequences – transport policy will have to deal with greater and greater challenges. It must chart the course for the future and ensure that the transport system remains effective – and remains a positive factor that helps make Germany an attractive location for industry and commerce. The public's demand for individual mobility must also be respected. Needless to say, this also applies to those who do not own their own vehicles. At the same time, environmental concerns must be taken into account, and transport-related pollution must be further reduced.

The Federal Government is carrying out a broadly diversified package of measures in order to reshape the transport system in keeping with principles of environmental protection and resources conservation.

Environmentally friendly, intermodal solutions are to be promoted, via an approach involving greater market orientation. Prices should have a guiding function also in the transport sector; the calculatory bases of relevant state taxation systems should be more strongly oriented to environmental criteria.

The example of introduction of emissions-based motor-vehicle taxation for automobiles provides proof of the effectiveness of such measures. From 1997 to

2001, the overall number of heavily polluting vehicles was reduced by two-thirds. One fourth of all automobiles newly registered in 2001 already conform to the "Euro 4" emissions standard, which will apply as of 2005/2006, and the emissions-based motor-vehicle tax has contributed to this progress. And motor-vehicle-tax breaks have provided incentives for market introduction of automobiles with especially low CO_2 emissions *(*so-called "3-litre autos"). The Federal Government thus considers broader incentives for use of low-emissions vehiclies, within the framework of motor-vehicle tax, to be an effective instrument.

In 2003, time-based truck fees will be replaced with distance-based electronic fees for heavy trucks, in order to make assignment of road-use costs more equitable. The distance-based autobahn-use fee for trucks, with emissions-based fee categories, will support transport-policy and environmental-policy aims. With its flexible fee schedule, it will provide incentives to shift goods transports from roads to railways and waterways. It should also reduce percentages of "no-load" trips. The measure is expected to reduce CO_2 emissions by 5 million t.

Per-kilometer tax deductions for commuters, and for trips that employees make to rejoin their families (for example, in cases where an employee works in a city other than his or her city of residence), are now the same for all modes of ground transportation. This change is in keeping with both environmental and sensible transport-policy criteria. Standardised distance-categories that cover all modes of transportation in the same way create a level playing field, in terms of taxation, between competing modes of transportation and improve the basis for local public transportation.

Continuing development of low-emissions vehicles must be encouraged. The voluntary commitment made by the German Association of the Automotive Industry (Verband der Deutschen Automobilindustrie - VDA) to reduce average fuel consumption of automobiles made by German manufacturers by 25%, by 2005, with respect to relevant 1990 levels, is an important and successful contribution to the

[4] The last available figure, and not including international transports. CO_2 emissions of international air transports increased by 43% between 1990 and 1999.

Federal Government's efforts to reduce CO_2 emissions absolutely for all road transports. The Federal Government calls on the German automobile industry to update its voluntary commitment in order to achieve reductions of over one-third. In discussions with the German automobile industry, the Federal Government is also seeking to convince German automakers to join the agreement with German industry on climate protection (climate agreement). Further reductions can be achieved by intensifying optimisation and use of environmentally friendly fuels. As of 1 November 2001, tax breaks are being given for early introduction of fuels meeting sulphur standards, as mandated for 2005 by the EU Fuels Directive (98/70/EC), of 50 mg/kg ("low-sulphur"). This is being accomplished by making mineral-oil taxes on gasoline and diesel fuel dependent on sulphur content. When the sulphur content of such fuels is greater than 50 mg/kg, they are subject to an additional 1.53 cents per litre, a measure which favours low-sulphur fuels. As of 1 January 2003, the relevant tax exemption will apply only to fuels with sulphur content of up to 10 mg/kg ("sulphur-free"). Oil companies had already begun selling only low-sulphur fuels by the time this tax incentive came into force. As a result, consumers have not suffered any relevant price increases.

Sulphur-free fuels make it possible to use engine technologies with up to 15 % lower fuel consumption than conventional engine technologies. Another advantage is that sulphur-free fuels can help reduce emissions and soot formation even in older engines.

The Federal Government is planning to engage the VDA in discussions aimed at introducing broad use, in new vehicles, of low-viscosity oils and tyres with low roll resistance. According to estimates, each of the aforementioned measures can reduce fuel consumption from 3 to 6 %. The Federal Highway Research Institute (Bundesanstalt für Straßenwesen) estimates that the measures can provide CO_2 reductions of 3 to 5.5 million t by 2005.

The Federal Government is also supporting the transport-sector energy strategy of German automobile and energy companies. The aim of the transport-sector energy strategy is to concentrate on one – or no more than two – alternative motor-vehicle fuels (for both passenger and utility vehicles) that meet technical, economic and ecological criteria for suitability. This will then provide a basis for developing a common strategy for broad, nationwide commercial introduction and for developing criteria for the necessary framework. For example, if hydrogen, under a long-term option, were implemented as a fuel in fuel cells or internal combustion engines, zero-emissions vehicles and drastic CO_2 reductions throughout the entire energy chain could be achieved – if hydrogen were produced via solar energy. Use of natural gas in the transport sector, an application that has already passed the pilot-scale phase, now provides an effective strategy for long-term transition to hydrogen via an environmentally friendly fuel. Certain other fuels, such as methanol, are also being considered as alternative-fuel candidates within the framework of the transport-sector energy strategy.

The EC Regulation "on substances that deplete the ozone layer", which will soon be adopted, will mandate annual inspections for stationary and mobile refrigeration systems filled with more than 3 kg of HCFC (and CFC) refrigerants. The required inspections are expected to reduce rates of leakage from such systems. Expansion of inspection commitments to cover refrigeration and air-conditioning systems with HFC refrigerants could reduce HFC emissions from such systems. The necessary basis for introducing such inspection commitments would include a national ordinance or an EU-wide regulation.

A legally defined prohibition on use of the main emissions sources of SF_6 is proposed. In automobile tyres, SF_6 can be replaced – with no sacrifice in quality – with a continually available substitute (air). Alternative window technologies can be used instead of SF_6 in order to meet soundproofing requirements as required by building codes. Relevant studies and experience in other European countries clearly prove the feasibility of this approach. In light of the risk for the earth's climate, a prohibition on use seems reasonable.

By promoting greater use of telematics systems in the transport sector, the Federal Government is pursuing an intermodal approach aimed especially at creating an efficient overall transport system integrating all modes of transport, at enhancing the efficiency of transport-infrastructure use and at reducing environmental burdens by optimising transport processes in passenger and goods transports. Even though telematics can lead to additional transports, it still holds the potential for reducing CO_2 emissions by 2005. In the next section, the potential reductions are included with the potential reductions that can be achieved by fleet-management systems.

The railway-structure reform has equipped railways for managing a higher percentage of the transport growth expected within the European framework. For this potential to be realised, the decreasing trend in the railway sector's share of total transports must be stopped and then, following such an initial phase, the trend must be reversed, within the framework of a medium-to-long-term strategy. Expansion of combined road-rail transports will play an important role in this connection. In addition, expansion of the high-speed-railway network is expected to help reduce short-distance air travel. The Federal Government's investment policies in the railway sector are also oriented to such potential shifts. To finance information measures, the Federal Government, within the framework of the Programme for Investment in the Future (Zukunftsinvestitionsprogramm - ZIP), is providing Deutschen Bahn (German Railways) with some 3.1 billion € from 2001 to 2003[5].

The Federal Government is carefully watching the dynamically growing air-transport sector. It holds that internalisation of external costs must also be introduced in this sector, via use of economic instruments, as a result of both environmental and economic needs. Use of economic instruments can enhance cost-effectiveness in development of technical reduction potential, while ensuring that concerned parties largely retain their entrepreneurial flexibility. The Federal Government plans to pursue this approach actively, on three levels:

International: Within the responsible ICAO bodies, the Federal Government is supporting introduction, as soon as possible and on an international basis, of a kerosine tax or a more environmentally effective emissions-based tax on greenhouse-gas emissions or an emissions-trading system that is at least as

[5] Funding from interest savings generated through use of proceeds from the UMTS-license auction.

environmentally effective as an emissions-based tax[6]. Before air transports can be integrated within any emissions-trading system, maximum emissions levels ("caps") must be defined, and international air transports must be included within the Kyoto Protocol.

European Union: Within the EU framework, the Federal Government is supporting introduction of an emissions-based tax. To this end, it strongly supports – in keeping with resolutions of the Council of Ministers of Transport, the Council of Environment Ministers and the ECOFIN Council – the Commission's action plan on "Air transport and the environment", and it encourages the Commission to present relevant proposals in 2002.

National: On the national level, the Federal Government plans to introduce emissions-differentiated take-off and landing fees[7]. This fees will be adjusted if there is overlapping with any EU-wide or global emissions tax.

One of the Federal Government's particularly important aims is for use of local public transportation to be intensified. Although this is an area in which the Länder have executive and financial responsibility, the Federal Government is focusing on it in an effort to lower road-traffic emissions. The Federal Government is thus providing the Länder with financial assistance for investments aimed at improving municipal transport systems, pursuant to the Act on financing of municipal transports (Gemeindeverkehrsfinanzierungsgesetz – GVFG), and it is financing relevant research projects. The Länder are also receiving federal funding under the Regionalisation Act (Regionalisierungsgesetz), which provides the Länder with funding for assuming responsibility for local public rail transportation within the context of local public rail reform. In 2002, the Länder will receive for this purpose the amount of € 6.745 billion from federal mineral-oil tax funds; from 2003 to 2007, the funding will then increase by 1.5 % annually. Together, the federal GVFG and regionalisation funding will reach a volume of over € 8.4 billion annually; as a result, the Länder will have enough funding, and a reliable enough planning framework, in order to provide adequate local public transportation services.

[6] Such emissions-trading systems are currently being discussed, but none have yet been defined.

The Federal Government considers promotion of bicycle use to be an effective way of considerably reducing short-distance automobile travel. Over half of all automobile trips made in Germany are shorter than 5 kilometres. This shows that considerable potential remains for increasing the numbers of short trips made by bicycle or on foot. In 1998, the Federal Government issued a first report on the situation in the "bicycle-transport sector". Accounting for 12 % of all trips made, in terms of numbers, bicycle transports play a relative significant role in Germany. The Federal Government is promoting cycling especially by means of its federal bicycle-path programme. As of the end of 2000, a total of some 15,000 km of bicycle paths were in place along federal roads. In its report of 23 May 2000 on measures to promote bicycle transports[8], the Federal Government laid out a national strategy for promoting bicycle use in a manner taking account of all concerned parties. It plans to continue developing this concept systematically, especially in co-operation with the Länder and municipalities and with the associations responsible for such issues.

On 24 April 2002, the Federal Cabinet approved a national plan for promoting use of bicycles.

[7] Similar models, without a CO_2-reduction component, have already been introduced in Sweden and Switzerland.
[8] Report of the Federal Government on measures to promote use of bicycles, BT DS 14/3445 of 23 May 2000

Name	Description/aim	GHG	Type	Implementation status	Institution carrying out	Expected effect in millions of t of CO_2 equivalents	
Transport						2005	2008 to 2012
Promotion of use of sulphur-free fuel	Promotion of low-sulphur and sulphur-free fuels to provide a basis for high-mileage, low-emissions engines; this is to be achieved by raising mineral-oil tax on fuels that do not meet the sulphur standards of 50 ppm, as of 1 November 2001, and 10 ppm, as of 1 January 2003 Aim: to reduce fuel consumption in transports	**CO_2**	E	In force as of 1 November 2001 and 1 January 2003	Federal Government	-2 to -5	
Railway-structure reform	Expansion of the railway network, expansion of combined road-rail transports Aim: for railways to transport goods now transported on roads	**CO_2**	E	Resolution of the Federal Government	Federal Government		
Autobahn toll for trucks	Distance-based autobahn toll for trucks, with emissions-based structure Aim: for railways and waterways to transport goods now transported on roads	**CO_2**	E	Resolution of the Federal Government; implementation no later than 2003	Federal Government	-5	

Emissions-based motor-vehicle tax for automobiles	Broader incentives for low-emissions automobiles, within the framework of motor-vehicle tax. Aim: to enhance energy efficiency of automobiles	**CO_2**	E	Resolution of the Federal Government	Federal Government	-1	
Reduction of the average fuel consumption of new automobiles	Upgrading of the German automobile industry's voluntary commitment on further reduction of average fuel consumption in new automobiles, as of 2005: a reduction of 30%, instead of 25%, compared to relevant levels in 1990 Aim: to enhance energy efficiency of automobiles	**CO_2**	V	Request directed at industry	Industry	-4 to -7	-10
Improved integration and links between different modes of transport	Telematics, logistics management and fleet management, anti-traffic-jam programme Aim: to reduce use of energy services	**CO_2**	I, E	Planned as of 2003	Industry	-3.5	

Campaign for climate protection in the transport sector	Campaign for climate protection in the transport sector, with the following emphases: fuel-saving driving habits, maintenance, low-viscosity oils and low-roll-resistance tyres, combination of modes of transport (bicycle, automobile, local public transportation, railway, air), "3-litre auto" Aim: to enhance efficiency and reduce use of energy services	**CO_2**	ET	Resolution of the Federal Government	Federal Government, industry	-5	NE
Emissions-based landing fees	Introduction of emissions-based take-off and landing fees at German airports Aim: to enhance energy efficiency in air transports	**CO_2**	E	Resolution of the Federal Government	Federal Government	-1	
Vehicle air conditioners	As of 2007, motor-vehicle HFC air conditioners are to be supplanted by CO_2 systems Aim: to use a gas with lower impacts on climate	**HFC**		Proposed	Federal Government, industry	< 0	-1
Prohibition on use of SF_6 for filling automobile tyres	A prohibition on filling automobile tyres with SF_6 would eliminate this source of SF_6 emissions. Aim: prevention of use of SF_6	**SF_6**	R	Proposed	Federal Government	-0.3	-0.7

Distance-based tax deduction that does not vary by mode of transport	Tax deductions for commuter travel. A tax deduction that does not vary by mode of transport will help to place all competing modes of transport on an equal footing for tax purposes. Aim: to improve the attractiveness of local public transportation	**CO_2**	R E	Adopted; came into force on 01 January 2001	Federal Government	NE	NE
Use of low-viscosity oils and low-roll-resistance tyres	Use of low-viscosity oils and low-roll-resistance tyres in new vehicles, in order to reduce fuel consumption Aim: to reduce fuel consumption in road transports	**CO_2**	V	Planned	Industry	-3 to -5	NE
Energy strategy for the transport sector	Agreement between automobile and energy companies regarding a maximum of 2 different alternative fuels for motor vehicles (automobiles and trucks) Aim: to reduce CO_2 emissions through use of alternative fuels such as hydrogen and natural gas	**CO_2**	V	Planned	Industry	NE	-1 to -2

Integrated transport planning	Development of an overall transport-sector concept that makes use of traffic-reducing settlement structures and strengthens regional structures Aim: to reduce transports by reversing the trend toward sprawl	**CO_2**	D R	Planned	Federal Government, Federal Länder	NE	NE
Anti-traffic-jam programme	Provision of needed transport-management capacities that can keep traffic running smoothly Aim: to reduce traffic-jam-related CO_2 emissions	**CO_2**	D R	Planned as of 2003	Federal Government, Federal Länder	-0.5	NE
Promotion of bicycle use	Implementation of the Federal Government's report on promotion of bicycle use Aim: to reduce automobile use, especially for short trips	**CO_2**	D	Planned	Federal Government	NE	NE

IV.2.4 Measures in the residential sector

Experts agree that the residential-buildings sector holds the greatest potential for CO_2 reductions. And the need to protect the climate is not the only reason why the greatest possible use should be made of this potential. In light of the difficult situation in the construction industry, and of the construction industry's impacts, as a "multiplier", on income and employment, measures in this sector could help stabilise employment – especially in small and medium-sized enterprises on the local level. This combination of factors makes this topic especially important: in it, climate protection and the agreement on employment (Beschäftigungspakt) complement each other in a highly useful way. The various relevant concerns in this area can thus be balanced only via an integrated approach that takes account of the planning sector, modern technologies and effective concepts and that incorporates both investors and users.

The Act on Energy Saving (Energieeinsparungsgesetz - EnEG), which provides the legal basis for the Ordinance on Energy Saving (Energieeinsparverordnung), was passed in 1976, under the pressures imposed by the first oil-price crisis. At that time, its primary purpose was to reduce Germany's dependence on oil imports. In light of the changed political framework, the Federal Government plans to review the extent to which the EnEG meets current criteria for climate-protection-oriented energy efficiency and whether it can be improved.

The Ordinance on Energy Saving (Energieeinsparverordnung - EnEV), which came into force on 01 February 2002, combines and tightens existing requirements, as set forth by the Thermal Insulation Ordinance (Wärmeschutzverordnung) and the Heating-Systems Ordinance (Heizungsanlagen-Verordnung). It is aimed at reducing the energy requirements of new buildings by an average of 30%, and at developing potential for improving energy efficiency in existing buildings by cost-effective, economically reasonable means. In the residential sector, the Ordinance on Energy Saving will reduce CO_2 emissions by up to 4 million t, by 2005. And it will lead to further CO_2 reductions in the industrial and institutional sectors.

The amendment takes special account of the following aspects:

- Optional introduction of energy-consumption indexes for existing buildings – for buildings in which commitments to carry out formal accounting of heating costs apply. In addition, the Federal Government is reviewing whether use of energy-consumption indexes could be made binding within the foreseeable future,
    - conditional requirements for existing buildings (externally applied thermal insulation),
    - retrofit requirements for insulation of buildings' top-storey ceilings,
    - Replacement of obsolete heating systems (boilers) and, possibly, insulation of piping systems,
- Orientation primarily to energy efficiency criteria,
- Implementation of advanced technical and ecological standards.

Due to constitutional protection for existing assets, only a small fraction of the potential CO_2 reductions in existing buildings (nearly 80 % of existing buildings were built before the Thermal Insulation Ordinance (Wärmeschutzverordnung) came into force in 1983; over two million heating systems are more than 20 years old) can be achieved via regulatory means. Experience has shown that economic incentives can provide effective impetus for modernisation, thereby significantly accelerating the pace with which planned investments are actually made (shorter investment cycles) and increasing modernisation rates significantly. In early 2001, the Federal Government launched a support programme for modernisation of old buildings – the CO_2-oriented building-modernisation programme of the Kreditanstalt für Wiederaufbau (KfW) promotional bank. This programme is aimed at meeting needs for climate protection, at providing impetus for employment and growth and at improving housing quality without imposing undue burdens on renters and owners. Wtih a total loan volume of over 5 billion €, the programme will enable more than 350,000 additional residences to be modernised in keeping with energy-efficiency criteria in the next few years. To finance the programme, the Federal Government plans to provide a total of over 1 billion € through 2005. In connection with other support measures oriented to existing buildings, this programme will reduce CO_2 emissions by 5-7 million t, compared to their 1990 level, by 2005.

Measures in the residential sector must not be confined to indoor-heating systems. They must also focus on households' electricity consumption. Today's households not only have appliances such as refrigerators, washing machines, dryers, freezers, etc.; they also have increasing numbers of office and communications equipment (such as PCs, answering machines, telefax machines, cell phones) and home entertainment systems (such as TV sets, VCRs, stereo equipment). As the numbers of such devices increase, so does the significance of this sector's electricity consumption.

The Federal Government thus plans to considerably intensify its efforts to improve the energy efficiency of household appliances, office and communications equipment and home-entertainment systems. Planned measures include product-specific labeling, energy labels, information and advising, R&D, agreements with makers of electrical appliances and with the electronics industry, energy standards and regulatory measures.

Name	Description/aim	GHG	Type	Implementation status	Institution carrying out	Expected effect in millions of t of CO_2 equivalents	
Private residential						2005	2008 to 2012
Ordinance on Energy Saving (in the residential sector)	Combines and tightens existing requirements from the Thermal Insulation Ordinance (Wärmeschutzverordnung) and the Heating-Systems Ordinance (Heizungsanlagenverordnung). Aim: to reduce energy requirements in new buildings by 30%, and to develop economically reasonable potential for improving energy efficiency of existing buildings	**CO_2**	R	In force since 1 February 2002	Federal Government	-4	NE
CO_2 –oriented building-modernisation programme of KfW	Economic incentives to modernise buildings – for example, to replace obsolete heating systems, add thermal insulation, replace windows Aim: ti enhance efficiency in production and use of indoor heat	**CO_2**	E	In force since February 2001	Federal Government	-5 to -7	NE

Improvement of the energy efficiency of household appliances	Measures in the area of electricity consumption – especially in the area of stand-by consumption of household electrical and electronic devices; voluntary commitments and tightening and expanding of the Act on labelling to show energy consumption (Energieverbrauchskennzeichnungsgesetz) Aim: to enhance efficiency of electricity use	**CO_2**	ET, V, R	Expand existing activities	Federal Government, industry	-5	NE
Promotion of use of natural gas	Greater use of natural gas in home heating and hot-water systems Aim: to increase use of a fuel with relatively low carbon content, and use of more efficient technologies	**CO_2**	V	Ongoing project	Industry	-3.1	NE

Eco-subsidies in incentives for home ownership	Review of eco-subsidies in incentives for home ownership. Under the Act on subsidies for homeowners (Eigenheimzulagengesetz), additional support is provided for installation of modern energy-saving technologies such as heat pumps, solar heating systems and thermal collection systems Aim: to conserve resources through use of energy-efficient technology	**CO_2**	E	Ongoing project	Federal Government	NE	NE
Promotion of "green" electricity	Expansion of the availability of "green electricity", i.e. electricity generated from renewable energies Aim: to increase renewable energies' share of the energy mix	**CO_2**	V	Ongoing project	Industry	NE	NE
Campaign for climate protection in private households	Information about possibilities for saving energy in private households Aim: to tap potential for saving energy in the residential sector	**CO_2**	I ET	Planned	Federal Government, industry	NE	NE

Intensified introduction of state-of-the-art systems for buildings	Creation of incentive for intensified use of state-of-the-art systems such as condensing boilers, small heat-power cogeneration systems, fuel cells, connection to district heating networks, modern measurement and control systems, etc.. Aim: to reduce energy consumption, through efficient technology	**CO_2**	I D	Ongoing project	Industry, crafts sector	NE	NE
Intensification of research, development and demonstration	Further optimisation of products and systems Aim: to increase energy efficiency of products and systems	**CO_2**	D	Ongoing project	Federal Government, industry, science sector	NE	NE

IV.2.5 Measures in the area of industry and commerce

Over the past ten years, greenhouse-gas emissions from industry and commerce have been considerably reduced. Nonetheless, this sector still holds many possibilities for improving efficiency of energy use and for reducing greenhouse-gas emissions still further.

German industry's declaration on climate protection is a key element of a package of industrial-sector measures with which German industry is contributing to climate protection.

From the outset, "German industry's declaration on climate protection" has been implemented via a step-by-step, ongoing process and has been continually refined. This process is based on the annual monitoring reports of the Rhine-Westphalia Institute for Economic Research (Rheinisch-Westfälisches Institut für Wirtschaftsforschung Essen – RWI). These reports analyse developments in the various economic sectors, validate data from official statistics and industry association statistics, identify deficits and make proposals for further development. Since 1996, this process has been used to establish and refine a controlling system that is unprecedented in form. This system continually provides companies in the relevant branches with new information about ways to save energy and to optimise energy use (benchmarking). Since 1995, a number of industry sectors, within their systematic efforts to optimise their energy use, have implemented energy audits, developed energy-saving concepts, carried out relevant investment projects earlier than originally planned, developed new concepts for ensuring a reliable energy supply, intensified their training and further training efforts and entered into inter-company co-operation arrangements. To date, the Rhine-Westphalia Institute for Economic Research has presented its third monitoring report, covering the period 1990-1999.

Since February 2000, the Federal Government and the industry associations participating in the voluntary commitment have engaged in intensive negotiations, on the basis of the monitoring reports, regarding further development of commitments announced on 10 March 1995 and updated on 27 March 1996. These negotiations resulted in an agreement of 9 November 2000, between the government of the Federal Republic of Germany and German industry, on climate protection.

German industry's current declaration on climate protection develops this agreement further in the following regards:

- Adaptation of the previous time frame (base year 1990 / target year 2005) to the time frame specified by the Kyoto Protocol (base years 1990/1995; target corridor 2008 / 2012);
- Inclusion of the other Kyoto gases (CH_4, N_2O, SF_6, HFCs and PFCs);
- Upgrading of targets: reduction of emissions of CO_2. CH_4, N_2O, SF_6, HFCs and PFCs by 35%, by 2012, compared to 1990 levels. Reduction of emissions of the greenhouse gas CO_2 by 28%, by 2005, compared to the 1990 level.
- General inclusion of possibilities for linking "German industry's declaration on climate protection" with the project-based Kyoto mechanisms "Joint Implementation" and "Clean Development Mechanism", as well as with trading in emissions certificates (emission trading).

Implementation of the "Agreement between the government of the Federal Republic of Germany and German industry on climate protection" will continue to be reviewed, as agreed, by an independent economic institute ("climate-protection monitoring"). The Federal Government, represented by the Federal Ministry of Economics and Technology (BMWi) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), will continue to contribute 50 % of the financing for climate-protection monitoring. German industry will bear the other 50% of the relevant costs. To date, a number of additional associations have joined the declaration.

The contributions that can result from improved training and further training, and from more intensive information provision and advising, should not be underestimated. As an initiative on advising carried out by the association of the energy and electrical power industry (Verband der Industriellen Energie- und

Kraftwerkswirtschaft - VIK) and numerous scientific studies have shown, many industrial and commercial enterprises need to improve – and can improve – their understanding of relevant energy relationships. For this reason, the Federal Government attaches great importance to energy-efficiency advising and energy diagnoses, especially for small and medium-sized enterprises. It also expects industry's self-administration institutions to contribute substantially to efforts in this area.

In order to make greater use of potential for reducing greenhouse-gas emissions in the industrial and institutional sectors, the Federal Government plans to review possibilities for considerably expanding economic incentives within existing relevant programmes of the Federal Government, the Länder, municipalities, industry and federal banks (DtA and KfW), and within the ERP Special Fund.

The EC regulation on "substances that deplete the ozone layer", which will soon be adopted, mandates annual inspections for stationary and mobile refrigeration systems filled with more than 3 kg of HCFCs (and CFCs) refrigerants. The required inspections are expected to reduce rates of leakage from such systems. Expansion of inspection commitments to cover refrigeration and air-conditioning systems with HFC refrigerants could reduce HFC emissions from such systems. The necessary basis for introducing such inspection commitments would include a national ordinance or an EU-wide regulation.

Policies for reducing emissions from relevant foams could be based on any of several different approaches. The spectrum of such approaches includes legal provisions (for example, prohibitions on use of HFC as propellants in certain applications, and prohibitions on placing certain HFC-containing foams on the market), economic instruments (taxation of HFC emissions, financial support/incentives for alternatives and/or emissions-reduction measures) and voluntary commitments by industry.
In propellants for PU insulation foams, propane/butane, in combination with dimethyl ether (DME), can substitute for HFC in most applications – this is already current

practice in Scandinavia, for example. But since propane/butane and DME are flammable, continued use of HFC, in small amounts, may be necessary in areas in which flammable propellants must be prohibited (for example, in mines).

Name	Description/aim	GHG	Type	Implementation status	Institution carrying out	Expected effect in million t CO_2 equivalents	
Industry and trade, commerce, services						2005	2008 to 2012
German industry's declaration on protection	Updates and upgrades German industry's voluntary commitment of 1996 on emissions reductions Aim: to reduce CO_2 emissions by 28%, by 2005; to reduce emissions of so-called "Kyoto gases" (CO_2. CH_4, N_2O, SF_6, HFCs and PFCs) by 35% by 2012	**CO_2**	V	Agreement reached on 09 November 2000	Federal Government, industry	-10	-10
Training and further training	Advising initiatives covering energy interrelationships, energy saving and energy diagnoses, especially for small and medium-sized enterprises Aim: to enhance energy efficiency	**CO_2**	ET	Request directed at industry associations	Industry, crafts	NE	NE
Improvement of loan programmes of ERP, DtA, and KfW	Expands economic incentives, within the framework of existing programmes Aim: to enhance energy efficiency	**CO_2**	E	Review	Federal Government	NE	NE

Ordinance on Energy Saving (in the industrial and institutional sectors)	Combines and tightens existing requirements from the Thermal Insulation Ordinance (Wärmeschutzverordnung) and the Heating-Systems Ordinance (Heizungsanlagenverordnung). Aim: to reduce energy requirements in new buildings by 30%, and to develop of economically reasonable potential for improving energy efficiency of existing buildings	**CO_2**	R	Resolution of the Federal Government in fall 2000	Federal Government	-6	NE
Improvement of efficiency of electric motors	Provides for replacement, with more efficient units, of electric devices such as electrical drive units, pumps, ventilators, compressors, etc.. Aim: to enhance efficiency of manufacturing processes, in order to reduce electricity consumption	**CO_2**	V D	Ongoing project	Industry	-2	NE

Use of "green" electricity	Increases use of "green electricity", i.e. electricity generated from renewable energies Aim: to increase renewable energies' share of the energy mix	**CO_2**	V	Ongoing project	Industry	-1 to -1.5	NE
Technical measures in adipic-acid production	Provides for thermal or catalytic decomposition, in order to achieve a 95% reduction of N_2O emissions in manufacture of adipic acid, a product needed for manufacture of artificial fibres Aim: to prevent N_2O emissions	**N_2O**	V	Voluntary measures implemented	Industry	-28	-28
XPS hard foams	Provides for use of CO_2 and ethanol as substitutes for HFCs in about half of all production, as at 2000 Aim: In replacement of ozone-depleting gas, to use gases with smaller impacts on climate	**HFCs**	V	In effect	Industry	-1	-1.3
Stationary refrigeration equipment	As of 2003, mandates maintenance requirements for systems with fill amounts of at least 1 kg Aim: to reduce leak rates	**HFCs**	R	Proposed	Federal Government	-1.6	-3.6

PU insulation foams	Provides for extensive use of propane, butane or DME as substitutes for HFCs; continued use of (small amounts) of HFCs in applications requiring fire-proofness Aim: Substitution	**HFCs**	R, E, V	Proposed	Federal Government, industry	-1.2	-2.6
PU foam products	Cancels plans to introduce HFCs as propellants; instead, use of pentane, cyclopentane or water (CO_2) Aim: In replacement of ozone-depleting gas, to use gases with smaller impacts on climate	**HFCs**	V	Proposed	Industry	-0.1	-0.2
XPS hard foams	Provides for convincing as many manufacturers as possible to use CO_2 and ethanol as HFC substitutes Aim: to use gases with smaller impacts on climate	**HFCs**	V	Proposed	Industry	-0.8	-1
Medical aerosol sprays	Provides for enlarging the market share of powder inhalers in asthma therapy Aim: to reduce use of gas with impacts on climate	**HFCs**	V	Proposed	Industry	-0.3	-0.5

Semiconductor manufacture	Provides for highly efficient waste-gas scrubbing for new etching chambres as of 2000. As of 2009, replacement of old systems	**HFCs**		Proposed	Industry	< 0	-0.1
Voluntary commitment of the German primary aluminium industry	Voluntary commitment, as agreed	**PFCs**	V	Approved in 1997	Industry	-0.8 (-107 t CF_4) (-11 t C_2F_6)	-0.85 (-114 t CF_4) (-11 t C_2F_6)
Aluminium production	Provides for additional modernisation measures and process optimisation	**PFCs**	V	Proposed	Industry	-0.1 (-18 t CF_4) (-2 t C_2F_6)	-0.1 (-18 t CF_4) (-2 t C_2F_6)
Semiconductor manufacture	Provides for use of a new process for cleaning plasma chambres; Use of NF_3 as a substitute for PFCs in etching	**PFCs**	V	Proposed	Industry	-0.5 (-23 t CF_4) (-34 t C_2F_6)	-1.3 (-66 t CF_4) (-90 t C_2F_6)

Precautions in scrapping of electrical equipment	Voluntary commitment of the VDEW and ZVEI operator and manufacturer associations: the recycling concept will ensure, in the large-scale scrapping of systems that is to begin in 2010, that SF_6 fill gas, amounting to over 50 t annually, is recollected as completely as possible and then recycled and disposed of properly. Aim: to prevent emissions and recycle SF_6	**SF_6**	V	Approved in 1996	Industry	NE	-1.2
Avoidance of use of SF_6 in filling automobile tyres	Automobile tyre manufacturers will stop recommending use of SF_6 for filling automobile tyres Aim: to use air as a substitute for SF_6	**SF_6**	I	In effect	Industry	-2.3	-2.3
Prohibition on use of SF_6 for filling soundproof windows	By 2005, SF_6 is to be phased out in new soundproof windows. In light of the gas' strong impact on climate, and of the available alternatives, a prohibition on use does not seem unreasonable. Aim: to use alternative window technologies that do not require SF_6	**SF_6**	R	Proposed	Federal Government	-0.9	-1.0

IV.2.6 Measures in the area of agriculture and forestry

Some 45% of methane emissions, and some 52.5% of laughing-gas emissions, come from agriculture. In addition, agriculture is responsible for about 90% of ammonia emissions (NH_3), which have an indirect impact on climate via processes in the atmosphere and the soil that convert them to N_2O. The agriculture sector's share of energy-related CO_2 emissions, on the other hand, is relatively small (about 3%).

Agriculture can contribute to climate protection by increasing the percentage of agricultural land used for organic farming and by using other extensive agricultural production processes. Organic farming is especially effective in conserving resources and protecting the environment, and it contributes significantly to protection of water and soil resources and of rare plants and animals. For this reason, it meets criteria for sustainable agriculture to a very high degree. Organic farming typically features diverse crop rotation; low-intensity animal husbandry, with livestock herd sizes tied to farm area; and maximally closed nutrient cycles emphasing organic fertilisers and feeds that farms produce themselves. Significantly, because it refrains from using chemical and synthetic pesticides and chemical nitrogen fertilisers, organic farming generates considerably lower CO_2 emissions, per unit of area, than predominant, conventional farming methods. Organic farming also produces lower methane and laughing-gas emissions, per unit area, since organic farms' livestock-herd sizes are tied to the feeds that farms can produce themselves. The Federal Government is seeking to expand Germany's total area under organic cultivation significantly.

By managing and protecting existing forests, and by carrying out initial afforestation, the forestry sector already contributes to long-term binding of carbon in biomass. This "sink" function corresponds to a CO_2-emissions volume totaling over 30 million t per year. German forests' function as a CO_2 sink is listed separately in greenhouse-gas inventories and is not balanced with emissions.

By providing raw materials and fuels that are largely CO_2-neutral, agriculture and forestry also prevent CO_2 emissions to an extent corresponding to the amounts of fossil-based fuels, raw materials and basic production materials that such environmentally friendly materials and fuels replace.

Sustainably managed forests bind atmospheric carbon over periods ranging from decades (thinning) to centuries (end uses). Wood products can lengthen this sink function by periods ranging from several months (for example, paper used as newsprint, including recycling) to several hundred years (for example, wooden buildings). In Germany, it is estimated that wood products currently in use are storing at least 340 million t of carbon (corresponds to about 1.2 billion t of CO_2). Current wood uses are increasing this amount by about 4 to 5 million t of carbon annually. The average duration of carbon storage, for all relevant products, is about 33 years. Additional wood use – especially in the construction sector – can further increase carbon storage in wood (a wooden house with 240 m^2 of living space stores about 22 t of carbon, or about 80 t of CO_2). As such examples show, wood products can extend forests' function as a "carbon sink" and thus represent an important part of the climate-protection strategy. And wood use not only adds to carbon storage, it reduces CO_2 emissions when it involves wood substituted for fossil raw materials and energies.

Biomass, when burned in modern firing systems, not only releases substantially smaller amounts of pollutants into the air than fossil fuels do, it also releases CO_2 only in the amounts that the relevant plants removed from the atmosphere as they were growing. Such systems thus have virtually closed CO_2 cycles. Increased use of renewable, continually plentiful raw materials can reduce CO_2 emissions via substitution for fossil fuels such as coal, oil or natural gas. For years, the Federal Government, acting via the Agency of Renewable Resources (Fachagentur Nachwachsende Rohstoffe), has supported research, development and demonstration projects in this area. A relevant support programme, "Renewable raw materials", has been expanded to include animal products and waste products, including biogas. In addition, the Renewable Energy Sources Act now provides higher compensation rates that considerably strengthen biomass' position over that under the old Act on the Sale of Electricity to the Grid. These rates, in combination with the new Biomass Ordinance, can be expected to lead to considerably increased biomass use in electricity generation in coming years. Within the framework of a market-incentives programme for renewable energies that has been in effect since 1993, the Federal Government annually provides sums in the tens of millions for bio-energy systems for production of heat and electricity. Furthermore, a specifically aimed market-introduction programme of the Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL), "Biogenic fuels and lubricants", entered into force in 2000 and is now promoting introduction of such relevant products to the market. This programme, which has annual funding of some 10 million €, is currently being expanded to include additional products made from renewable raw materials. The various support measures in this area will help agriculture provide the largest possible amounts of raw materials for production of biogenic fuels that can substitute for fossil fuels. Via such materials, agriculture will be able to make an important contribution to CO_2-emissions reduction. What is more, the programme may also help protect jobs in agriculture.

Name	Description/aim	GHG	Type	Implementation status	Institution carrying out	Expected effect in millions of t of CO_2 equivalents	
Agriculture and forestry						2005	2008 to 2012
Fertiliser ordinance	Provides for biogas use in liquid-manure-treatment systems built primarily for manufacturing fertiliser products for precision nitrogen fertilisation Aim: to use substitutes for fossil fuels	**CH_4**	R	In force since 1996	Federal Government	NE	NE
Fertiliser ordinance	Provides for fertiliser use in keeping with proper practice; this is expected to reduce nitrogen input into the soil from 174 kg/ha in 1990 to 160 kg/ha in 2005 Aim: to prevent N_2O emissions	**N_2O**	R	In force since 1996	Federal Government	-2.1	-2.1
Expansion of organic farming	Promotes organic farming, a farming method that is especially effective in conserving resources and protecting the environment Aim: to reduce emissions of CO_2. CH_4 and N_2O	**CO_2** **CH_4** **N_2O**	E V	Ongoing project	Federal Government agriculture	NE	NE

Management and protection of existing forests / initial afforestation (CO_2 sink)	Afforestation and forest conservation Aim: Long-term binding of carbon in biomass	**CO_2**	E,R V	Ongoing project	Federal Government, Federal Länder, forestry sector	(-30 million t CO_2 storage)	(-30 million t CO_2 storage)
Use of biogas in agriculture	Reduces use of fossil fuels, through use of biogas Aim: to use fuels with lower carbon content, and to close CO_2 cycles	**CO_2**	E V	Ongoing project	Federal Government, agriculture	-0.7	-1.4

IV.2.7 Measures in the area of waste management

The waste management sector is also helping to reduce greenhouse gases. Ecologically oriented waste-management policies can contribute significantly to thrifty, environmentally oriented use of resources.

Considerations regarding climate protection in this sector begin with closed-substance-cycle waste management. Execution of the Technical Instructions on Waste from Human Settlements (TA-Siedlungsabfall) of 1993 was inadequate in a number of areas. As a result, new binding waste-storage requirements were imposed via the Ordinance on Environmentally Compatible Storage of Waste from Human Settlements (Verordnung über die umweltverträgliche Ablagerung von Siedlungsabfällen), which has been in force since 1 March 2001. This ordinance maintains high ecological standards throughout certification of mechanical and biological waste-treatment processes. As of 1 June 2005 at the latest, waste may be stored only if it does not endanger achievement of potential reductions in emissions of greenhouse gases. If this aim is to be achieved, relevant storage requirements for settlement waste (no storage of untreated household waste) must be implemented on time.

In addition, separate collection of biological waste in recent years, along with use of the relevant produced compost – as governed by the Ordinance on Bio-Wastes (Bioabfallverordnung), which has been in force since 1998 – has kept considerable amounts (in 2000, some 7 million t) of biologically degradable waste out of landfills and ensured that this waste is properly recycled. Furthermore, the Ordinance on the Management of Waste Wood (Altholzverordnung; scheduled to come into force at the beginning of 2003) will create a framework for old-wood recycling that, even before 2005, will keep large amounts of old wood out of landfills – where the wood would otherwise end up, leading to formation of landfill gas.

In the area of waste requiring special supervision, provisions of the 1991 Technical Instructions on Waste Management (TA-Abfall), in combination with specific support programmes, have led to considerable reductions of greenhouse-gas emissions over the past 10 years. These requirements were made legally binding in the Ordinance on Landfills (Deponieverordnung), which came into force on 1 August 2002.

Measures in the area of settlement-waste storage have the potential to achieve reductions of greenhouse-gas emissions totaling some 28 million t by 2005, and totaling some 31 million t by 2012 (potential reductions of emissions of CO_2 and other greenhouse gases, expressed in CO_2 equivalents pursuant to IPCC). In future, even greater use must be made of potential reduce greenhouse-gas emissions – especially via energy-oriented use of landfill gases (particularly methane); use of waste for energy generation, instead of fossil fuels; and increased waste recycling, leading to reduction of greenhouse-gas emissions in raw-materials production.

The concept of closed-substance-cycle waste management includes product-oriented responsibility whereby low-waste processes are used in production and products are designed to generate as little waste as possible. Two ordinances on product responsibility are relevant to climate protection. As a result of the Ordinance on Packaging (Verpackungsverordnung), which has been force since 1991, annual packaging consumption has decreased by 1.4 million tonnes, and rates of packaging recycling have increased. The End-of-life Vehicle Ordinance (Altautoverordnung), which has been in force since 1998, has increased the percentages of old-automobile waste that are recycled. Furthermore, the recycling rate for graphic papers has been increased to over 80 %, thanks to a voluntary commitment that has been in place since 1994 and was updated in 2001.

The Commercial Wastes Ordinance (Gewerbeabfallverordnung), which comes into force on 1 January 2003, establishes requirements for improved waste separation and more effective pre-treatment. As a result, it will lead to higher recycling rates for commercial waste from settlements, and for certain types of construction and demolition waste, thereby providing energy savings.

The amended version of the Ordinance on Management of Waste Oil (Altölverordnung), which has been in force since 1 May 2002, creates binding priorities for reprocessing (i.e. recycling for material recovery) in management of some 450,000 t of waste oil produced annually.

Name	Description/aim	GHG	Type	Implementation status	Institution carrying out	Expected effect in millions of t of CO_2 equivalents	
Abfall						2005	2008 to 2012
Technical Instructions on Waste from Human Settlements (TA-Siedlungsabfall) and Ordinance on Environmentally Compatible Storage of Waste (Ablagerungsverordnung)	Provides for prevention of landfill-gas generation in new facilities; extensive collection of landfill gas and use of gas for energy production in old landfills Aim: to prevent CH_4 emissions and use substitutes for fossil fuels	**CH_4**	R	In force since 1993 / In force since 1 March 2001	Federal Government, Federal Länder	-28	-31
Technical Instructions on Waste Management (TA-Abfall), Part 1, and Ordinance on Landfills (Deponieverordnung)	Provides for prevention of biological decomposition of organic components in waste requiring special supervision Aim: to prevent CH_4 emissions	**CH_4**	R	In force since 1991 / In force since 1 August 2002	Federal Government, Federal Länder	-0.3	-0.3

IV.2.8 Measures of the Länder

In keeping with the distribution of responsibilities between the Federal Government, the Länder and local authorities, the Länder have a very important role to play in developing and implementing Germany's climate-protection strategy. Many Länder are assuming special responsibility for climate protection. For example, on 31 March 1995 the Länder approved a resolution in the Bundesrat that underscored the need to develop and implement measures for achieving the reduction target established for Germany. Pursuant to the resolution, the Länder support the Federal Government's relevant objectives.

In this area, it is important to understand the different situations in the various Länder. CO_2 emissions differ as a result of difference in population, energy sources used, infrastructure, etc.. A few figures easily illustrate how the Federal Länder differ in this regard. The state of North Rhine-Westphalia (with a population of about 18 million, making it the most populous of all the Länder), for example, has annual CO_2 emissions of about 200,000 Gg, about the same as the annual CO_2 emissions of Spain or the Netherlands. The state of Berlin (with a population of about 3.5 million) annually emits about 25,000 Gg CO_2, or about half as much CO_2 as Denmark emits. The relatively sparsely populated state of Mecklenburg-West Pomerania, which has an area of 23,559 m^2 and population of about 2 million, has annual CO_2 emissions of 30,000 Gg.

Many Länder have established **new institutions** – such as Baden-Württemberg, with its new climate-protection and energy agency, and Bremen, with its new energy advisory board and interdisciplinary working groups concerned with climate protection. Schleswig-Holstein has created a number of new institutions. Many of the Länder institutions in question were involved in preparing the first climate-protection programmes and concepts of the Länder in which they are located. And many Länder have given their environment ministries responsibility for their energy sectors.

Many Länder began developing their climate-protection policies by preparing (or commissioning preparation of) **climate-protection programmes**, concepts and reports and relevant studies.

The Länder have focused their climate-protection policies especially on the energy sector. In keeping with this focus, all Länder are carrying out priority measures for improving energy efficiency in existing buildings (private residences, municipal properties and state properties), in companies and in public-sector facilities, since this is the area in which the largest CO_2 reductions can be achieved. All Länder are also promoting renewable energies, in order to support their commercial establishment. In general, biomass systems are seen to hold the largest growth potential. In addition, the Länder support expansion of heat-power cogeneration and district heating. Some also support increases in natural gas' share of the energy mix (Thuringia, Saxony, Lower Saxony, Bavaria and Baden-Württemberg). Development of new, low-emissions energy technologies such as hydrogen-based systems is also being considered (Bavaria, Mecklenburg-West Pomerania and Saxony-Anhalt).

IV.2.9 Measures of municipalities

Municipalities – cities and communities, i.e. the local level – continue to be an area that holds considerable potential for reducing emissions of CO_2 and other greenhouse gases.

This considerable potential results from the various functions and tasks of local authorities:

- They are the administrative level that carries out federal and Länder laws,
- They establish standards for their local communities,
- They function entrepreneurially in cases where the power supply is provided by a municipal power company,
- They own municipal properties such as administrative buildings, schools, kindergartens and swimming pools,
- They provide relevant support through municipal support programmes for CO_2 reduction, especially programmes to save energy and use renewable energies.

Important areas for municipal action in support of climate protection:

Sector	Measures
Ecologically oriented urban-development planning and regional planning	• Integration of climate-protection and energy-efficiency criteria in urban-development planning, construction planning and building permits • Emphasising of urban structures that tend to reduce CO_2 emissions (multi-functional structures, the "city of short distances", etc.) • Increasing the amounts of green and open areas in cities / unsealing of paved areas (carbon binding; CO_2 sinks); use of additional potential green areas (rooftops, facades)
Information, advising and public awareness	• Establishment of local and regional centres for energy advising • Inclusion of climate-relevant information in environmental advising
Energy-saving in consumption sectors	• Improvement of energy efficiency in municipal buildings, by means of structural improvements in thermal insulation, measures to enhance efficiency of heating, measurement and control systems, establishment of municipal energy management structures and use of other suitable measures to reduce heat and electricity consumption • Promotion of efficient use of heat and electricity in other consumption sectors: residential, institutional (commerce, crafts, services), manufacturing/industry and other public institutions/authorities (by means of information, planning and other supporting measures)
Environmentally compatible energy infrastructure	• Expansion of the line-based energy infrastructure (including that for providing energy for heating buildings: gas networks, small-scale / large-scale district heating networks) • Fuel conversions (for example, from coal to natural gas) • Conversion of the energy infrastructure to allow greater use of combined heat/power (CHP) generation / small-scale CHP systems • Use of renewable and local energy sources (wind power, hydroelectric power, solar energy, biomass, waste heat, etc.)
Environmentally compatible development of the transport sector	• Reduced use of private automobiles, coupled with greater use of local public transportation and environmentally compatible, low-emissions modes of transport • Improvement of the quality of the public transportation infrastructure, especially of local public transportation and other, less energy-intensive modes of transportation (bicycle paths/lanes, pedestrian zones, etc.) • Environmentally compatible development of goods transports (expansion of regional supply networks, etc.)
Municipal waste management and wastewater treatment	• Waste avoidance, waste separation for collection, re-use and recycling of materials in waste • Waste treatment (as part of a systematic policy of waste avoidance, re-use and recycling): use of waste and landfill gas for generation of heat and power; use of biogas systems fed with biomass waste, use of composting systems • Wastewater treatment: use of sewage gas, reduction of energy consumption in processes

IV.3 Other players in climate-protection policy

IV.3.1 Deutsche Bundesstiftung Umwelt

The Deutsche Bundesstiftung Umwelt (DBU; German Federal Environment Foundation) in Osnabrück was established as an independent private-law foundation by resolution of the German Bundestag and at the initiative of the Federal Government. In began functioning in 1991 and is now one of Europe's largest foundations.

Its support guidelines, which were modified in September 1998, cover a total of 12 support areas, within main sections:

Environmental technology

Support area 1: Environmentally friendly and healthy processes and products
Support area 2: Energy technology
Support area 3: Architecture and construction
Support area 4: Closed-cycle systems and emissions reduction

Environmental research/environmental protection

Support area 5: Applied environmental research
Support area 6: Environmentally compatible land use
Support area 7: Grant programme
Support area 8: Environmental management in medium-sized companies

Environmental communication

Support area 9: Environmental communication for small and medium-sized companies
Support area 10: Provision of environmental information
Support area 11: Environmental education
Support area 12: Environment and cultural assets

The grant programme listed as support area 7 is used to support young scientists, on a nationwide basis, working in the area of environmental protection. It also promotes the establishment of, and endows, academic chairs for environmentally oriented research and teaching.

Each year, the foundation awards an environmental prize of 500,000 € to honour commitments and services that have played a decisive, exemplary role in protecting and conserving the environment or that in future will significantly help to reduce environmental stresses.

Since its inception, Deutsche Bundesstiftung Umwelt (DBU) has supported a total of over 3,900 projects, with total funding of more than 818 million €.

IV.3.2 Deutsche Energie-Agentur (dena)

The **Deutsche Energie-Agentur (dena; German Energy Agency)** was founded on 29 September 2000 as a national competence and information centre for energy efficiency and renewable energies. dena is not a subordinate authority of any ministry; instead it is a limited-liability company (GmbH). Its present shareholders, each of which has a 50 % stake, are the Kreditanstalt für Wiederaufbau (KfW) promotional bank and the Federal Republic of Germany, represented by the Federal Ministry of Economics and Technology (BMWi), the Federal Ministry of Transport, Building and Housing (BMV) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

dena is charged with carrying out flexibly designed projects that support certain types of Federal Government activities in the areas of efficient energy use, renewable energy sources and climate protection. It also provides information to municipal and regional energy agencies and consumer-advocacy centres. Furthermore, it assists interested parties, whether in private households, companies, associations or government authorities, in obtaining information. Finally, the agency also has the important task of trading experience and carrying out projects with international partners and advising the Federal Government in connection with such international activities.

IV.3.3 Deutsche Bahn AG

Deutsche Bahn (German Railways), taking into account

- national and international developments in the area of environmental protection,
- relevant entrepreneurial interests and possibilities and
- society's expectations,

has established the following strategic aims:

- Reduction of specific primary energy consumption for traction by 25% by 2005, based on the 1990 level;

- Further reductions of absolute primary energy consumption in stationary processes,
- Reduction of emissions, especially carbon-dioxide emissions, by 25% to 30%.

V Emissions scenarios and projections, and assessment of the effects of measures

V.1 Reliability of forecasts, scenarios, projections

Forecasts and scenarios play an indispensable role, in connection with climate-protection strategy, in forecasting potential future developments and potential impacts of measures under consideration. They are subject to considerable uncertainties, as is also explained in Chapter V.

Participants in political discussion often forget that the future cannot be predicted with certainty and that scenarios cannot be more than "if-then" statements. Forecasts are always closely tied to identified "probable" trends, and conclusions derived from scenarios always depend on the relevant underlying premises. In other words, descriptions of future developments depend on assumptions regarding key economic, demographic and political trends, and on assessment of interrelationships relevant to energy consumption, and thus different, consistent and contradition-free descriptions of the future are always possible at any given time. Target-oriented forecasts are referred to as "projections". In each instance of a projection, careful studies will provide the best possible determination of whether the projection is realistic – i.e. of whether its targets can be achieved.

As to methods, emissions projections are based on impacts analyses, combining assessment of individual measures with integrated views of the overall effects of measures and policies. The longer the time periods covered by projections, the greater the need for numerical models – which by their nature can only provide a limited view of reality. As the time axis lengthens, framework conditions become increasingly blurred, and impacts analyses covering only individual measures produce increasingly unreliable conclusions. The projections presented below do not take into account the resolutions of 14 July 2000 on phasing out nuclear energy. Furthermore, the Federal Government has not officially endorsed the following projections and scenarios.

V.2 Reductions of greenhouse-gas emissions

V.2.1 Projections for carbon dioxide (CO_2)

Table V.2.1.1 presents emissions projections for CO_2, along with emissions trends to date and taking into account the expected impacts of the emissions-reduction measures described above. In this context, the year 2010 stands for the period 2008 - 2012. This data is based on the research report "Policy scenarios for climate protection II", 1999, and on calculations made the Federal Environmental Agency (UBA), taking into account current emissions trends and the results of the National Climate-Protection Programme (Resolution of the Federal Government of 18 October 2000).

Tab. V.2.1.1 Projections of carbon-dioxide emissions

CO_2 equivalent (Gg) (Kt)	1990	1995	1999	2005	2010
Sectors	Inventory			Projections*	
Total emissions (not including sinks)	**1014500**	**903737**	**858511**	**759000**	**694000**
1 Energy	**986832**	**877107**	**832036**	**734000**	**669000**
A Combustion	986832	877107	832036	734000	669000
1 Energy conversion sector	412896	356954	329754	276000	247000
2 Industry	196457	149050	139028	117000	111000
3 Transport	162281	176468	186110	201000	187000
4 Other sectors	203439	190544	174402	140000	124000
5 Other (military)	11760	4091	2742	NE	NE
B Production, processing and distribution of fuels	NE	NE	NE	NE	NE
2 Industrial processes	**27668**	**26630**	**26475**	**25000**	**25000**
3 Solvent use and other product use	**NO**	**NO**	**NO**	**NO**	**NO**
4 Agriculture	**NO**	**NO**	**NO**	**NO**	**NO**
5 Land use and forestry**	**-33719**	**-33430**	**-33430**	**-30000**	**-30000**
6 Waste	**NE**	**NE**	**NE**	**NE**	**NE**

The projections do not take account of the resolutions of 14 July 2000 on phasing out nuclear power. The Federal Government has not officially endorsed the emissions scenarios and projections.
**Remark: only changes in forest reserves (area as of 1990); land-use changes not included due to the lack of relevant data.

Remark: The projections for carbon dioxide are estimates prepared on short notice in keeping with current needs. They take into account the National Climate-Protection Programme (Resolution of the Federal Government of 18 October 2000), and they are based on the study used in the 1999 greenhouse-gas monitoring report, "Policy scenarios for climate protection II". A certain degree of uncertainty regarding the absolute amounts of the estimated emissions cannot be ruled out, due to the complexity of the energy system that is the main source of CO_2 emissions in Germany.

In December 2001, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) commissioned a follow-on study, "Policy scenarios for climate protection III", in order to take into account the recent changes in Germany's relevant framework.

The trend of decreasing CO_2 emissions – with an emissions reduction of some 15% by 1999, with respect to the 1990 level – has been interrupted in the past few years. The Federal Government has taken the above-described measures in an effort to attain its ambitious climate-protection objectives nonetheless (Table V.2.1.2). For 2005, CO_2 emissions reductions of 25%, with respect to 1990, are expected.[7]

Tab. V.2.1.2 Changes in carbon-dioxide-emissions projections with respect to 1990

%		1995	1999	2005	2010
Sectors		Inventory		Projections*	
Total emissions		**-11%**	**-15%**	**-25%**	**-**
1 Energy		**-11%**	**-16%**	**-26%**	**-32%**
A Combustion		-11%	-16%	-26%	-32%
1 Energy conversion		-14%	-20%	-33%	-40%
2 Industry		-24%	-29%	-40%	-43%
3 Transport		9%	15%	24%	15%
4 Other sectors		-6%	-14%	-31%	-39%
5 Other (military)		-65%	-77%	NE	NE
B Fuel production, processing and distribution		NE	NE	NE	NE
2 Industrial processes		-4%	-4%	-10%	-10%
3 Use of solvents and other products		**NO**	**NO**	**NO**	**NO**
4 Agriculture		**NO**	**NO**	**NO**	**NO**
5 Land use and forestry		**NE**	**NE**	**NE**	**NE**
6 Waste		**NO**	**NO**	**NO**	**NO**

* The projections do not take account of the resolutions of 14 July 2000 on phasing out nuclear power.
The Federal Government has not officially endorsed the emissions scenarios and projections.

Industry, the energy-conversion sector and the other areas summarised under "other sectors" – households and commerce, crafts and services – probably will have similarly high rates of CO_2-emissions reduction between 1990 and 2010. The transport sector is expected to have about 15% higher CO_2 emissions in 2010, with respect to 1990. Significantly, as of 2005 the transport sector can be expected to have both absolute (see Table V.2.1.1) and relative (see Table V.2.1.2) emissions reductions – in 2005, about 24%, with respect to 1990. The reduction in 2010 will amount to about 14%.

[7] These projections do not take account of the resolutions of 14 July 2000 on phasing out nuclear power.

V.2.2 Projections for methane (CH_4)

Table V.2.2.1.2 shows emissions projections for CH_4 together with emissions trends to date, taking into account the effects of the above-described emissions-reduction measures. The year 2010 represents the period 2008 - 2012. The table is based on the research report "Policy scenarios for climate protection", 1997.

Tab. V.2.2.1 Methane-emissions projections

CO_2 equivalent (Gg) (kt)	1990	1995	1999	2005	2010
Sectors	Inventory			Projections	
Total emissions	**116990**	**81774**	**68695**	**54301**	**45538**
1 Energy	**37273**	**27426**	**21172**	**17787**	**16401**
A Combustion	4492	2289	1705	1701	1554
B Fuel production, processing and distribution	32781	25137	19467	16086	14847
2 Industrial processes	**0**	**0**	**0**	**0**	**0**
3 Use of solvents and other products	**NO**	**NO**	**NO**	**NO**	**NO**
4 Agriculture	**39949**	**32739**	**30849**	**25930**	**21850**
5 Land use and forestry	**NO**	**NO**	**NO**	**NO**	**NO**
6 Waste	**39768**	**21609**	**16674**	**10584**	**7287**

Tab. VI.2.2.1 does not include the more precise 2001 data of the Association of the German Hard-Coal-Mining Industry (GVSt).

Methane is emitted primarily in non-energy-related processes. The main sources are found in the areas of agriculture, waste management and fuel production and distribution (hard-coal mining and gas-distribution networks). The approved measures are likely to reduce methane emissions by about 50% between 1990 and 2010 (Table V.2.2.1).

Tab. V.2.2.2 Changes in methane-emissions projections with respect to 1990

%		1995	1999	2005	2010
Sectors		Inventory		Projections	
Total emissions		**-30%**	**-41%**	**-46%**	**-60%**
1 Energy		**-26%**	**-43%**	**-52%**	**-56%**
A Combustion		-49%	-62%	-62%	-65%
B Fuel production, processing and distribution		-23%	-41%	-51%	-55%
2 Industrial processes		**0%**	**0%**	**0%**	**0%**
3 Use of solvents and other products		**NO**	**NO**	**NO**	**NO**
4 Agriculture		**-18%**	**-23%**	**-35%**	**-45%**
5 Land use and forestry		**NO**	**NO**	**NO**	**NO**
6 Waste		**-46%**	**-58%**	**-73%**	**-82%**

All areas exhibit emissions reductions.

In the waste sector, an emissions reduction of 82% is expected between 1990 and 2010, resulting especially from implementation of the Ordinance on Waste Storage (Abfallablagerungsverordnung), the Technical Instructions on Waste from Human Settlements (TA-Siedlungsabfall), the Ordinance on Landfills (Deponieverordnung) and the Technical Instructions on Waste Management (TA-Abfall), Part 1 (TA Sonderabfall (on waste requiring special supervision)), all of which are expected to drastically reduce landfill-gas emissions. The emissions reductions will result through requirements for collection and treatment of landfill gas, as well as from requirements, effective as of 2005, mandating that waste may be stored in landfills only if it will generate virtually no landfill gas.

The emissions reduction of about 14% in the agriculture sector, between 2010 and 1990, will result from measures for storage of animal excrement and intensified use of biogas.

In the fuel production, processing and distribution sector, reductions in hard-coal mining, and increasing use of pit gas from decommissioned mines, are expected to reduce methane emissions from 17.1 million t of CO_2 equivalents in 1990 to 5.4 million t of CO_2 equivalents in 2010, i.e. by about 68%.

V.2.3 Projections for nitrous oxide (N_2O)

Table V.2.3.1 shows emissions projections for N_2O, along with emissions trends to date and taking into account the effects of the above-described emissions-reduction measures. The year 2010 represents the period 2008 - 2012. The data in the table is based on the research report "Policy scenarios for climate protection", 1997

Tab. V.2.3.1 Nitrous-oxide-emissions projections

CO_2 equivalent (Gg) (kt)	1990	1995	1999	2005	2010
Sectors	Inventory			Projections	
Total emissions	**66216**	**64852**	**43741**	**46457**	**45185**
1 Energy	**11346**	**12586**	**12121**	**13361**	**13361**
A Combustion	11346	12586	12121	13361	13361
3 Transport	3193	5580	5580	6510	6510
B Fuel production, processing and distribution	NE	NE	NE	NE	NE
2 Industrial processes	**25420**	**25420**	**4030**	**6634**	**6634**
3 Use of solvents and other products	**1860**	**1860**	**1860**	**1860**	**1860**
4 Agriculture	**26350**	**23746**	**24490**	**23362**	**22090**
5 Land use and forestry	**NO**	**NO**	**NO**	**NO**	**NO**
6 Waste	**1240**	**1240**	**1240**	**1240**	**1240**

Germany's nitrous-oxide emissions are generated mainly by industrial production processes (especially adipic-acid manufacture), agriculture and combustion. Measures approved to date are expected to reduce nitrous-oxide emissions by about 30% between 1990 and 2010 (Table V.2.3.1).

Tab. V.2.3.2 Changes in nitrous-oxide-emissions projections with respect to 1990

%		1995	1999	2005	2010
Sectors		Inventory		Projections	
Total emissions		**-2%**	**-34%**	**-30%**	**-32%**
1 Energy		**11%**	**7%**	**18%**	**18%**
A Combustion		11%	7%	18%	18%
3 Transport		75%	75%	104%	104%
B Fuel production, processing and distribution		NE	NE	NE	NE
2 Industrial processes		**0%**	**-84%**	**-74%**	**-74%**
3 Use of solvents and other products		**0%**	**0%**	**0%**	**0%**
4 Agriculture		**-10%**	**-7%**	**-11%**	**-16%**
5 Land use and forestry		**NO**	**NO**	**NO**	**NO**
6 Waste		**0%**	**0%**	**0%**	**0%**

Measures in the area of industrial processes, to which emissions from nitric-acid and adipic-acid production are assigned, are expected to play the largest role in the expected development. Adipic-acid production was responsible for about one-third of N_2O emissions. Now that manufacturers have been phasing in systems for thermal and catalytic decomposition of N_2O, an N_2O-emissions reduction of about 75% can be expected in the area of industrial processes, as of 2005, with respect to 1990.

In the agriculture sector, slightly decreasing use of nitrogen fertilisers is expected to lead to an emissions reduction of 16% between 1990 and 2010.

The energy sector exhibits two different developments. On the one hand, more and more common use of 3-way catalytic converters in motor vehicles, and overall increases in transports, have increased N_2O emissions. On the other hand, N_2O emissions from stationary combustion systems have decreased, in a trend paralleling that for CO_2 emissions. Introduction of improved catalytic converters can keep transport-related N_2O emissions at moderate levels. This development is supported by the European Fuels Directive (98/70/EC), which provides for gradual introduction of low-sulphur fuels and has been in force since 1 January 2000. As of 2005, the total N_2O-emissions increase in the transport sector, with respect to 1990, is likely to stabilise and remain at about 100%.

V.2.4 Projections for hydrofluorocarbons (HFCs)

Table V.2.4.1 presents emissions projections for HFCs, along with emissions trends to date, taking into account the presumed effects of the above-described emissions-reduction measures. The year 2010 represents the period 2008-2012. The data in the table is based on the research report "HFCs, PFCs and SF_6 emissions in Germany, and potential reductions", 1999.

Tab. V.2.4.1 Hydrofluorocarbons – emissions projections with approved measures

CO_2-equivalent (Gg) (kt)	1990	1995	1999	2005	2010
Sectors	Inventory			Projections	
Total emissions	**2340**	**3130**	**4278**	**14980**	**19840**
2 Industrial processes	**2340**	**3130**	**4278**	**14980**	**19840**

Since the early 1990s, hydrofluorocarbons (HFCs) have been increasingly used as substitutes for CFCs and HCFCs, which deplete the earth's ozone layer and promote the greenhouse effect. As a result, HFC emissions come primarily from use of these gases in an broad range of applications: as propellants in polyurethane insulation-foam sprays, for stationary and mobile refrigeration, in polyurethane foams (some of which are foamed with HFCs), as aerosols in asthma sprays and industrial cooling and compressed-air sprays and in semiconductor manufacture. Approved measures by themselves will permit HFCs emissions to increase by about 750% by 2010.

Currently, many application sectors are preparing the way for future technologies. Whether introduction of climate-friendly technologies becomes possible will depend centrally on the political framework. Table V.2.4.2 presents the expected effects of the above-described additional measures for HFC-emissions reduction.

Tab. V.2.4.2 Hydrofluorocarbons – emissions projections with additional measures

CO_2-equivalent (Gg) (kt)	1990	1995	1999	2005	2010
Sectors	Inventory			Projections	
Total emissions	**2340**	**3130**	**4278**	**10670**	**10770**
2 Industrial processes	**2340**	**3130**	**4278**	**10670**	**10770**

As the table shows, the increase in HFC emissions could be limited to 360% in 2010, with respect to 1990. This estimate is based on the assumption that HFC use will be discontinued in the application areas of solvents and fire retardants, apart from exceptions. Reducing rates of leakage from supermarket and industry refrigeration/freezer systems is seen as another important measure. In addition, use of halogen-free substances as HFC substitutes in propellants for PU insulation-foam sprays also provides significant potential for reductions. HFC emissions from PU and XPS foams will increase in coming years; such emissions could be effectively reduced, in a great many products, via use of CO_2 as a substitute for HFC propellants.

V.2.5 Projections for perfluorocarbons (PFCs)

Table V.2.5.1 presents emissions projections for PFCs, along with emissions trends to date, taking into account the presumed effects of the above-described emissions-reduction measures. The year 2010 represents the period 2008-2012. The data in the table is based on the research report "Emissions of HFCs, PFCs and SF_6 in Germany, and potential reductions", 1999.

Tab. V.2.5.1 Perfluorocarbons - emissions projections with approved measures

CO_2-equivalent (Gg) (kt)	1990	1995	1999	2005	2010
Sectors	Inventory			Projections	
Total emissions	**2694**	**1764**	**1709**	**2038**	**2525**
2 Industrial processes	**2694**	**1764**	**1709**	**2038**	**2525**

Currently, production of primary aluminium is by far the largest source of PFC emissions. The second-largest source is semiconductor production, in which such gases are used in etching processes. PFCs are also emitted in production of circuit boards, and increasing amounts are being released from refrigeration equipment, in which PFCs gases are used as refrigerants. Taking into account approved measures, such as the primary-aluminium industry's voluntary commitment, and the sharp increase in emissions from the semiconductor industry, only a small PFC-emissions reduction – 6% – can be expected in 2010, with respect to 1990.

One suitable option for slowing the increase in emissions from the semiconductor industry is to use NF_3 as a substitute for PFCs in etching processes. This additional measure could probably cut the emissions increase from this source by more than half, since NF_3, while an effective greenhouse gas, is largely broken down during relevant processes and is not emitted in waste gases. Table V.2.5.2 presents the expected effect of the described additional measures for PFC-emissions reduction.

Tab. V.5.2.2 Perfluorocarbons - emissions projections with additional measures

CO_2-equivalent (Gg) (kt)	1990	1995	1999	2005	2010
Sectors	Inventory			Projections	
Total emissions	**2696**	**1764**	**1554**	**1441**	**1132**
2 Industrial processes	**2696**	**1764**	**1554**	**1441**	**1132**

As the table shows, a 58% reduction in PFCs emissions could be achieved in 2010, with respect to 1990.

V.2.6 Projections for sulphur hexafluoride (SF_6)

Table V.2.6.1 presents emissions projections for SF_6, along with emissions trends to date, taking into account the presumed effects of the above-described emissions-reduction measures. The year 2010 represents the period 2008-2012. The data in the table is based on the research report "Emissions of HFCs, PFCs and SF_6 in Germany, and potential reductions", 1999.

Tab. V.2.6.1 Sulphur hexafluoride - emissions projections with approved measures

CO_2-equivalent (Gg) (kt)	1990	1995	1999	2005	2010
Sectors	Inventory			Projections	
Total emissions	**3896**	**6238**	**5473**	**4015**	**4995**
2 Industrial processes	**3896**	**6238**	**5473**	**4015**	**4995**

The most important sources of SF_6 emissions include automobile tyres, soundproof windows and electrical systems and equipment. Smaller emissions sources include use of SF_6 as a protective gas in aluminium casting and as an etching gas in the semiconductor industry. With only the measures approved to date, along with voluntary commitments by manufacturers and users of switching equipment and SF_6 producers – aimed at preventing emissions release from switching systems taken out of service – and declining demand for SF_6 as a fill gas for automobile tyres (a result of improved environmental awareness), an emissions reduction of about 35% can be expected between 1995 and 2005. On the other hand, an expected rising demand for soundproof-window replacements after 2005 is likely to increase SF_6 emissions through 2010 to such an extent that the emissions reduction by 2010 might be as low as 20%, with respect to the 1995 level, and as low as 28% with respect to 1990.

With additional measures, such as a prohibition on use of SF_6 in automobile tyres and alternative soundproof-window technologies, SF_6 emissions could be reduced by about 24 % between 1990 and 2010 (Table V.2.6.2).

Tab. V.2.6.2 Sulphur hexafluoride – emissions projections with additional measures

CO_2-equivalent (Gg) (kt)	1990	1995	1999	2005	2010
Sectors	Inventory			Projections	
Total emissions	**3896**	**6243**	**5688**	**2677**	**2947**
2 Industrial processes	**3896**	**6243**	**5688**	**2677**	**2947**

VI Expected impacts of climate change and risk assessment

The impacts of climate changes always occur 'locally', in the relevant systems. Assessments must thus be based on forecasts of future regional climate development. Regionalised projections of future climate developments still represent the very limits of forecasting with current model calculations. While some regional predictions have been made, their reliability is considerably limited. These limitations apply even more strongly to predictions regarding rainfall and extreme events than to forecasts of annual mean temperatures, and yet rainfall and extreme-event data is particularly significant in terms of possible impacts.

Nonetheless, a picture seems to be emerging for Europe whereby higher temperatures and smaller amounts of rainfall are expected, especially during the warmer half of the year, for the Mediterranean and, in part, for eastern Europe, with the result that the summer droughts already prevailing in regions of Spain, Italy and Greece are likely to intensify.

The expected changes for western and northern Europe include milder, wetter winters and a trend toward drier, warmer summers.

The trends for Germany are difficult to predict in that the boundary between the two trends is likely to run through Germany.

VI.1 Agriculture

Germany's climate, with moderate temperatures and usually adequate and well-distribution rainfall, is relatively favourable for agricultural production (farming), although moderate temperatures limit production to one annual harvest.

With a range of options in annual crop selection and farming methods, Germany's farmers are likely to be able to deal with climate changes in the foreseeable future, and thus no climate-related problems are expected to occur in the area of food production – especially since higher CO_2 concentrations and higher temperatures could have a positive effect on crop yields.

On the other hand, problems could occur in eastern regions such as Brandenburg, where sandy, poor soils tend to keep yields relatively small and a relatively continental climate already provides little rainfall. Higher temperatures and even smaller amounts of rainfall could create deficits in soil moisture and lead to resulting structural changes.

And rainfall frequencies and distribution, in addition to total rainfall amounts, could also play an especially important – possibly problematic – role.

VI.2 Forests

After agriculture, forestry, conducted on 1/3 of the country's total area, is the second-most important type of land use in Germany. Forests perform a broad range of functions. They supply wood, a key raw material, they bind/store CO_2, thereby protecting the soil, water, air and climate, and they provide habitats for many plant and animal species. Forests also protect human beings against natural dangers (such as rockslides and avalanches) and they provide people with a haven for many forms of recreation and relaxation.

It is simply impossible to predict how the climate changes scientists consider likely will affect forests. The reasons for this are as follows:

- The uncertainty in predictions regarding the nature and direction of regional climate changes is greater than that in derivations of average global values.
- Annual temperature and rainfall cycles play a more important role in plant growth – especially growth of forest ecosystems – than do temperature and rainfall averages. Weather extremes, which can place stresses on forest ecosystems, also play a highly significant role.
- Climate changes must be seen in connection with other components of global change – especially substance inputs – as well as with the direct impacts of forest management on forest ecosystems. The various effects can reinforce each other or cancel each other out.
- No single reaction pattern prevails; forest ecosystems can react in different ways, depending on the vegetation zone, forest type and location concerned, to changes in temperatures, rainfall and substance inputs.
- The climate at any forest location influences not only the various plants and animals involved in building the forest, it also influences their relationships and interactions (for example, competition, predator-prey relationships, host-parasite relationships, symbioses, etc.).

The following risk factors are interrelated with climate change:

- The climate of the future could differ sharply from that to which today's forest ecosystems are adapted. In any given case, it is impossible to predict whether processes of adaptation to new climate conditions will take place slowly, through gradual changes in prevailing tree species, via generational changes in forests, through appearance and disappearance of species and through gradual formation of new communities, or whether the adaptation will occur via catastrophic events involving the collapse of entire forest areas. In any case, it is clear that today's forests will experience considerable changes, within their tree lifespans (depending on tree species, between about 100 and 300 years), changes whose magnitude may exceed key critical thresholds.
- As part of forest management, attempts can be made to prepare for expected climate changes – for example, via selection of suitable tree species. This option has limited usefulness, however, due to the considerable uncertainties prevailing in regional climate forecasts and the longevity of forest trees.
- But even gradual adaptation, actively supported by forest management, is likely to lead to losses of biodiversity: animal and plant species that are unable to move to new biotopes, due to the isolated locations of their current habitats or to their slow rate of propagation, could die out. Climate change will also spark directional genetic selection (loss of genetic diversity).
- Increased dryness in spring and summer, and higher temperatures, could increase the frequency and severity of forest fires.
- Higher summer temperatures, in combination with the same or lower levels of summer rainfall, could increase the danger of drought stress.
- The developmental cycles of many insect species depend strongly on temperatures. Higher temperatures lead to faster growth of individuals, faster rates of reproduction and larger generations. These factors, in turn, enlarge the risk of population explosions. Furthermore, range shifts can occur, i.e. forest-damaging species can move into areas where they previously did not occur. Climate change can encourage the growth of natural enemies and parasites of such insects, but it can also slow their growth.
- The frequency of extreme weather events such as storms can increase.

These risk factors interact with each other and with other dangers, and they can reinforce each other.

Apart from its aforementioned risks, climate change could also promote forest growth, depending on location and combinations with other influences. For example, a study of the European Forest Institute (EFI) concluded that the rate of forest growth throughout Europe has been increasing. Discussion of the possible reasons for this trend has focused on a combination of factors, including forests' recovery from earlier overuse, nitrogen inputs, higher atmospheric CO_2 content and longer growing periods as a result of the climate changes that have already occurred. The relative significance of such individual factors is difficult to quantify, and any such weighting would also have to depend on location. This "positive" trend comes at the cost of serious destabilisation of forest ecosystems, and its positive sides should not be overemphasised. As a rule, climate change – especially in connection with air pollution – tends to reinforce stresses. In 1997, to improve understanding of possible trend scenarios, the Federal Government commissioned a research project entitled "Germany's forests and forest-management sector under global change".

In an integrated, model-based analysis of potential effects, this study considered impacts of climate changes on forest-development dynamics and forest growth, impacts of various forest-management decisions and economic consequences in the forest sector. The study also linked forest-inventory data with location information and interpolated climate data and designed a "model forestry operation" comprising Germany's most important forest types. The development of this model forestry operation was then simulated in light of different management strategies and two different climate models. The two climate models differ primarily in terms of their assumptions regarding annual rainfall amounts and distribution. The comparison showed that the simulated systems reacted very sensitively to variations in rainfall amounts and seasonal distribution in a future climate. The study also indicated that climate change would have different effects, depending on location and tree species. Reduced growth rates are likely at locations increasingly stressed by drought. Where moisture is sufficient, however, productivity can increase. Of the tree species considered, namely fir, beech, oak and pine, fir proved to be most sensitive. It exhibited reduced growth rates at almost all locations considered; in the driest regions, it was no longer able to survive. And the simulations did not take into account tree species' special sensitivity to extreme events – for example, events such as storms and explosion of bark-beetle populations. Under the climate scenarios studied, beech, oak and pine trees would fare better, but even these species would be subject to increased drought stress in drier regions.

With regard to wood production, the study found that a further increase would occur under the wetter climate scenario, while a decrease would occur under the drier scenario. The authors concluded that overall, Germany's forest-management sector would be able to deal with the impacts of climate change. In locations with unfavourable conditions, however, serious ecological and socio-economic consequences would be possible.

VI.3 Natural ecosystems

Ecosystems are considered "natural" if they are subject to little or no anthropogenic management and if they are especially well-adapted to specific local conditions. High-alpine vegetation communities are examples of such ecosystems.

Changes in climatic conditions and increasing atmospheric CO_2 concentrations both affect species spectrums, because both of these factors favour some species and inhibit others.

In addition to undergoing changes in their species compositions, ecosystems' natural responses to changes in climatic conditions include migrations toward areas where their original conditions are found. In the case of warming, therefore, ecosystems could tend to wander toward the poles and, in mountain areas, to higher elevations.

The land-use conditions in Germany would preclude northward migrations in many cases, since the country's agricultural land, and especially its farmland, would function as a barrier and since relevant biotopes are linked only to a very limited extent.

In mountain regions, migrations to higher elevations are of course limited by the heights of the mountains concerned; Germany high mountains include only the northern periphery of the Alps, with a maximum elevation of 2963 m (Zugspitze).

VI.4 Water resources

Climate change could increase frequency of winter flooding, while also lengthening dry periods in summer. In surface waters, these two factors could lead to persistent run-off levels below critical thresholds, with corresponding impacts on water quality and aquatic ecosystems. The expected reductions in run-off would occur primarily through reductions in total rainfall, coupled with seasonal shifting of rainfall from spring and summer into cooler months. Increased evaporation in spring and summer can cause low-lying areas, pond areas and bogs to absorb extreme amounts of water from near-surface groundwater and from run-off.

While the available long-term water supply will probably not change, its seasonal distribution can be expected to change.

VI.5 Infrastructure

Global climate change could increase the number and intensity of extreme events such as storms, torrential rainfall and floods, hail, etc.. In each case, the resulting damage would affect relevant owners.

The world's largest re-insurance company has been calling attention to the increasing frequency of extreme events, especially storms and floods, in recent decades. In areas at risk, damages from such events increase especially sharply when no countermeasures are taken – for example, when human uses are not adapted to potential risks and no suitable structural measures are taken.

This insurer had to pay an estimated 2 billion DM in claims as a result of damages caused solely by the December 1999 storms "Lothar" and "Martin".

Extreme events affect the transport sector, especially air and water transports. While aircraft operations profit from warmer winters, with less snow and ice, they are hindered by storms. Shipping operations suffer under both high-water and low-water conditions.

The tourism sector is highly sensitive to weather conditions. Germany's North-Sea and Baltic Sea resorts could profit from a trend toward warmer summers. Winter resorts could suffer, since milder winters will tend to produce poorer snow conditions.

VI.6 Human health

With milder winters, rates of cold-related illness could be expected to decrease. On the other hand, summer heat waves could be expected to lead to considerable increases in rates of illness and death, especially among people with health problems and weaker constitutions – including older people and children.

Changes in climatic conditions could also change habitats for a number of disease-transmitting agents, and thus such vectors could change their ranges. Since a general warming trend is prevailing, vectors can be expected to enlarge their ranges into northern latitudes, and thus Germany could find itself confronted with diseases previously confined largely to subtropical areas. Such developments must also be seen in the context of a globalised economy and global tourism.

To date, there are indications that ticks and Leishmaniosis vectors have been changing their ranges in Germany.

VI.7 Coastal regions

To be able to assess climate change's impacts on ecological and economic development and use of coastal regions, one must be able to assess climate-related changes in hydrography (for example, changes in water levels, flow relationships or sea states, as a result of change in wind strength). No reliable findings have yet been obtained regarding the extent of such changes on Germany's coasts. On the other hand, the IPCC's forecasts concerning development of global sea levels can serve as a guideline in this area. These forecasts predict a mean rise of 0.09 - 0.88 cm in sea levels in 100 years.

Coastal habitats cannot be conserved and developed unless coastal-protection measures are taken. German coastal-protection facilities are designed to provide a level of protection in keeping with analysis of long-term observations of storm-flood events and careful consideration of any expected impacts of climate changes.

For this reason, Germany's coastal-protection structures have long been designed to include a safety margin, with respect to sea-level increases, of 25 - 30 cm in 100 years and of 15 - 25 cm in 100 years in Mecklenburg-West Pomerania. Developments along coastlines are continually monitored and carefully evaluated, to permit prompt response to any changes that cannot be foreseen at the present time. Especially careful attention must be given to changes in the frequency and intensity of extreme events such as storms and storm floods, since the high-water levels and changes resulting from extreme weather situations provide indications of how coastal-protection systems and facilities need to be enlarged in order to protect coastal dwellers and property. The evidence clearly shows that the frequency of medium and severe storm floods along the North-Sea coast has increased over the past three decades. The high-water marks of storm floods of 1976, 1981 and 1994, for example, were all higher than that of the 1962 flood. Nonetheless, it is not possible at present to identify trends caused by climate changes, as explained above.

Ever since the catastrophic storm flood of 1962, construction of coastal-protection structures has been given special priority. The inhabited areas that must be protected along the German North-Sea and Baltic-Sea coasts comprise some 11,000 km^2 of lowland areas (land lower than 5 m in elevation). While no precise statistics are available concerning the numbers of people and amounts of assets that must be protected in these areas, it is clear that very considerable numbers of inhabitants and amounts of assets are involved. For example, it is estimated that the following numbers of people and amounts of assets must be protected: in the Weser-Marsch region, 76,000 inhabitants, 30,900 jobs and 8 billion € in assets; in Hamburg, 180,000 inhabitants and 10 billion € in assets; and in Mecklenburg-West Pomerania, a flood plain totaling 105 km^2 in area and harbouring 163,000 inhabitants and assets worth some 2 billion €.

Today, 90 % of Germany's North-Sea and Baltic-Sea coastlines are already protected by means of coastal-protection structures. The protection afforded by these structures is such that, given current coastal-protection practice, impacts on protection levels for people and assets in coastal regions could occur only if sea levels were to rise, quickly, to levels higher than today's safety margins. Such rises in sea levels are not currently expected. Today, 249 km, or 70%, of Mecklenburg-West Pomerania's Baltic-Sea coast is retreating. The mean rate of coastal retreat is 34 m / 100 years. Such land losses could accelerate, however.

The working group "Coastal protection and increases in sea levels" of the Trilateral Wadden Sea Conference studied the possible impacts of higher sea levels on the natural systems of the Wadden Sea, along the North Sea. In this working group, experts responsible for coastal protection and nature conservation along the North Sea coast worked jointly. In its report, the group concluded that the Wadden Sea ecosystem is highly adaptable and would thus be able to compensate for changes resulting from a sea-level rise of 25 cm over 50 years. As explained above, current understanding indicates that such a sea-level rise will not occur, or be exceeded, along German coasts. As a result, no negative impacts on the Wadden Sea's natural systems, such as changes in species composition or bioproductivity, are expected. On the other hand, for such a scenario, the group estimated that 5 - 15 % in additional costs would be incurred in maintaining current levels of protection afforded by coastal-protection systems.

VII Financial support and technology transfer

VII.1 Principles and priorities for co-operation with other countries

The central message provided by the United Nations Conference on Environment and Development (UNCED), which took place in 1992 in Rio de Janeiro, is that the **environment and development** are inextricably linked. The declarations and agreements resulting from that conference, including the Rio Declaration, Agenda 21 and global conventions on biodiversity, climate and desertification, testify to the joint responsibility of industrialised and developing countries in promoting sustainable development.

The Federal Government's development-assistance policies, the responsibility for which lies with the Federal Ministry for Economic Cooperation and Development (BMZ), are in keeping with the principle of sustainable development. Cooperation in designing international agreements, and support for developing countries in implementation of such agreements, represents an important contribution to global structural policy. Development assistance helps create the favourable frameworks necessary for implementation of global environmental-policy and development-policy aims. With such assistance and co-operation, the Federal Government also meets contractual commitments from a growing number of international agreements.

Environmental and resources protection is an overarching task in German development-assistance policy, as well as a sectoral focus that the Federal Government seeks to apply in co-operation with individual partner countries. Protecting the natural environment is always an integrated aim of development-assistance projects. All development-assistance projects, for example, must undergo a mandatory environmental-impact-assessment procedure.

Funding for environmental protection and resources-conservation has steadily been growing, percentage-wise; it now accounts for about one-third of all bilateral development assistance of the Federal Ministry for Economic Cooperation and Development (BMZ).

Climate protection has been playing a more and more important role in development assistance since the 1992 UNCED Conference in Rio de Janeiro and the signing (at that conference) of the United Nations Framework Convention on Climate Change (FCCC). It is clear that developing countries are especially threatened by the impacts of climate change – even though it still impossible, in spite of progress in research on the consequences of climate change, to predict exactly what these impacts will be, for human beings and natural systems. It is clear that the poorest countries and people will increasingly suffer from the consequences of the rise in the earth's average temperature: from weather extremes (storms, floods, droughts), the expected sea-level rise, drought-related crop failures and faster spread of tropical diseases.

According to rough estimates, climate change will generate worldwide costs in the hundreds of billions. The most recent forecasts of the Intergovernmental Panel on Climate Change (IPCC), as reported in the IPCC's Third Assessment Report, represent a major challenge – also for the Federal Government's development assistance: climate protection, in the form of **emissions reductions**, can be seen as urgently required, worldwide, in order to protect decades of efforts in development aid. For this reason, climate protection is an important aim of the Federal Government's development assistance. Binding emissions reductions in the industrialised countries are keys to launching a long-term process of climate protection. On the other hand, climate-protection efforts must also be intensified in developing countries, with the support of industrialised countries. It is thus important to consider, in a long-term light, how developing countries that play an important role in climate policy – especially countries that already have high emissions levels or whose emissions are rapidly increasing – can be more effectively integrated, internationally, in emissions-reduction policies. This need is oriented especially to the commitments such countries have made to limit their emissions as of 2013.

And yet reduction of greenhouse-gas emissions alone will not suffice, even if this aim, in keeping with the precautionary principle, will remain a central priority of any future climate policy. **Adaptation to climate change** is increasingly also becoming a topic of bilateral and multilateral development assistance. Above and beyond providing effective assistance in connection with disasters, assistance must be provided in the area of disaster preparedness. In addition, the need for adaptation to climate change must also be taken into account in relevant projects in the areas of water resources, ecosystems, agriculture, infrastructure and health care. The Federal Government's Action programme 2015 includes efforts in the area of adaptation to climate change, as a contribution to worldwide efforts to reduce extreme poverty by half.

In sum, climate policy is becoming one of the most important tasks in long-term sustainable development.

The Federal Government considers its emphasis in the area of climate-oriented development-assistance measures to lie in "**no-regret" and "win-win" measures**. These terms refer to measures that enhance economic performance, as a result of cost reductions from lower consumption of energy and raw materials, as well as minimising environmental stresses – especially climate-harming impacts – via reduction of emissions and waste. Successful climate-protection measures should generate both **local and global benefits**. For example, small, non-central photovoltaic systems in sunny countries or efficiency enhancements in old power stations can contribute to climate protection by reducing emissions, can improve local air quality, can provide low-cost electricity to rural and urban populations and can reduce firewood consumption, thereby protecting forests. Careful planning of settlements, and selection of adapted grain crops, can minimise weather extremes' impacts on people.

Partner countries should be enabled to carry out and shape their roles in climate protection actively and **responsibly**. Industrialised countries can help by creating the necessary framework, providing supporting financing and helping, via development of capacities and modern, adapted technologies, to build environmentally compatible, resources-conserving economic systems.

It is thus not surprising that partner countries' demand for projects in the areas of environmental protection, resources conservation and sustainable energy supplies has been growing sharply in recent years.

It is important to note that developing countries are already making considerable efforts of their own in climate protection and adaptation to climate change, even though they are not yet expressly obligated to make such efforts. The Federal Government is giving priority to supporting such efforts; a key basis for the long-term effectiveness of such efforts is that they be integrated within climate-oriented programmes and projects in national action programmes and sector strategies. In particular, it is important to make use of, or build on, existing sustainable development strategies or other action programmes (such as programmes to combat desertification or to protect biodiversity). Such integration is necessary in order to achieve catalytic and synergies effects, as well as the required **policy coherence**.

Close co-operation between industrialised countries and developing countries is an indispensable element of climate protection in developing countries. With regard to current climate negotiations, this means that the frameworks and structures for international climate protection must be designed in keeping with developing countries' interests in economic and social development.

The Federal Government attaches special importance to the **Clean Development Mechanism** (CDM). The CDM integrates developing countries in industrialised countries' emissions-reduction commitments under the Kyoto Protocol (see also VIII.2.1).

In the multilateral sector, the **Global Environment Facility (GEF)** is an important instrument for financing climate protection and its integration within policy aims of developing countries and with support aims of other development-assistance institutions (see also VIII.3.1). The Federal Government strongly supports strengthening the GEF and consolidating its tasks.

VII.2 Bilateral co-operation

The area of environmental protection and resources conservation represents one of the emphases of the Federal Government's bilateral co-operation. About one-third of the total bilateral financial support provided by the Federal Ministry for Economic Cooperation and Development (BMZ) goes toward environmental projects, most of them involving climate-protection measures. As part of its contribution to prevention and management of climate changes, the Federal Government supports developing countries in their efforts to fulfil their commitments to implement the Framework Convention on Climate Change and to prepare themselves for the possible impacts of pending climate change. With such actions, the Federal Government provides important financial and conceptual contributions to the strengthening of climate protection. The measures it has developed in cooperation with partner countries apply to sectors that, pursuant to Article 4.1.c of the Framework Convention on Climate Change, have particular significance in combatting climate changes: energy, traffic and transport, industry, agriculture and forestry. Support for partner countries in preparation for mechanisms for sustainable development is becoming increasingly significant.

Even through it is seldom possible to calculate how many tonnes of greenhouse gases individual development-assistance projects carried out through bilateral cooperation save, many such projects support aims of the Framework Convention on Climate Change. The Federal Government regularly reports to the FCCC Secretariat regarding such projects. The group of projects includes efforts in the areas of renewable energies, including wind power, small hydroelectric power stations, biogas and solar stoves; modernisation of power stations; gas-and-steam power stations; efficient energy use; transport; waste; forestation and forest protection.

The Federal Government plans for future bilateral co-operation to give even greater consideration to global environmental concerns – i.e. to increase the share of measures with contributions to climate protection still further. Such plans are the starting point for the initiative "Protecting the future through climate protection". In two areas of emphasis – renewable energies and tropical forests – funding was increased in 2000, and it is to be maintained at a high level. Annual support for renewable energy amounts to 200 million DM, a level considerably higher (plus 25%) than the average level of support provided in previous years. Total annual support for tropical-forest protection amounts to 250 million DM.

VII.2.1 The Convention project "Climate-protection programme in developing countries"

Since 1992, support has been provided for the Convention project "Climate-protection programme in developing countries", with the aims of helping developing countries in fulfilling their commitments under the Framework Convention on Climate Change, in making use of the resulting development opportunities and in integrating adaptation to climate change within development strategies. A total of 20 million DM have been invested in the programme. In recent years, intensified support has been provided to measures for preparation of implementation of the "Clean Development Mechanism" (CDM). The CDM is to remain a strategic emphasis of the project. In addition, intensified consideration is to be given to measures in the area of adaptation to climate change. The programme works to mobilise partners for climate protection in developing countries, among other development-assistance institutions, in private industry and among non-governmental organisations. An important aim of these efforts is to integrate climate-protection aspects within Germany's relevant bilateral development assistance projects (cf. Table VII.5.2).

VII.2.2 Capacity building

Strengthening of institutional and personnel capacities (capacity building) plays an especially significant role for developing countries. Relevant measures are aimed at strengthening relevant organisations and institutions, as well as enhancing their personnel resources, to enable such organisations and institutions to carry out urgent measures and to detect environmental problems promptly and, increasingly, manage such problems with their own resources.

Development-assistance projects can draw on a broad range of instruments in capacity building: knowledge transfer, organisational development, advising, training and further training of native experts and managers – for example, of decision-makers in the areas of policy and industry, with respect to environmental-management issues. A range of supporting measures, carried out in the framework of the Federal Government's financial co-operation, strengthen personnel and institutional capacities.

Especially important focuses of these participation-oriented and process-oriented projects include methods for environmental management, environmental communication and conflict management, and use of market-economic instruments in environmental policy. In addition, projects provide and jointly develop know-how that supports networking between different players in state and non-state sectors. Environmental and climate problems normally affect a broad range of sectors and different players whose interests can conflict. To deal with such problems, concerned parties must cooperate, balance their interests and manage their conflicts.

Capacity building, within the framework of the Framework Convention on Climate Change, provides an important basis that developing countries need in order to fulfill their commitments and make use of opportunities under the Convention and the Kyoto Protocol. The group of least developed countries (LDCs) is especially dependent on this support, since these countries have the least resources for carrying out climate-protection policy and preparing themselves for climate change. The Federal Government thus supports partner countries in building and expanding scientific and technical infrastructures. It supports technology centres, research institutes and institutions for promoting economic development.

VII.2.3 Clean Development Mechanism

The Clean Development Mechanism (CDM) represents a new approach in development assistance in the area of climate protection. Players in industrialised countries can meet their own reduction commitments under the Kyoto Protocol via certain climate-protection projects in developing countries. The Federal Government attaches special importance to the CDM, since the CDM helps achieve two complementary aims – climate protection and sustainable development. Private industrial involvement in the CDM ensures that funding directed at these aims is efficiently allocated. For developing countries, the CDM provides important opportunities to modernise their energy supply systems. In addition, it can be used, to a limited extent, for afforestation and re-afforestation measures. Germany considers it especially important, with regard to the CDM, that it be used to achieve high-quality emissions reductions, that opportunities for early public participation in project planning and review be provided and that relevant environmental impact assessments be carried out, to ensure that other ecological or social concerns are not neglected. With such an approach, the CDM can develop into one of the most important new instruments for co-operation between North and South.

Via its Convention project "Climate-protection programme in developing countries", the Federal Government supports partner countries in preparing for the CDM. This work includes development of national CDM strategies, sector studies and project approaches. In addition, the programme engages in the capacity building needed for efficient approval and management of CDM projects. Further-training measures, such as workshops for international dialog on climate protection in developing countries, on enhancement of CDM methods or on project monitoring, help strengthen personnel resources.

Capacity-building measures can help enhance equality of opportunity in competition, between developing countries, for CDM projects. The Federal Government has thus begun working with relevant local partners in order to identify and prepare – in an exemplary approach – projects with CDM potential.

Financing of projects for emissions-reduction certificates is the responsibility of the private sector, however. Funding from development assistance (ODA - official development assistance) is not to be used for such financing. The Federal Government is working to provide the basis for intensified involvement of the private sector in the CDM [in part, via "public-private partnerships" (PPP)].

VII.2.4 Energy

As the 21st century opens, industrialised countries are still the largest emitters of greenhouse gases. Industrialised countries' per-capita emissions are five-to-ten times as high as those of developing countries. Nonetheless, developing countries also play a role in the continuing growth of global emissions. Even if industrialised countries meet their commitments under the Kyoto Protocol, emissions growth in developing countries will cause global emissions of greenhouse gases, in the first commitment period (2008 – 2012) to be higher than emissions in 1990. With continuing increasing use of fossil fuels, such as oil and coal, in electricity generation and for heating, cooking and mobility, by 2025 developing countries will be responsible for nearly half of all greenhouse-gas emissions and thus will contribute significantly to global climate change. Also as a result of their justified development requirements, developing countries will play an important role in the forecast doubling of primary energy consumption over the next 50 years.

As a result, not only must industrialised countries make major efforts in areas such as energy-saving, efficient energy use and spread of renewable energies, countries in transition and developing countries must also make intensified efforts in such areas. Development assistance can, and must, contribute to reduction of growth in energy consumption. Since half of all greenhouse-gas emissions occur in the energy sector, energy efficiency and renewable energies represent key approaches to a sustainable energy supply and are the central components of ecologically sustainable policy. The Federal Government is aiming, in its co-operation with developing countries, to slow growth of energy-related emissions by means of relevant measures. At the same time, selected measures should promote development. The Federal Government thus supports the use and spread of sustainable, decentralised energy-production technologies, especially renewable energies, and it is calling for efficiency improvements in energy generation and distribution and is urging consumers to use energy more efficiently.

Aims in co-operation with partner countries include:

- Meeting energy requirements in order to improve living conditions,
- Ecologically, economically and socially sustainable economic development,
- Strengthening developing countries' technological capabilities in the energy sector,
- Reducing developing countries' dependence on imported energy,

- Supporting developing countries in implementing resolutions of the UN Conference on Environment and Development, especially the Framework Convention on Climate Change.

There are still many hindrances to the spread of renewable energies and energy efficiency. A broad range of different approaches is needed in order to achieve the decisive strategic effects required for worldwide economies of scale, viable markets and access to long-term loans (also in rural areas). The Federal Government is thus continuing to help reform sector policies in developing countries – away from dirigistic subsidies for old energy-generation technologies and toward greater private involvement – and it is working to help provide funding for long-term financing for new technologies.

VII.2.5 Industry

Important components of the Federal Government's climate-oriented activities in developing countries include improvement of energy efficiency in industry and introduction of elements of closed-substance-cycle waste management: provision of new, cleaner process technologies, as well as use of downstream "end-of-the-pipe" technologies where appropriate.

Another key instrument, along with technological improvements, consists of cost-covering energy prices. Such prices contribute effectively to energy-saving, since retrofits and modernisation of installations normally pay off only following revamping of price structures, i.e. following introduction of cost-covering rates. A new instrument that is also being applied consists of environmentally oriented lines of credit for local development banks charged especially with advising small and medium-sized companies in making their production processes environmentally compatible, and with providing relevant financing.

VII.2.6 Agriculture and forestry

Destruction of tropical forests (including rain forests and forests in drier areas), with its serious impacts on global climate, on species diversity and on living areas of local populations, is one of the world's largest environmental problems, as the IPCC's most recent assessments have again confirmed. Forest fires and forest clearing destroy forest biomass, which binds carbon and thus is a natural CO_2 sink. Many developing countries' significant emissions sources include such activities, which release greenhouse-gas emissions and create irreparable damage – not only for the climate. Forest loss also brings about widespread soil erosion and desertification, disrupts water cycles and causes shortages of wood for cooking and building, effects that threaten the existence of many millions of people in rural areas of developing countries.

Conservation of remaining forests thus plays a special role in development assistance. Sustainable forest management and development of "buffer zones" are important instruments for protecting forests. And yet slowing forest destruction – whether resulting from clearing, forest fires, logging or flooding – has proved to be a particularly daunting task, as a result of the many different types of factors and interactions at work. Rapid, determined efforts by affected countries and the international community are needed to combat loss of tropical forests, with its global threats and impacts and its complex causes and contexts.

For many years, therefore, German development assistance in the environmental sector has emphasised conservation of tropical forests. The Federal Government has been helping to develop and implement national tropical-forest programmes in numerous developing countries. Each year, the Federal Government provides some 250 million DM[9] for projects in developing countries, thereby making Germany the largest funder of bilateral projects for tropical-forest conservation.

Within the context of its bilateral co-operation, the Federal Government is a key financial participant in multilateral initiatives for conservation of tropical forests. Germany's contribution to implementation of the international pilot programme for conservation of tropical rain forests in Brazil (PPG7) is particularly significant. The Federal Government provided the initiative for this effort in 1992. To date, a range of funders have provided over 353 million US$ (as of October 1999) for core projects within PPG7, with Germany paying the largest share. Internationally, the pilot programme is seen as a good example of an overarching, coordinated programme

[9] Differences between this figure and figures in Table 9. 2. 1 result from the fact that Table 9. 2. 1 includes only forestry-sector activities with direct impacts on climate.

approach, involving both industrialised and developing countries, for conservation of tropical forests.

Forests will survive only when it becomes more profitable to manage them sustainably than to clear them for other uses. This is why, in past development of regional and national forest-use strategies, all approaches that were out of harmony with the needs of the people who lived in, or from, forests proved ineffective. And for this reason, development-assistance programmes and projects are aimed at enabling people – especially local populations, indigenous peoples and non-governmental organisations – to participate suitably in forest-management planning and in earnings from forest uses. Projects supported via forestry-sector co-operation must be oriented to forest conservation and sustainable forest management and must be in keeping with the needs of local rural populations. The most important basis for such orientation includes regional and national land-use planning – which is still often lacking – and integration of forestry measures in relevant national development strategies.

The climate-change problem is closely related not only to issues such as conservation of tropical forests and protection of biodiversity, but also to key issues in the area of agriculture and rural development. In dry regions especially, climate change is closely tied to desertification. Sub-humid, semi-arid or arid regions, as well as regions subject to flooding, droughts and desertification, are particularly vulnerable to the negative impacts of climate change. While the IPCC, in its Third Assessment Report, is still unable to predict how increasing concentrations of greenhouse gases in the atmosphere will affect desertification, there is already solid evidence showing that changes in temperature, evaporation and rainful intensify desertification in many regions. At the same time, desertification affects climate, especially local climate. As land turns to desert and its surface moisture decreases, more energy becomes available for warming the soil and, thus, the atmosphere's lower layers. What is more, soil erosion and thinning of vegetation reduce the land's ability to bind CO_2.

Since the mid-1980s, combatting desertification has been one of the Federal Government's support emphases and a priority area for co-operation with developing countries.

VII.2.7 Transport and traffic

Rapidly growing transports are responsible for an ever-growing share – also in developing countries – of total greenhouse-gas emissions. In addition, automobile and truck exhaust contains ozone-precursor substances (NO_X and VOC), which intensify the greenhouse effect. Some 40% of energy used by developing countries is used in the transport sector. As a result, reasons of climate protection also dictate that local public transportation be promoted in such countries. The Federal Government has been supporting relevant projects in a range of cities, including Shanghai, Canton, Jakarta, Surabaya and Santiago de Chile. By helping to expand local public transportation systems – especially rail systems – in cities, as well as helping to improve transport planning and training and further training (for many different types of players, covering a spectrum from decision-makers to automobile mechanics), German development assistance is helping to improve the performance of transport sectors, with regard to both mobility efficiency and climate protection.

VII.2.8 Measures for adaptation

It is still impossible to predict what the specific consequences of climate change for people and the natural environment will be. On the other hand, it is already clear that those with the lowest greenhouse-gas emissions – namely, developing countries – will suffer the most under the impacts of climate change. As a result, anthropogenic climate change is also an issue of equity between North and South. When the earth's average temperature increases and sea-levels rise and weather extremes (storms, floods, droughts) become more common, millions of people in coastal areas could lose their land. Drought-related crop failures could increase in frequency, fruit-growing regions in the tropics could be threatened and vectors for malaria and other tropical diseases could spread rapidly.

The natural disasters of recent years (central America, Indian subcontinent, Mosambique and Madagascar), which have destroyed the fruits of years of development assistance, have brought the vulnerability of people and the natural environment into ever sharper focus and have given an idea of how strongly developing countries could be affected by the impacts of climate changes. According to UN estimates, climate change will generate costs of some US$ 300 billion worldwide, and it will affect living standards especially in developing countries.

Consequently, relevant efforts in future must not be confined to reducing greenhouse-gas emissions and protecting and enlarging CO_2 sinks; more and more attention must be given to mitigating the negative impacts of climate change and to reducing relevant countries' vulnerability, via suitable measures for adaptation. This issue is of key importance especially for the most strongly affected countries – in Africa, central America and Asia and the group of small island states.

Even through discussion regarding suitable measures for adaptation to climate change is still at a very early stage (the extent, time and local impacts of climate change have not yet been precisely determined), the Federal Government is already seeking to support its partner countries in their efforts to prepare themselves.

Measures for adaptation in developing countries particularly threatened by climate change are to be financed via the existing GEF Fund and three new climate funds under the GEF umbrella. One innovative way to finance measures for adaptation is to use part of the earnings from the CDM. The Federal Government is supporting such measures – especially within the context of its bilateral co-operation – by helping to develop proposals for adaptation strategies for developing countries and by supporting policy-oriented scientific research.

Another important way of supporting measures for adaptation is to strengthen institutional and personnel resources in developing countries. Via such "capacity building", the Federal Government is working to help affected countries identify relevant problems. These efforts include strengthening institutions in such a way that adaptation issues enter into development-policy planning and approved policies are more effectively implemented (for example, with regard to specific development plans). A broad spectrum of measures is available for supporting adaptation to climate change. In addition, to construction of protective infrastructure (such as dams and dikes), this spectrum also includes: forward-looking settlement planning in protected areas, adaptation of crop selection (including use of salt-resistant plants, for example), measures to support food security, including measures for food storage and food sales, introduction of sustainable irrigation methods, provision of information to local populations regarding potential risks, efficient early-warning systems, removal of barriers to migration of flora and fauna, improvement and reorganisation of the health-care sector and small-scale afforestation.

Measures in the areas of organisation, information and preparation can help to mitigate damage without generating major expense. Such efforts enhance opportunities for implementing cost-effective measures for adaptation, especially in poor countries. It is thus important for project planning in the aforementioned areas to take account of required adaptation to climate change, to ensure that projects' sustainability is not threatened.

Emphases to date of the Federal Government's support for measures directly related to climate change include combatting of desertification, protection of biodiversity and integrated coastal protection (conservation of intact ecosystems in coastal areas, such as mangrove forests and coral reefs). Activities in areas such as health care, regional planning and rural development also have positive impacts on developing countries' ability to adapt.

Outside of its regular programmes, and in the framework of its emergency and disaster assistance, the Federal Government provides food, emergency relief and immediate aid. In these areas, it spent a total of 200 million DM in 1998 and 283 million DM in 1999. This funding is augmented by many millions in charitable donations provided for emergency assistance, via non-governmental organisations, in developing countries. Special attention is being given, in such efforts, to sustainable improvement of national and local disaster preparedness and relief resources in areas especially at risk. Funding for emergency assistance and disaster relief is now also beginning to be used for introduction of sustainable protection mechanisms.

VII.3 Multilateral co-operation

In addition to its bilateral co-operation, the Federal Government also acts within a multilateral context – especially the Global Environment Facility (GEF) – to provide important contributions, in the form of both funding and know-how, to climate protection in developing countries. The Federal Government is working to have climate protection receive greater consideration within multilateral development assistance of the European Union, the European Investment Bank (EIB), the World Bank, regional development banks, UNDP, etc.. In the supervisory bodies of these organisations, the Federal Government is striving to ensure that support programmes reflect the aims of the Framework Convention on Climate Change.

In 1997, the Federal Government provided a total of 2.4 billion DM to multilateral organisations within the framework of public development assistance. In 1998 and 1999, it provided a total of 2.5 billion DM (i.e. in each year) to such organisations. It is not yet possible to break down such international organisations' services by direct relevance to the aims of the Framework Convention on Climate Change, however.

VII.3.1 The Global Environment Facility (GEF)

The Global Environment Facility (GEF) is the financing mechanism of the Framework Convention on Climate Change. It complements existing instruments of bilateral and multilateral development assistance. By assuming additional costs for measures that provide global benefits, parties to the Framework Convention on Climate Change (like parties to other international agreements such as the Montreal Protocol for protection of the earth's ozone layers, the Biodiversity Convention, the Convention on Persistent Organic Pollutants, the Convention on Desertification) can effectively fulfill their common – yet differentiated – responsibility. The GEF is also used to finance measures for protection of international waters, for combatting desertification and for forest conservation. The GEF's organisational and decision-making structure, which integrate interests of both donor and recipient countries, represents an important step toward the worldwide environmental and developmental partnership, as initiated at the 1992 Rio conference, for stabilisation of the global ecosystem.

In the area of climate protection, the GEF finances measures by which developing countries can fulfill their Convention commitments (especially their reporting commitments): greenhouse-gas inventories, strategies for emissions reduction and strategies for adaptation to climate change. The largest share of the facility's climate portfolio, however, goes toward specific measures for reduction of greenhouse-gas emissions and for binding of carbon dioxide (forest conservation). The GEF plays a global, leading role in introduction of new climate-protection technologies and in overcoming market barriers – especially in promotion of renewable energies, which account for over half of the GEF's climate-protection portfolio.

Since 1991, the GEF has provided some 1.3 billion US$ for climate-protection projects, an amount representing 37% of all of the GEF's commitments. GEF funding is complemented by funding, totalling some 6.4 billion US$, from other sources – mostly public-sector funding, but also funds from private companies and non-governmental organisations. The Federal Government contributes a share of some 12% - the third-largest of all countries' shares – to the resources of the GEF fund, the financing mechanism of the Framework Convention on Climate Change. When the fund's resources were replenished for the second time, Germany's contribution amounted to 236 million US$ (417 million DM). Within the framework of negotiations for the third replenishment of the GEF (the period until 2006) – negotiations which are to be concluded in 2002 – the Federal Government is working to have the GEF confirmed as the central financing mechanism for global environmental protection. In the negotiations, it is important to ensure that the GEF is suitably replenished, so that it can continue to carry out its tasks, without having to restrict activities to date.

Table VII.3.1.1 New and additional funding within the framework of the financing mechanism of the Framework Convention on Climate Change

	Germany's contributions, in millions of DM		
	1997	**1998**	**1999**
Global Environment Facility (GEF)	94	83	82

Source: Federal Ministry for Economic Cooperation and Development (BMZ)

VII.4 Programmes for technology transfer

The success of efforts for technology transfer depends on numerous factors. One of the most important such factors is a clearly regulated market that permits private companies to operate and that provides clear incentives for innovations in the environmental sector.

Development assistance can contribute to the establishment of such markets by providing advising relative to economic and sector-oriented policies. Furthermore, it can support exemplary projects that introduce new technologies and that help bring about the development of a "critical mass" of demand that enables new technologies to become profitable. What is more, such assistance can directly support projects for capacity building and network formation in the area of technology transfer. While the following section discusses only the last of these areas, the Federal Government is active in all three areas.

Within the framework of bilateral technical co-operation, technology transfer is promoted especially by the German Appropriate Technology Exchange Programme (GATE) involving the Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ).

GATE's purpose is to further the technological competence of industry, of non-governmental organisations and of other involved groups and to promote technologies that use existing resources optimally and are in keeping with partner countries' ecological and socio-economic needs. The programme provides comprehensive advising in the area of adaptation and dissemination of technologies. It supports delivery and exchange of technological know-how by regional partners, testing of new, innovative technologies and improved information services.

With focuses that include renewable energies, waste recycling, wastewater and waste treatment and resources-conserving agriculture, the programme operates an information centre for adapted technologies and produces documentation and relevant publications. GATE maintains cooperative partnerships with numerous organisations in Latin America and Asia, and it works with regional networks in Africa.

In addition, the Kreditanstalt für Wiederaufbau (KfW) promotional bank, with a location-establishment and technology programme running until 1998/1999, supported introduction of new technologies, by small and medium-sized German companies in developing countries, via long-term, low-interest loans. Within this programme, a total of some 35 million DM in low-interest loans was provided annually.

Tab. VII.4.1 Bilateral financial and technical co-operation with relevance to the Convention aims - 1997 (amounts in millions of DM)[10]

Recipient country	**Measures for reduction of GHG emissions**						**Measures for adaptation[11]**	**Other measures***
	Energy	**Trans-port**	**Forestry**	**Agriculture**	**Waste manage-ment**	**Industry**		
Egypt					5.8			
Ethopia			4					2.8
Albania	4							
Argentina						2.045		
Armenia	27.5							
Bangladesh		22					10.65	
Benin			0.7					
Brazil			20	2			15	
Chile			1					4
China	61.5	28	3				40	14.1
Costa Rica								0.54
Cote D‘ Ivoire			0.56					1.64
Ecuador			3					
Gabun								3

[10] It is not possible, with available statistical methods, to break these projects down to show their specific climate-protection components.
[11] Not including emergency prepareness and disaster assistance.

Gambia			0.48					1.5
Georgia	24							
Ghana					2			
Guinea			0.373					
Guyana								4
India	85						35	2.5
Indonesia	2		12.5					
Yemen				3.5				
Cameroon			3.5					
Cape Verde	9.2							
Kenya	28.2			4			8	
Columbia	3						3	
Lesotho			4.67					
Mali	0.76							1
Morocco								0.8
Mexico					5.5			
Mongolia	15							3.5
Nepal	12							
Pakistan	40					0.5		
Palestinian Territories					4			
Peru			4				5.5	

Philippines	3		5						4.5
Zambia			3.5						
Sao Tome & Principe									1.3
Sri Lanka	8		1						
Tanzania								2.5	
Thailand	3				3.5				
Turkey					45				
Tunisia					10				
Supra-regional projects	7		3		3			5.29	28.75
Vietnam	8	30	16						4
Central African Republic									0.32
Total	**341.16**	**80**	**85.8**	**9.5**	**78.8**	**2.55**		**124.94**	**78.25**

*) For greenhouse-gas inventories, pursuant to Article 4.1 (a) UNFCCC

Tab. VII.4.2 Bilateral financial and technical co-operation with relevance to the Convention aims - 1998 (amounts in millions of DM)[12]

Recipient country	**Measures for reduction of GHG emissions**						**Measures for adaptation[13]**	**Other measures*)**
	Energy	**Trans-port**	**Forestry**	**Agriculture**	**Waste manage-ment**	**Industry**		
Egypt	40							
Ethopia			2					
Albania	11							
Argentina						4		
Bangladesh	15						5	
Benin			3.82					
Bolivia							6	
Botswana					2			
Brazil	1.5		7				2.5	
Chile			0.4					
China	123	60	27					6.5
Costa Rica			3					
Dominican Republic			0.37					

[12] It is not possible, with available statistical methods, to break these projects down to show their specific climate-protection components.
[13] Not including emergency prepareness and disaster assistance.

Ecuador			0.5					
Gambia								0.56
Georgia	47							
Guinea	3		5.4					
Honduras			6.155					0.3
India		2						1.5
Indonesia							4	
Jordan	1							
Cameroon			3.8					
Madagascar			5		1.6			
Malaysia						3		4
Mongolia	10							
Nepal	81		6.5					
Nicaragua	5						0.88	
Niger			5					
Palestinian Territories					3.5			
Panama			4					
Paraguay			15					
Philippines					2.3			
Zimbabwe			1					
Tanzania	4		3				3	

Thailand	3.5							
Turkey					42			
Tunisia					2			
Supra-regional projects	26	2.5	2			4.3	6.53	
Vietnam		22	10					
Central African Republic			3					
Total	**371**	**86.5**	**113.95**		**53.4**	**11.3**	**27.91**	**12.86**

*) For greenhouse-gas inventories, pursuant to Article 4.1 (a) UNFCCC

Tab. VII.4.3 Bilateral financial and technical co-operation with relevance to the Convention aims - 1999 (amounts in millions of DM)[14]

Recipient country	Measures for reduction of GHG emissions						Measures for adaptation[15]	Other measures*)
	Energy	Trans-port	Forestry	Agriculture	Waste manage-ment	Industry		
Egypt	40							
Albania	5							
Bangladesh	25							
Bhutan			5					
Botswana					2			
Brazil			35					
China	20		12		82.77			9
Chile			13				3.5	
Dominican Republic	10							
El Salvador						3		
Ghana			6					
India						5	6	

[14] It is not possible, with available statistical methods, to break these projects down to show their specific climate-protection components.

[15] Not including emergency prepareness and disaster assistance.

Indonesia		25	5					
Cambodia								3.5
Cape Verde	4		3					
Kazakhstan	10							
Kenya							0.5	
Columbia			6					
Malaysia								1.5
Mali	14.9				1.7			
Mexico	1							
Mosambique					7			
Nepal	9		5					
Philippines					0.7		4	
Sri Lanka	20							
South Africa	11							
Thailand						4		
Tunisia					6			
Supra-regional projects	9.98		6.4				3.7	7.57
Vietnam			10					4
Total	**179.88**	**25**	**106.4**		**100.17**	**12**	**17.7**	**25.57**

*) For greenhouse-gas inventories, pursuant to Article 4.1 (a) UNFCCC

VII.5 Summary of projects

Tab. VII.5.1 Pilot programme for conservation of the Brazilian rain forests (PPG7)

Project name: Pilot programme for conservation of the Brazilian rain forests			
Project aim: Protection and conservation of the Amazon rain forest; reduction of carbon-dioxide emissions			
Recipient country/-region: Brazil	**Sector:** Forestry	**Funding:** 500,000,000 DM	**Duration:** since 1992
Project description: At their 1990 summit meeting in Houston, Texas (USA), the heads of state and government of the seven leading industrialised countries (G7 countries), together with Brazil, the European Union and the member states of the Amazon Pact, agreed to initiate a pilot programme in the Amazon, aimed at protecting the forest, supporting sustainable management and reducing environmental threats to the global climate – and thereby enhancing the survival changes of future generations. This agreement led to the world's largest international cooperation programme in the environmental sector. The very task of coordinating the programme, which was entrusted to the World Bank, is an unprecedented one – virtually no relevant comparable examples and experience are available to draw on. As a result, the Bank has had to develop its own solutions, gradually, to the often difficult planning and coordination problems involved. Local control of projects, and co-ordination with the World Bank, are carried out jointly by the Kreditanstalt für Wiederaufbau (KfW) promotional bank and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). These two organisations also			

coordinate all relevant German activities. The project and support activities carried out in the various measures areas (sub-programmes) of the PPG7 are oriented to a range of different dimensions and aspects of deforestation problems, including approaches to protection of forest ecosystems and of living areas for indigenous peoples, sustainable management of useful forest resources and locations, relevant forest and natural resources policies, institutional development, effective participation and organisation of target groups and programme participants, research, etc.. The programme's successes include clearly enhanced environmental awareness (regarding the importance of sustainable Amazon policy), Brazil's willingness to assume national responsibility for the programme, introduction of partnership processes in policy development and planning, strengthening of institutions relevant to the programme, demarcation of extensive protected areas for the indigenous population, the gaining of a fund of experience, via testing of improved forest-use and land-use methods, and reductions in greenhouse-gas emissions.
Contact: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH Dag-Hammarskjöld-Weg 1 D-65760 Eschborn Telephone: 0049-6196-79-0   Kreditanstalt für Wiederaufbau (KfW) Palmengartenstraße 5–9 60325 Frankfurt/Main Telephone: 0049-69-7431-0 World Bank Brazilian Forest Ministry, Brasilia
Impact on greenhouse-gas emissions: cannot be quantified

Tab. VII.5.2 Climate protection-programme for developing countries

Project name: Climate protection-programme for developing countries (KAP)			
Project aim: For partner organisations in developing countries to give increasing consideration to climate protection (GHG reduction, and adaptation) in relevant projects carried out via German development assistance (mainstreaming)			
Recipient country/-region: Asia, Africa, Latin America	**Sector:** Energy, industry, transport, adaptation-relevant sectors	**Funding:** 20,000,000 DM	**Duration:** since 1992
Project description: This Convention project, which was established in 1992, is supporting implementation of the Framework Convention on Climate Change and of the Kyoto Protocol. The project's aim is to support partner organisations in developing countries in taking climate protection (GHG reduction, and adaptation) into account in relevant projects of German development assistance. To this end, the project is carrying out a broad range of individual measures, in cooperation with partner organisations in over 20 different countries. This enables bilateral technical co-operation to contribute effectively to preparation of greenhouse-gas inventories, to identification of climate-change threats to developing countries, and to capacity building for better integration of climate protection within ongoing development assistance. At the same time, partner countries are being given more and more support in preparation for the CDM and execution of adequate measures for adaptation to the negative impacts of climate change. Finally, increasing efforts are being made to mobilise partners, from other development-assistance institutions, private industry and non-governmental organisations, on behalf of climate protection in developing countries.			

While the project's emphasis is on the energy sector, it also includes measures in the areas of industry, waste, transport and traffic and adaptation-relevant sectors.
Contact: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH Dag-Hammarskjöld-Weg 1 D-65760 Eschborn Telephone: 0049-6196-79-1352
Impact on greenhouse-gas emissions: cannot be quantified

Tab. VII.5.3 Zafarana Windpark project

Project name: Zafarana Windpark I – III			
Project aim: To contribute to global climate protection by preventing CO_2 emissions; to contribute to cost-effective provision of clean electrical energy, as an alternative to energy that would otherwise have to be generated from fossil fuels.			
Recipient country/-region: Egypt	**Sector:** Energy	**Funding:** 145,000,000 DM	**Duration:** since 04/1999
Project description: Egypt generates about 80% of its electricity in thermal power stations, most of which are gas-fired. Within the context of long-term preparations for an environmentally compatible and reliable energy supply, the Egyptian government decided to establish a windpark in Zafarana, on the Red Sea. This project, which is being supported by the German Federal Government, is generating clean electricity cost-effectively. It is thus contributing both to local air quality and to global climate protection (the latter by reducing CO_2 emissions). A total of some 140 individual wind turbines are planned. Each is rated at between 500 and 600 KW, and their total electrical output will be 78-85 MW. Once all the park's wind turbines are in place, it will feed some 300 GWh of electrical energy per year into the national grid. The project includes measures for connection to the grid (construction and expansion of transformer stations, and installation of a transmission line), as well as construction of the wind turbines themselves.			
Contact: Kreditanstalt für Wiederaufbau (KfW) Palmengartenstraße 5–9 60325 Frankfurt/Main			

Telephone: 0049-69-7431-0   New and Renewable Energy Authority, Egypt
Impact on greenhouse-gas emissions: Avoidance of some 180,000 tonnes of CO_2 per year, or 3.6 million t of CO_2 over the park's lifetime, with regard to generation of similar amounts of electricity in thermal power stations fired with natural gas and heavy oil.

Tab. VII.5.4 Energy-efficiency enhancement in coal-fired power stations

Project name:			
Enhancement of energy efficiency and CO_2 reduction; cooperation with the Centre for Power-Station Technology and the Energy Industry			
Project aim:			
Enhancement of efficiency and reduction of CO_2 emissions, through introduction of improved technologies in coal-fired power stations			
Recipient country/-region: PR China	**Sector:** Energy	**Funding:** 7,500,000 DM	**Duration:** 10/1995 - 09/2001
Project description:			
The PR of China generates nearly 70 percent of its electricity from coal. Many of its power stations are obsolete and highly inefficient (only the average, only 29 percent). As a result, they pollute their local environments with soot and produce CO_2 emissions that contribute to the global greenhouse effect. Since the late 1980s, Germany has been supporting both construction of new power stations and optimisation of existing ones. The project's pilot phase, which has been carried out in co-operation with the "Centre for Power-Station Technology and the Energy Industry" has been very successful. In southern China, the GTZ is testing use of a broad range of German measuring equipment. Efforts are also being made in the area of capacity building. Via training seminars (and other measures), relevant institutions' personnel-qualification levels and overall resources have been improved, especially in poorer provinces lacking in know-how and equipment. The GTZ has had particular success with a mobile measuring lab that has now been used in over 30 of China's 400 largest power stations. Its measurements have made possible power-station efficiency improvements that to date have saved some 240 million DM of coal (in world-market prices). Via the Kreditanstalt für Wiederaufbau			

(KfW), and acting under a loan agreement, the Federal Government is supporting procurement of additional mobile measuring laboratories starting in 2001. These vehicles will be used to optimise 400 power stations with a total output of 72,000 megawatts. The GTZ is charged with training Chinese experts in using the new measuring equipment. The new measuring vehicles are expected to facilitate savings of 1.8 million tonnes of coal, along with a CO_2 reduction of about 3.6 million tonnes.
Contact: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH Dag-Hammarskjöld-Weg 1 D-65760 Eschborn Telephone: 0049-6196-79-0 China Longyuan Power Group Corporation (CLYPG)
Impact on greenhouse-gas emissions: 2.7 million tonnes of CO_2 since the project began

Tab. VII.5.5 Promotion of biogas systems

Project name: Programme for promotion of biogas systems, I and II			
Project aim: Improvement of living conditions in rural households and reduction of pressure on the natural environment. Long-term use of biogas systems for generation of renewable energy, in rural households, for cooking and lighting; use of composted sapropel for fertilisation			
Recipient country/-region: Nepal	**Sector:** Energy, biomass	**Funding:** 29,000,000 DM	**Duration:** 03/1997 – 03/2003
Project description: This programme is helping to protect forest and wood resources, to improve the overall health-care situation and to reduce the workload on women and children. The biogas programme, which began in 1975, has been technically and financially supported since 1992 by development assistance programmes of the Netherlands. Since 1997, KfW has participated in the financing. In the first phase of the third follow-on programme (from March 1997 to June 2000), and via cooperation between Nepal, the Netherlands and Germany, a total of 38,600 systems (with estimated lifetimes of 20 years) have been installed. The second phase (BSP III-2) is slated to install an additional 63,500 systems. KfW provides funding partly as construction subsidies and partly as funding for refinancing loans issued by Nepali banks.			
Contact: Kreditanstalt für Wiederaufbau (KfW) Palmengartenstraße 5–9 60325 Frankfurt/Main Telephone: 0049-69-7431-0			

Agricultural Development Bank of Nepal (ADB/ N) Netherlands Development Organisation (NEDA)
Impact on greenhouse-gas emissions: Positive, but not quantified, reduction, via reduction of burning of wood from non-sustainable wood harvests

Tab. VII.5.6 Integrated solar-thermal power station

Project name: Mathania integrated solar power station			
Project aim: Demonstration and proof of feasibility of commercial operation of solar-thermal parabolic-trough technology, in combination with a gas-and-steam power station, in a developing country. As a result, initiation of worldwide replication of this technology, which is expected to reduce relevant costs significantly. Contribution to reliability and efficiency of production (productivity) of commercial consumers, through provision of additional energy. As a result, contribution to economic growth.			
Recipient country/-region: India, state of Rajasthan	**Sector:** Energy	**Funding:** 250,000,000 DM	**Duration:** 05/2001 - 05/2004
Project description: The project comprises the construction and operation of an integrated solar-thermal power station with gas-and-steam turbine (ISCC) and rated output of about 140 MWe. Some 35 to 40 MWe of this output will be generated solar-thermically, by means of a parabolic-trough mirroring system. The integration of solar-generated steam in a combined-technology power station is unprecedented worldwide. The system is expected to feed some 800 GWh/year of electrical energy into the grid; some 65 GWh/year of this electricity will be solar-based. A private general contractor, obtained through an international tendering process, will be charged with detailed planning, construction and operation for the first five years. The project is a pilot project that is to lead to a series of similar projects, planned in Mexico, Morocco and Egypt. To ensure that adequate institutional and logistical support is also available for any future expansion of the solar-thermal power station, the project framework also includes			

provision of technical support – including training programmes for local technicians.
Contact: Kreditanstalt für Wiederaufbau (KfW) Palmengartenstraße 5–9 60325 Frankfurt/Main Telephone: 0049-69-7431-0   Global Environment Facility
Impact on greenhouse-gas emissions: Some 13,090 million tonnes of CO_2 over the project's 25-year lifespan, compared to a power station fired with hard coal.

Tab. VII.5.7 Extinguishing of coal fires in the People's Republic of China

Project name: Extinguishing of coal-seam fires in the northern provinces of the People's Republic of China (PPP measure)			
Project aim: Development of strategies for extinguishing coal-seam fires in the People's Republic of China			
Recipient country/-region: VR China	**Sector:** Energy	**Funding:** 246,000 DM	**Duration:** 09/2000 - 11/2000
Project description: Large coal fires in China's northern provinces release large amounts of environmentally harmful CO_2 and methane – with local, national and even global impacts. In this project, carried out as a PPP measure and with a total volume of 871,000 DM, field studies of selected fires and their causes were carried out in cooperation with local Chinese partners. Comprehensive know-how was provided to enable Chinese experts to use modern techniques for constraining and preventing coal fires. To provide a framework for future co-operation in two pilot regions, RAG AG, Essen, and China's State Administration of Coal Industry (SACI) signed an agreement on cooperation in extinguishing and preventing coal fires. The GTZ will cooperate in the programme's execution.			
Contact: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH Dag-Hammarskjöld-Weg 1 D-65760 Eschborn Telephone: 0049-6196-79-0			
Impact on greenhouse-gas emissions:			

cannot yet be quantified

Tab. VII.5.8 CO_2 reduction in the transport sector of Surabaya

Project name: Pilot project for CO_2 reduction in the transport sector of Surabaya			
Project aim: Development of options to reduce CO_2 emissions of urban traffic in Surabaya			
Recipient country/-region: Indonesia	**Sector:** Transport	**Funding:** 1,350,000 DM	**Duration:** 11/1995 - 12/2001
Project description: Surabaya, Indonesia's second-largest city, is plagued with major traffic problems, including extremely dense, health-endangering air pollution caused by automobile emissions. No systematic findings are available regarding the suitability of emissions-reducing measures in developing countries' urban transport sectors. A study, carried out under commission to the Federal Ministry for Economic Cooperation and Development (BMZ), is preparing a concept for assessing and identifying instruments for reducing transport-sector CO_2 emissions. By reducing overall emissions and enhancing efficiency, the project will provide local benefits in the areas of health care, cost-effectiveness and ecology, as well as making a global environmental contribution. The project is operating under a municipal approach that is to make use of experience gained, in industrialised countries and, to a lesser extent, in other developing countries (for example, Curitiba in Brazil), with new ways of using transport systems. During the pilot project, experience gained with various CO_2-reduction approaches / concepts will be evaluated and processed relative to Surabaya's needs. In addition, a plan will be prepared for reducing CO_2 emissions in Surabaya's transport sector, and			

exemplary measures from an action plan for introduction of new transport systems and new forms of transport management will be phased in and implemented. Surabaya is thus serving as a pilot project for development of a sustainable urban transport system and for development of options and models for reducing transport-sector CO_2 emissions in large cities in developing countries.
Contact: Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH Dag-Hammarskjöld-Weg 1 D-65760 Eschborn Telephone: 0049-6196-79-0
Impact on greenhouse-gas emissions: About 880,000 tonnes of CO_2 per year

Tab. VII.5.9 Introduction of improved, energy-saving kilns (for ceramics) in Thailand

Project name:			
Thai-German project for promoting energy efficiency			
Project aim:			
Improvement of production quality and production management; reduction of energy costs and CO_2/ SO_2 emissions			
Recipient country/-region:	**Sector:**	**Funding:**	**Duration:**
Thailand	Energy	12,520,000 DM	10/1993 - 12/2001
Project description:			
A range of various new technologies was provided within the framework of the German-Thai project for promoting energy efficiency.			
For example, a new German kiln model was introduced to help modernise the very obsolete equipment and production methods used in the Thai ceramics industry. The new kilns are helping to enhance production quality and production management and reduce energy costs. Over a five-year period in this technology-transfer project, training seminars and workshops were carried out, and a training handbook was prepared, in order to familiarise companies with the new production methods. The new kilns have reduced primary energy consumption by 73% and energy costs by 70%. Since the first kiln was introduced, more than 1,500 ceramics kilns have been installed and are now providing major reductions in CO_2 emissions. This successful technology has also been introduced in Vietnam, the Philippines, India and Brazil, and it is also contributing significantly to CO_2-emissions reductions in these countries.			
Contact:			
Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH Dag-Hammarskjöld-Weg 1 D-65760 Eschborn			

Telephone: 0049-6196-79-0
Impact on greenhouse-gas emissions: 250,000 tonnes of CO_2 per year 3,000 tonnes of SO_2 per year

Tab. VII.5.10 Environmentally compatible energy supply in the Mekong region, as a contribution to sustainable development and to global climate protection

<table>
<tr><td colspan="4">Project name:

Environmentally compatible energy supply in the Mekong region, as a contribution to sustainable development and to global climate protection</td></tr>
<tr><td colspan="4">Project aim:

In the Mekong region, ongoing enhancement of awareness, and of planning and technical expertise, regarding cost-effective options for using environmentally compatible energy-conversion technologies and renewable energies</td></tr>
<tr><td>Recipient country/-region:

Mekong region (Laos, Vietnam, Cambodia, Yunnan/China, Thailand)</td><td>Sector:

Energy</td><td>Funding:

1,926,000 DM</td><td>Duration:

since 2000</td></tr>
<tr><td colspan="4">Project description:

Via a joint dialog and training project, CDG and CORE (Council on Renewable Energy in the Mekong Region) are promoting the spread of renewable energies, as a contribution to a sustainable energy supply. CORE is a network of experts from public institutions, and from private-sector and public-sector companies, in Laos, Cambodia, Vietnam, Thailand and the Chinese province of Yunnan. The training project is assisting private and state companies in offering electricity and energy services on the basis of renewable energies. As part of this work, authorities and institutions responsible for energy planning are being advised in formulating strategies for intensified use of renewable energies.

The Mekong region's energy sector is highly diverse. In Laos, Cambodia and Vietnam, over 80% of rural residents are not connected to central electricity networks. Only 10% of all residents in the entire province of Yunnan are not connected to the grid. The</td></tr>
</table>

situation in Thailand is even more favourable.

The network's countries / regions also differ considerably in their current use of renewable energies. The Chinese province Yunnan and Thailand already have their own native production systems for solar-thermal collectors and photovoltaic modules. On the other hand, Laos and Cambodia have made virtually no use to date of such technology. The countries also differ in the extent of their experience with ultra-small hydroelectric power stations and biogas systems. The training project is thus supporting exchanges of experience between the countries in the Mekong region. At the same time, the project is contributing significantly to derivation of action plans from the countries' master plans for bringing electricity to rural areas – where action plans have already been formulated for intensified use of renewable energies (Vietnam) – and it is advising policy-makiners who are developing a strategy for concerted efforts to expand use of renewable energies (PR China).

In helping to provide a reliable energy supply and protect the climate, the project is not only promoting intensified use of renewable energies – it is also providing measures and methods for optimally efficient energy use. In the long term, it will also help to ensure that technical and vocational schools intensify their teaching of practical knowledge and skills in the area of renewable energies.

The project is being carried out in close co-ordination with the GTZ and with the support of German companies in the renewable energies sector.

Contact:

Carl Duisberg Gesellschaft e. V. (CDG)
Lützowufer 6-9
D-10785 Berlin
Telephone: 0049-30-25482110

Impact on greenhouse-gas emissions:

cannot be quantified

Tab. VII.5.11 Expanding use of wind power in Brazil and Argentina, in order to provide a sustainable energy supply

Project name: Expanding use of wind power in Brazil and Argentina, in order to provide a sustainable energy supply			
Project aim: To enable planners in engineering and consulting bureaus, power utilities and operating companies to plan megawatt-scale wind-park projects in accordance with technical and economic criteria, to develop the necessary financing concepts and to manage execution of projects. To enable companies in Argentina and Brazil to assume responsibility for maintaining and repairing installed systems, to manufacture relevant components and to build and install wind-energy systems under license arrangements.			
Recipient countries: Brazil and Argentina	**Sector:** Energy	**Funding:** 1,878,000 DM	**Duration:** since 1999
Project description: Before greater use can be made of wind resources, potential investors / operators must be comprehensively informed about the performance and cost-effectiveness of the latest generation of grid-connected wind-energy systems. Favourable financing agreements must be reached to give project planners, power utilities and other operators and systems access to national and international funding. And potential wind-farm operators must engage in discussions with financing institutions, in order to learn about loan conditions and options, including risk protection, guarantees, structures of contracts with electricity companies, etc.. By preparing business plans, and varying their parameters, planners can precisely analyse the factors that determine what wind-energy projects are cost-effective and can be partly financed via markets. This dialog and training project is also advising energy policymakers and regulatory authorities responsible for designing the political and economic framework for wind-energy use. Technical aspects of wind-energy use are being treated in special technical seminars; the principles of wind-energy use are being taught in introductory courses at various			

universities. At locations with good wind conditions and adequate network quality, wind-energy systems are very close to reaching the break-even point. Argentina and Brazil have the necessary technical basis for production of components for wind-energy systems. Both countries could be enabled to build their own wind-energy systems – either in joint ventures with German companies or under license arrangements. Furthermore, both countries provide a favourable basis for establishment of subsidiaries of German manufacturers of wind-energy systems. The effort is set up as a PPP project. The CDG's relevant, highly practically oriented dialog and training events are being carried out in cooperation with representatives of the German and Brazilian wind-energy industry. A number of scientific institutions, energy authorities, financing institutions and non-governmental organisations are involved as partners.
Contact: Carl Duisberg Gesellschaft e. V. (CDG) Lützowufer 6-9 D-10785 Berlin Telephone: 0049-30-25482110
Impact on greenhouse-gas emissions: cannot be quantified

Tab. VII.5.12 Highly efficient use of natural gas, as a contribution to an environmentally compatible energy supply in Brazil (PPP project)

Project name: Highly efficient use of natural gas, as a contribution to an environmentally compatible energy supply in Brazil (PPP project)			
Project aim: Provision of know-how – to managers, senior engineers and marketing and PR experts from the Brazilian natural-gas industry – regarding highly efficient technologies in Germany and Europe for transporting, distributing and using natural gas.			
Recipient country: Brazil	**Sector:** Energy	**Funding:** 220,000 DM	**Duration:** 2000 - 2002
Project description: Natural gas is playing an increasingly important role in meeting Brazil's energy needs. As a fuel for thermal power stations, natural gas produces significantly lower emissions than diesel and coal and is thus more environmentally compatible than those fuels. Natural gas can also benefit the environment when used as a fuel for transport. In cooperation with the Brazilian gas-industry association, ABEGÁS (Associação Brasileira das Empresas Estaduais Distribuidoras de Gás Canalizado), CDG has carried out training events for the Brazilian gas industry. These events have focused on providing know-how about highly efficient technologies for using natural gas – for example, in combined heat-power-refrigeration systems and in engines for buses and automobiles. The training project is also providing introductions to fuel-cell technology and information about technological progress in reformation of natural gas to hydrogen, storage of hydrogen and enhancement of fuel-cell efficiency. From a perspective of sound development-assistance policy and environmental policy, it is important to transfer know-how about this area to industries and research			

establishments in Latin America, since natural gas can only be considered a transition to fuel-cell technology and hydrogen-based systems. Yet another important aspect of the programme is that it provides opportunities for exchange between representatives of the Brazilian gas industry and German manufacturers of natural-gas systems.
Contact: Carl Duisberg Gesellschaft e. V. (CDG) Lützowufer 6-9 D-10785 Berlin Telephone: 0049-30-25482110
Impact on greenhouse-gas emissions: cannot be quantified

Tab. VII.5.13 Programme for investment in the future (Zunkunftsinvestitionsprogramm - ZIP)

Project name: BMU FuE ZIP			
Project aim: Study and development of environmentally compatible, non-nuclear energies			
Recipient countries:	**Sector:** Renewable energies	**Funding:** A total of about 30 million euros	**Duration:** 2001 to 2003
Project description: Research and development are being carried out in the following areas: - geothermal electricity generation - solar-thermal electricity generation - ecological supporting studies relative to offshore wind-energy systems - ecological supporting studies relative to use of stationary fuel cells - ecological supporting studies relative to use of biomass			
Contact: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit Referat Z II 7/ Herr Ludger Lorych 11055 Berlin Telephone: 01888 305-2351			
Impact on greenhouse-gas emissions: Potential for very large reductions; since the programme consists of R&D measures that do not begin reducing greenhouse gases until relevant results are implemented, the possible reductions cannot yet be quantified, however.			

VIII Research and systematic monitoring

Research on "environmentally sound sustainable development", encompassing research on "global change", is carried out in Germany primarily with funds from the Federal Ministry of Education and Research (BMBF) and the German Research Foundation (DFG). Funding from the BMBF is provided as project funding or – with co-financing from individual or several *Länder* – as institutional funding at the Helmholtz Society of German Research Centres (HGF) or by means of corresponding financing options at institutions of the Max Plank Society (MPG), the Fraunhofer Society (FhG) and the Leibnitz Association (WGL), financed on the basis of the "Blue List" model. Individual research institutions and projects are also funded by other German ministries – for example, by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), via the Federal Environmental Agency (UBA), and by the Federal Ministry of Transport, Building and Housing (BMVBW), via the German Weather Service (DWD). The *Länder* also provide support for research in this field, partly in cooperation with the Federal Government.

In 1997 the governmental programme "Research for the environment" set new priorities for all ministries involved. The chosen policy approach, with the guiding principle of "global sustainable growth", now gives greater consideration to the economic and global perspectives of sustainability. The concept of sustainability is gradually developing as a future-oriented development which gives equal consideration to ecological, economic and social requirements.

Annual government spending on "environmentally sound, sustainable development" amounted to around one billion DM in 1998; there were three focal points for this funding:

- "Socio-ecological research – regional sustainability": 40%
- "Industry-related sustainability – integrated environmental technology": 37%
- "Global change": 23%

With regard to the issue of "global change", the Advisory Council on Global Change (WBGU), set up in 1992, regularly submits recommendations for action and research to the Government. Previous annual reports from this Council focused on different issues, including soil (1994), freshwater (1997), environmental risks (1998), biospheres (1999) and global environmental policy (2000). The complexity of global relationships and the resulting challenge facing research became repeatedly clear in these reports. The WBGU addressed the issue of "climate change" in more detail in special reports on the Kyoto Protocol (1998), CO_2 reduction targets (1995) and climate-protection aims (1997).

A review of national and international research activities in the field of "global change" – started in 1997 and now completed – has led to a partial new orientation of research funding in Germany with regard to research topics and methods, and in particular to greater concentration on integrative approaches. The structure of funding for "global change" incorporates recommendations from the National Committee on Global Change Research (NKGCF), which was set up by the Deutsche Forschungsgesellschaft (DFG) in collaboration with the BMBF. These recommendations are geared towards strengthening integrativity, interdisciplinarity and internationality.

The funding for "global change" is based on four pillars: the BMBF project funding measures, set up in 1999 and 2000 and subsequently interlinked, on the issues of

- "Global change in the hydrological cycle" (GLOWA);
- "Biodiversity and global change" (BIOLOG);
- "Atmospheric research 2000" (AFO 2000);
- "German climate research programme" (DEKLIM).

In view of the bewildering diversity of relevant, very different, influencing factors, the scientific search for sustainable pathways of global change requires the barriers between scientific sectors to be overcome. This becomes clear even in defining the tasks related to climate change:

- Study of the global climate system, its current and previous changes and – on this basis – the development of instruments for predicting future climatic development;
- Provision of the necessary information for reliable assessments of the diverse impacts (including impacts on ecosystems) of climate change and the related development pathways;

- Development of technological and socio-economic strategies for action to prevent non-sustainable development paths; policy consultation.

The German climate research programme – DEKLIM – launched in 2000 for a period of 5 years, builds on previous funding measures by the BMBF: "climate system research" (1987-1994), sectoral funding measures on research into the impacts of climate change (1990-2000) and the "applied climate and atmospheric research" measure (1997-2000). In addition to these measures, the DEKLIM measures – like GLOWA, BIOLOG and AFO 2000 – pursue a policy of greater integrativity, interdisciplinarity and internationality, while at the same time promoting young scientists in this field.

The BMBF promotes the incorporation of German global change research into international and European programmes and enables the scientists involved to participate in and contribute to coordination meetings at national level, and to the organisation of international cooperation. The funded institutions include:

- The international secretariats of the IHDP, of BAHC (the IGBP core project), of BALTEX, the established European regional project within the GEWEX WCRP experiment, and of the EUROTRAC-2 EUREKA project;
- A national coordination office for contacts to the IPCC and the international programmes (WCRP, IGBP, IHDP, DIVERSITAS).

The German coordination office for contacts to the IPCC, financed by the Federal Ministry of Education and Research (BMBF) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), supports the incorporation of the results of German climate research into the IPCC process, most recently during the preparation of the 3rd Assessment Report (TAR). Many German climatologists are involved in the IPCC, several in key positions.

The BMBF is a member of the International Group of Funding Agencies for Global Change Research (IGFA), an informal group comprising national funding organisations from 25 countries. The BMBF took over the chair of this group in October 2000 for a two-year period; the IGFA Secretariat is located in Germany for the duration of this period.

VIII.1 Climate system and variability

Understanding natural climate variability is an important prerequisite for predicting future climatic development with sufficient certainty (taking into consideration anthropogenic influences). The importance of this issue is clear from the working title of the German climate research programme DEKLIM: "Climate development – from understanding variability to prediction", and its emphasis "climate variability and predictability."

Research into the causes of climate variability requires the assessment of directly measured and indirectly derived observations both of today's climate and the climate situation in the earth's history, together with further improvement in the modelling of linked systems (in particular, ocean and atmosphere, but also biosphere, land and ice surfaces).

In the DEKLIM emphasis on "climate variability and predictability", research linked to the relevant core projects of the WCRP (CLIVAR) and the IGBP (PAGES) is funded. This work is complemented by related contributions from the DEKLIM "paleoclimatology" study emphasis. With the aim of developing a consistent description of the spatial and chronological patterns of past climate conditions, these efforts emphasise use and proper combination of bioscientific and geoscientific data from various archives, together with the creation of a synthetic global time scale and the development of transfer functions for determining climate variables.

Paleoclimate projects with a close link to climate modelling are also funded. The focus here is on the catalogue of questions elaborated as part of the CLIVAR-PAGES initiative and on projects that can make significant contributions above and beyond this to understanding natural climate variability with a view to the predictability of future climatic developments. Study concentrates especially on those developments responsible for the variability, on a range of different timescales, including seasons, years, decades and several centuries.

Institutionally funded research in this area is carried out primarily at the Alfred Wegener Institute for Polar and Marine Research (AWI) and the Geo-Research Centre (GFZ). Some HGF research Centres (AWI, GFZ, FZJ, GSF, GKSS), financed by the HGF strategy fund, operate the project "Natural climate variations in historical times (KIHZ)". Universities and WGL institutions are also involved within the framework of funding from the Federal Ministry of Education and Research (BMBF).

VIII.1.1 Hydrological cycle

The global hydrological cycle is a fundamental component of the climate system. If ecosystems and societies are to be managed sustainably, in future-oriented ways, the causes and consequences of global changes in the hydrological cycle must be understood – in connection with understanding the availability, quality and distribution of water in different climate zones.

To this aim, the Federal Ministry of Education and Research (BMBF) launched GLOWA in 2000 for a period of 8 years. The goal of this funding measure is to elaborate integrated strategies for the sustainable and foresighted management of water and water bodies on a regional scale, taking into account global links between ecosystems and socio-economic framework conditions. Case studies, of different complexities, will seek to identify the key issues and detail parameters of global change in the hydrological cycle, with regard to water availability and the quality and distribution of water resources in various river basins and research them within an interdisciplinary framework. This work generates many links to DEKLIM.

Several river basins are being investigated within the GLOWA framework, giving due consideration to varying climatic zones:

- GLOWA IMPETUS (Draâ/Marocco, Ouémé/Benin)
- GLOWA Volta
- GLOWA Danube
- GLOWA Elbe
- GLOWA Jordan River

The following issues are of key scientific importance:

- Natural and anthropogenic rainfall variability and its influence on the hydrological cycle;
- Interaction between the hydrological cycle, biosphere and land use;
- Water availability and conflicts of use: population development, urbanisation, migration and industrialisation and the resulting changes in demands

regarding water available and quality; interaction between water (availability, quality and distribution) and human health.

The scope of tasks for the GLOWA funding measure is processed in the form of integrative and interdisciplinary projects; the first phase of funding covers a period of three years.

Regional process studies are also carried out in GEWEX, a WCRP experiment on the global hydrological and energy cycle. These studies include BALTEX, a project with established international cooperation that is studying exchange of water and energy in the Baltic Sea region. Germany's funding for BALTEX, in particular for BRIDGE, its intensive measuring phase, is a separate focal point of DEKLIM.

The key issues in this focal point include the influence of large-scale climate anomalies on climate variability in the Baltic Sea region; the influence of the variability of heterogeneous land surfaces, and of the Baltic Sea and its annual ice coverage, on the hydrological and energy balance in the Baltic Sea region; the development of an integral model system for identifying the interactions between the atmosphere, the Baltic Sea, the land surface, lakes and water cycles. From a methodical perspective, the new data assimilation techniques, and model validations with data from the operational measuring network, measuring projects and remote sensing, are especially relevant.

VIII.1.2 Atmosphere

Despite national reduction measures, pollution emissions in mid-latitude industrialised regions remain high and in some cases continue to rise. The rapidly growing emissions rates in developing countries and newly industrialised countries are increasingly polluting the atmosphere. Changed trace gas concentrations in the troposphere not only directly affect the prosperity of the people living in the greatly polluted regions and the ecosystems there; they also affect the regional and global climate. Building on the funding measures "climate system research" (1987-1996), with their most recent funding measures, inter alia, on "climate variability and signal analysis", "trace substance cycles" and "hydrological cycle", and supplementary to this support, funding from the Federal Ministry of Education and Research (BMBF) for basic research on atmospheric processes over recent years has comprised the following measures:

"Troposphere research"	[TFS],
"Pollution in aviation"	[SLF],
"Atmospheric aerosol"	[AFS],
"Ozone research programme"	[OFP],
"Atmospheric research 2000"	[AFO 2000].

The goal of the BMBF funding measure TFS (1996-2000) was to further understanding of the troposphere system, particularly regarding the problem of photooxidant formation (ozone pollution, summer smog) and resulting changes in oxidation capacity (the atmosphere's capacity to break down volatile organic trace gases) and to improve the scientific basis for future political decisions in the environmental sector within the framework of state precautionary research. The activities were divided into three categories:

- Elaborating and applying a meso-scale model hierarchy for diagnosis and prediction of pollution distribution over Germany and Europe;
- Anthropogenic and biogenic emissions, deposit of trace substances;
- Process studies on oxidant formation and oxidation capacity.

The climate link lies primarily in the considerable temperature dependency of the processes involved (e.g. the release of biogenic trace gases, and chemical reactions in the troposphere).

One of the goals of the BMBF funding measure SLF (1992-1997) was swift implementation, in aircraft technology (especially engines), of findings on aviation-related physical and chemical processes in the atmosphere. As well as collecting emissions data and indexes and investigating dispersion and transformation processes in the wake of aircraft, climate-relevant work was also at the forefront in the final phase:

- Investigating the global effects of condensation trails (influence on the radiation balance);

- Modelling the impacts of aircraft exhaust gases on ozone chemistry and the climate.

The BMBF measure OFP (1989-1999) analysed the seasonally variable, yet clearly observable, trend in depletion of stratospheric ozone in the northern hemisphere. The background for this was the threat from ozone depletion to the function of this layer as a natural filter for solar UB-V radiation, the resulting hazards (such as an increase in skin cancer) and the need for targeted measures to combat the causes (emission of halogenated hydrocarbons). The OFP encompasses projects on clarifying the ozone-relevant trace gas chemistry in the stratospheric gas phase and on the surfaces of stratospheric aerosols, on precise spectral measurement of UV-B radiation, on measuring ozone variability and on developing model-based instruments for improving predictability. The results, elaborated in close cooperation with European research partners, include findings, identified via the atmospheric radiation balance, on the interaction between the ozone layer and climate.

The BMBF funding measure AFS (1997-2001) studied an important link between climate system research and atmospheric research: the field of aerosol research. Aerosols can locally force negative radiation to an extent that overcompensates positive radiation forcing by greenhouse gases. Anthropogenic aerosols in the atmosphere are, however, very short-lived, so it was extremely important

- To describe atmospheric aerosols with regard to their physical and chemical properties,
- To investigate the cycle and distribution of particulate components in the troposphere and their interaction with atmospheric chemistry and the climate, and
- To take atmospheric aerosols' direct and indirect impacts on climate into account in order to help improve the significance of global climate models considerably.

A climatology of the vertical distribution of aerosol parameters at selected locations in Germany (LIDAR measuring network) was developed, via broadly harmonised national and international cooperation, along with the continuation and expansion of this network to Europe. Further significant results include findings from studies of the influence of aerosols on the earth's radiation field and important findings on particle formation and transformation processes, including precise information on optic, hygroscopic and chemical properties of aerosols, properties which are highly significant as factors influencing the lifetime and climate-relevant properties of clouds and cirri. Results also included improved descriptions of aerosol distribution in global climate models, inclusion of different aerosols and parametric development on the basis of AFS findings relative to microphysical and chemical processes. Findings from AFS provide the basis for realistic parameterisation of the above processes – which, in turn, is the basis for correct description in global chemical, transport and climate models.

The BMBF's AFO 2000 funding measure, launched in 1999 for a period of five years, provides a new foundation for support of German atmospheric research. Instead of the previous, rather isolated treatment of specific issues – mainly divided according to spatial compartments – the activities of the four previously named funding emphases are now combined in a new, integrative systematic approach. AFO 2000 pursues 3 main research goals:

- Improvement of understanding of the atmospheric system;
- Development and provision of environmental policy instruments;
- Funding of young scientists in the field of atmospheric research.

Research work is organised in the framework of the following four interdisciplinary and integrative groups:

(1) Interaction between the earth's surface and the atmosphere
Analysis of energy and substance cycles in the atmosphere, with the earth's surface as a source or sink for relevant factors.

(2) Chemistry, dynamics, radiation and their interaction
Investigation of the interactions between the different atmospheric layers – including the mesosphere, stratosphere and troposphere – and of the interactions between dynamic, physical and chemical processes.

(3) Multi-phase processes
Studies of aerosols (particles in the liquid and solid phase) and cloud systems, and of polar stratospheric clouds.

(4) Atmospheric systems analysis: models and data

Summarising analysis of monitoring data (in particular from satellites) and the results of complex numerical model calculations.

The results are expected to provide a basis for sustainable use of the atmosphere and for precautionary action to protect human health and biodiversity, both of which are directly and indirectly harmed by air pollution. They will also contribute to an improved understanding of the central interactions between changes on the earth's surface and climate, interactions which are conveyed by the entire atmosphere.

Progress in this field makes it possible to detect relevant changes earlier and make more precise predictions. It thus improves forecasts of the consequences of climate change and enhances the reliability of assessment of the effectiveness of environmental policy measures.

AFO 2000 is closely linked to DEKLIM, especially to its "climate variability" funding emphasis. Institutionally funded research on trace substance cycles is carried out inter alia at the Max Planck Institute (Max Planck Institute) for biogeochemistry in Jena.

VIII.1.3 Agricultural and forest emissions and sinks

Agricultural activities contribute directly to emissions of greenhouse gases, in particular CH_4 and N_2O. Furthermore, NH_3 emissions indirectly affect the heat and substance balance of the earth's atmosphere: NH_3 emissions lead to the formation of secondary aerosols, which may significantly influence the radiation balance. They contribute to eutrophication of natural and semi-natural ecosystems and to indirect emissions of N_2O. Nitrogen inputs from the air, in the case of natural soils, and soil cultivation and fertilisation, in the case of agricultural soils, can promote mineralisation of organic components, resulting in CO_2 emissions that, unlike the usual agricultural CO_2 emissions, do not have a neutral effect on the overall CO_2 "balance sheet". On the other hand, organic carbon can be bound in soils and forests (sinks).

In contrast to emissions estimates for other industrial sectors, estimates of emissions from agriculture and forestry, and of this sector's sink function, are still quite imprecise. Relevant agricultural research has thus focused on providing experimental and statistical foundations for suitable emissions inventories and on preparing such inventories. Research institutes of the Federal Ministry for Consumer Protection, Food and Agriculture (BMVEL) cooperated internationally in this regard, for example, in the EU concerted action "Biogenic emissions of greenhouse gases caused by arable and animal agriculture". They also coordinated their efforts at the national level, e.g. in the programme "Adaptation of German emissions-calculation methods to international guidelines, determination of levels of ammonia emissions from German agriculture and development of scenarios for reducing these emissions by 2010."

Work has commenced in the MIDAIR project, which is aimed at quantifying climate-relevant emissions from animal husbandry. The VERTIKO project (Vertical Transports of Energy and Trace Gases at Anchor Stations and Their Spatial and Temporal Extrapolation under Complex Natural Conditions; a programme within the Atmospheric Research Programme 2000 – AFO 2000) is studying the exchange of trace gases between agricultural land and the atmosphere. It incorporates measurements in atmospheres with increased CO_2 concentrations (FACE technique). In a study project of the Federal Ministry of Education and Research (BMBF) on "forest ecosystem research in Eberswalde – the influence of low precipitation and increased nitrogen inputs on pine, oak and beech forest ecosystems", institutes of the Federal Ministry of Food, Agriculture and Forestry (BML; former name) studied the exchange of substances between forests and the atmosphere. Smaller projects focused on quantification of climate gas emissions and the N balance in pasture farming and composting. The resulting measurements of substance and energy flows have been incorporated in the BIATEX-2 sub-project of the EUREKA EUROTRAC-2 environmental project.

VIII.1.4 Marine and polar research

The main objective of climate-related marine and polar research is to enhance understanding of the ocean's and polar regions' roles in global climate. The ocean directly influences the earth's heat and substance balances, and certain ocean areas, and the polar regions, are key regions with regard to global climate (polar ice and deposits are thus 'climate archives' that can reveal past climate changes). Climate changes, in turn, affect oceanic flow systems and the mass balance of polar ice caps, and they can fundamentally alter flows of climate-influencing gases and of heat.

Germany is involved in the corresponding core projects of the WCRP (especially ACSYS, WOCE, CLIVAR) and of the IGBP (especially JGOFS, PAGES). Studies on global circulation and heat transport, the global hydrological cycle and the global carbon cycle, including associated gases, are at the forefront of such efforts.

However, the role of the world's oceans in the climate system can only be fully understood through studies of the deep sea. The Federal Ministry of Education and Research (BMBF), in cooperation with scientific experts, has developed and implemented a deep-sea research concept in order to quantify, model and predict substance and energy transport in the deep sea.

Sediment and ice deposits in key areas are being investigated within the framework of PAGES, ODP (Ocean Drilling Programme) and EPICA (European Project for Ice Coring in Antarctica). These investigations are providing paleoclimatological findings about development of climate and bio-geochemical substance cycles throughout the earth's history. These findings form a basis for models and predictions of future changes in the interlinked ocean-atmosphere system. This work is closely linked to the DEKLIM funding emphasis "climate variability and predictability".

VIII.1.5 Monitoring systems

It is important to monitor a) the current state and development of the climate system, and of its subsystems; and b) the conditions of natural and human-used systems and structures that are affected by climate changes or global change in general.

German institutions such as the German Weather Service (DWD) and the Alfred Wegener Institute for Polar and Marine Research (AWI) play a significant role in international networks for monitoring the atmosphere and oceans.

Within the framework of funding for German environmental research, suitable measuring instruments have been developed and employed for measuring projects, both for in situ measuring and remote sensing. Balloons, aircraft and research ships (inter alia the Polarstern) are available for use as measuring platforms.

Systematic "Integrated Monitoring" (Allgemeine Ökologische Umweltbeobachung - ÖUB) plays a key role in the provision of ecological data. This monitoring is being set up in cooperation between the Federal Government and the *Länder*, in particular in UNESCO biosphere reserves. These efforts are focused on

– Harmonisation and merging of suitable monitoring systems of the Government and the *Länder*;

– Establishment of a network of permanently monitored areas, to support monitoring of the most important ecosystems;

– Integration of data within one information system.

The spectrum of German activities in the area of satellite-based earth monitoring is diverse. For instance, Germany is closely involved in missions of the ERS-1 European remote sensing satellite, which are used for environmentally oriented earth-monitoring, as well as in analysis of the resulting data. Germany also plays an important role in the POEM-1 programme, which was approved by the European Space Agency's 1991 Council Conference in Munich, and which consists of the ENVISAT-1 environmental satellite and the METOP-1 operational meteorological satellite.

The main goal of the ENVISAT mission is to make significant contributions to the study of the environment, especially in the areas of atmospheric chemistry and ocean/ice. Plans also call for monitoring the earth's surface with radar sensors, which can "see" through clouds or darkness. ENVISAT carries 10 different scientific instruments on board including the Scanning Imaging Absorption Spectrometer for Atmospheric Cartography (SCIAMACHY), which will provide major progress in the field of atmospheric sensing. SCIAMACHY was provided to ESA by Germany, the Netherlands and Belgium. The German part in this cooperation received sizable financing from the Federal Ministry of Education and Research (BMBF).

SCIAMACHY, MIPAS ("Michelson Interferometer for Passive Atmospheric Sounding") and MERIS ("Medium-Resolution Imaging Spectrometer") together make up an ENVISAT payload package that has been optimised in keeping with the goals of the ATMOS programme. MIPAS is a horizontally looking passive Michelson interferometer for study of atmospheric trace gases. It operates in the mid-infrared range. Installation of a ground segment for scientific analysis, and a comprehensive supporting scientific study relative to the development of the MIPAS sensor, were financed within the ATMOS framework. The MERIS instrument, a wide-angle spectrometer with mid-range geometric resolution, will be used to observe the oceans and land in the visible and near-infrared spectral range. With the ATMOS framework, special data products were developed for MERIS that will greatly enhance the quality of the data provided by ESA, and significantly broaden the relevant applications.

Germany's activities in preparation for the ENVISAT mission were integrated within the ATMOS programme as of 1989. The objective of this programme was to provide high-quality satellite data for research into global change. The ATMOS programme ended with the launch of ENVISAT and the conclusion its test and calibration phase (commissioning phase). In the interest of optimal use of ENVISAT, the Federal Ministry of Education and Research (BMBF) has begun shifting its funding in this area away from preparation for use and toward scientific use of ENVISAT data products. This emphasis has already been incorporated within funding criteria for the BMBF's AFO 2000 and DEKLIM funding emphases.

With regard to the field of operational monitoring, Germany contributes significantly, with its involvement in the METEOSAT programme, to a satellite system that will provide long-term availability – until 2012 – of earth-observation data. Such long-term availability is a fundamental requirement in any studies seeking to detect climate changes. By establishing a lead facility for use of data from operational meteorological satellites, in climate monitoring (satellite application facility (SAF) for climate monitoring), the German Weather Service (DWD) is working to contribute significantly to satellite-based remote monitoring of significant components of the climate system.

With the EUMETSAT Polar System (EPS), the European Organisation for the Exploitation of Meteorological Satellites (EUMESAT) will contribute to the global system of polar-orbiting satellites. The main focus of this mission is on long-term operational global weather and climate monitoring. Germany is bearing over 25% of the costs of the EPS. The corresponding development and supplementary activities are being carried out within the METOP-1 programme, which is also being supported by ESA and EUMETSAT.

Detailed information on German activities in the field of systematic monitoring is presented in Chapter VIII.5 ff.

VIII.1.6 Data and information management

In view of the vast amount of data gathered from systematic monitoring, information management is required that permits

- User-friendly processing of the data;
- Constant monitoring of data quality;
- Secure archiving of data and
- Easy access to data.

Germany offers the following information systems, which use data catalogues and meta-databases to facilitate users' data searches, and some of which can be directly accessed via the Internet:

The Remote Sensing Data Centre (DFD) of the German Aerospace Center (DLR) stores, manages and analyses satellite remote-sensing data. The "Intelligent Satellite Data Information System" (ISIS) is available to assist data users.

The Central Climate and Environmental Data Information System (ZUDIS) at the Karlsrule Research Centre (FZK) provides information on data compilations and databases containing climate-relevant data obtained from measuring and monitoring programmes in Germany.

In order to improve provision of climate-relevant data, a network of existing national databases and an information system are being set up under the supervision of the German Climate Research Centre (DKRZ). All authorities, scientific institutions and major research establishments able to provide climate-relevant data are involved in this project. This is also a contribution to the G7 ENRM project (Environmental and Natural Resources Management). The German Weather Service (DWD) provides a climate information system (KLIS) in the Internet.

At the German Oceanographic Data Centre, the German Maritime and Hydrographic Agency (BSH) collects oceanographic data gathered by German institutions.

There Alfred Wegener Institute for Polar and Marine Research (AWI) and the Potsdam Geo-Research Centre (GFZ) both maintain palaoclimatological databases.

The Environmental Planning and Information System (UMPLIS) of the Federal Environmental Agency (UBA) contains fundamental data on environmental protection, including emissions data for climate-relevant substances. The Environmental Research Catalogue (UFOKAT) provides an overview of research projects with environmental relevance in Germany. UV-B data is also collected and stored together with data from the Federal Agency for Radiation Protection (BfS) and data from the Länder in a central database at the UBA.

Further examples of information systems providing information on the environment in Germany include the LANIS Landscape Information System at the Federal Agency for Nature Conservation (BfN), the German Centre for Documentation and Information in Agriculture (ZADI) and various Länder information systems. A Federal/Land working group (BLAK UIS) is responsible for coordinating and harmonising the development of environmental information systems.

Research carried out on behalf of the Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL) collects, reviews, archives and processes data for inventories of agricultural emissions, including emissions of climate-relevant gases. BMVEL and BMU have agreed on the establishment of a joint database on "agricultural emissions", which will also cover climate-relevant emissions and sinks in the agricultural sector.

An environmental research information system (UFIS) is being set up at the GSF National Research Centre for Environment and Health to collect data from environmental research projects funded by the BMBF to date, with the aim of analysing the data in order to define overarching principles of model development and data collection.

The following data and information systems are in place in Germany in the context of international activities:

In addition to its efforts on behalf of the national climatological archive, the German Weather Service collects, processes, checks and archives international data distributed via the GTS, within the framework of the WMO's World Weather Watch programme. The German (DWD) and Japanese (JMA) weather services jointly operate a centre for monitoring the availability and quality of climate data (with the DWD focusing on precipitation data, and the JMA concentrating on temperature data) from the stations in the GCOS surface network.

International data centres for relevant data on the global hydrological cycle have been set up in Germany within the framework of the WCRP:

– The Global Precipitation Climatology Centre (GPCC), run by the German Weather Service (DWD);

– The Global Runoff Data Centre (GRDC) at the German Institute of Hydrology (BfG).

Both Centres are important components of the Global Climate Observing System (GCOS).

The Federal Environmental Agency (UBA) has taken on the task of setting up one of three centres worldwide for assuring and monitoring data quality within the framework of Global Atmosphere Watch (GAW). It is currently being supported in this effort by the Fraunhofer Institute for Atmospheric Environmental Research.

Central archives of data collected worldwide have been set up at the Institute for Marine Research (IfM; for marine data) at Kiel University, as part of JGOFS, an IGBP core project, and at the Alfred Wegener Institute for Polar and Marine Research (AWI; for paleontological data). Data assimilation (dynamic interpolation of data using global models) is being carried out within the framework of WOCE, a WCRP core project, at a special research centre at the Max Planck Institute for Meteorology, in cooperation with the German Maritime and Hydrographic Agency (BSH).

VIII.2 Modelling and prediction

Both short-term and longer-term predictions of climate development can have important implications for society. Since climate modelling is currently the only available instrument for attempts to predict the future climate, it is vitally important to improve the reliability of climate modelling. As a result, model methodology has been made a funding emphasis of DEKLIM.

Climate predictions are based on complex numerical climate models that describe global atmospheric and oceanic circulation as precisely as possible. The German Climate Research Centre (DKRZ), established in 1987 and financed by the Ministry of Education and Research (BMBF), provides computing resources for other German research institutions. A new supercomputer for climate modelling, also financed by the BMBF, is to be purchased in the immediate future. The DKRZ coordinates the European Climate Computing Network (ECCN), a network of the major climate computing centres in Europe, including the Hadley Centre and Météo France. The DKRZ and the Hadley Centre jointly coordinate the model calculations for the IPCC.

Climate simulations are carried out at the DKRZ. This work includes use of the ECHAM model, which was developed in cooperation with the Max Planck Institute for Meteorology, Hamburg, and has been used for IPCC status analysis. Simulation with coupled ocean-atmosphere circulation models makes possible study of climate variability and detection of the climate "signal" within the "noise" of climate variability. The focus of such efforts has been, and continues to be, the issue of the anthropogenic "fingerprint" in climate data recorded since the beginning of the industrial revolution.

Further development of existing model hierarchies is geared towards concrete applications, especially those from other DEKLIM funding emphases. Existing experimental data (from data networks, measuring programmes, paleoclimatology, remote sensing) is used for model validation; conversely, models are used for reconstruction and interpretation of present and past climate situations.

VIII.3 Impacts of climate change

VIII.3.1 Ecosystems

Assessment of the biosphere's possible reactions to climate change began at an early stage in Germany, especially in connection with modelling of the global carbon cycle. Initially, such assessment was highly aggregated and empirical (including statistical models on the net primary production of biomes).

If they are to be reliable, conclusions regarding the biosphere's long-term reaction to climate change must be based on ecosystem studies. Terrestrial ecosystem research deals with the structure, function and dynamics of representative ecosystems such as forests, river and lake landscapes, agricultural landscapes and urban-industrialised landscapes; research into marine ecosystems is carried out as part of marine research (see below).

Ecosystem research provides important information on the sensitivity of major ecosystems to climate changes, as well as on options for sustainable use or structuring of such ecosystems, especially with regard to the problems of global change. Integration of findings gathered from different disciplines can make it possible to recognise potential hazards at early stages.

Funding for climate-related ecosystem research in Germany comes from the Federal Ministry of Education and Research (BMBF) in the form of project funding and institutional funding. The institutions for ecosystem research that include research into aspects of climate change include:

- The Bayreuth Institute for Terrestrial Ecosystem Research (BITÖK)
- The Forest Ecosystems Research Centre in Göttingen (FZW)
- The Agroecosystems Research Network in Munich (FAM)
- The Ecosystems Research Project Centre in Kiel (ÖZK)
- The Centre for Environmental Research in Leipzig-Halle (UFZ)
- The Centre for Agricultural Landscape and Land Use Research (ZALF)

System properties of agroecosystems are also studied by research institutions of the Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL). The main goals of this work are the elaboration of models for plant growth, water balance, ecosystems and land use under changing atmospheric heat and substance flows.

Ecosystem research in Germany is linked to the UNESCO "Man and the Biosphere" (MAB) programme and to IGBP projects such as GCTE.

VIII.3.2 Agriculture and forestry

The possible impacts of climate change on agriculture and forestry were studied early on in Germany, in pilot projects.

In-depth study of the impacts on forests and forestry in Germany and of options for action is the subject of the project "Forests and forestry in Germany in the context of global change" (1997-2001), funded by the Federal Ministry of Education and Research. The BMBF has also funded pilot projects on the impacts on agriculture (including impacts on crop cultivation).

Within the competence of the Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL) numerous research projects with the following funding emphases are in progress, or are planned:

- The role of agricultural and forestry activities in climate change,
- The impacts of changing climate elements on agriculture, forestry and fisheries,
- Options and strategies for emissions reduction, carbon storage and adapting agriculture and forestry to climate changes,
- Systems analysis monitoring of agriculture and forestry as an instrument for precautionary policy decisions.

VIII.3.3 Coastal regions

The goal of the Federal-Länder project "Climate change and coasts" (1993-2001), which was funded mainly by the Federal Ministry of Education and Research (BMBF), was to create a scientific basis for development of decisions and application strategies, particularly with a view to any necessary measures (and possible conflicts of aims) for protecting people and ecosystems in coastal regions from rising sea levels and flooding.

Research in this field was organised primarily within interdisciplinary project networks. In the case studies with a regional focus (the island of Sylt, the Weser estuary), research was carried out via interdisciplinary integration and in cooperation with the regional institutions and authorities concerned.

A related project network is being funded in the context of the DEKLIM funding emphasis "climate impact research". Institutionally funded research on coastal zones management is carried out inter alia at the GKSS research centre.

VIII.4 Options for action

The results achieved thus far in the field of climate-impact research are incorporated within the DEKLIM funding emphasis "climate impact research", which aims to provide interlinked orientation and action approaches on the impacts of climate changes, including both short-term natural climate changes (such as ENSO, NAO) and longer-term climate changes, in part presumably anthropogenic.

Relevant research is focused on the impacts on natural and cultural landscapes and on socio-economic systems, and on their reactions to, and repercussions on, climate and climate-relevant trace substance cycles. This climate-impact research also gives due consideration to the reactions of socio-economic systems to existing, predicted or anticipated climate changes, to the social framework conditions that form the basis of such reactions and to the costs and benefits of such reactions. Great importance is attached to research targeting the identification of options for reducing greenhouse gas emissions, especially CO_2.

A close connection is thus striven for between "traditional" climate impact research and relevant contributions from the socio-economic field. The necessary methodical steps include integrated modelling of the different systems being studied, incorporating socio-economic models, and reliance on the instincts of relevant experts.

Research areas under the DEKLIM funding emphasis on "research into the impacts of climate change" include: the climate sensitivity of the ecosphere and of particularly affected socio-economic systems, incorporation of socio-economic reaction patterns into existing climate models, study of methods for protection against climate changes and their impacts (research on the impact of measures), analysis of the resilience of different systems when faced with unexpected climate changes and the relevant framework conditions at the regional and global levels (climate-relevant resilience and governance research).

VIII.4.1 Integrated environmental protection, sustainable business

Support and funding of research and development in the field of reducing greenhouse gas emissions has also been integrated within the funding emphasis entitled "Business-related sustainability; integrated environmental technology". As opposed to "end-of-the-pipe" environmental engineering, research in the field of integrated environmental protection focuses on production processes, on product design and on product use, as well as on overarching topics such as the instruments that companies need for sustainable business and the framework conditions for relevant innovations.

Preventive integrated environmental protection which takes account of technical aspects, the relevant legal and social framework and the relevant demand, is often more effective and comprehensive than "end-of-the-pipe" measures in achieving economic sustainability. Technology-oriented research support and funding for sustainable management seeks to optimise integrated environmental protection with regard to production processes and products and to implement closed cycles, ensuring that from the very beginning

- Products and production processes produce no emissions (waste gases, waste, waste water), and
- Consumption of raw materials and energy in manufacturing, use and disposal of products is minimised.

Further support measures for sustainable management concern the following areas:

- Framework conditions for innovations and instruments for sustainable business,
- Opportunities for new product-use strategies, and their limitations.

In order to further optimise the ecological sustainability of operating processes, products and material flows, approaches must be practically oriented. In projects already initiated, support is provided for exemplary demonstrations of technical, organisational and economic feasibility of integrated environmental engineering, in different industries. As there is also a broad demand for research in non-technical areas, the Federal Government also supports and funds projects regarding relevant fundamental topics and ecological studies in support of technological projects.

In the waste management sector, new technical solutions are also being developed, in keeping with the Closed Substance Cycle and Waste Management Act, aimed at prevent any additional pollution. One example is a joint research project that is studying potential for recycling industrial by-products in the construction sector as well as techniques for mechanical/biological pretreatment of landfill waste. These projects also involve CH_4 reduction.

On the whole, the environmental protection technologies sector is becoming important for the whole economy, with positive effects on employment. Via sustainable management, including integrated environmental solutions as well as downstream scrubbing and recycling technologies, this sector is gaining a significant share of the international market and is generating economic growth. At the same time, it is easing the burden on the environment, also by helping to reduce energy requirements.

VIII.4.2 Energy research and energy technology

Most of Germany's CO_2 emissions are emitted when energy is converted and consumed. In the effort to reduce such emissions, it is thus only logical to make the available energy supply technologies more efficient and cost-effective, in addition to providing new technical options and developing new technological potential. Support for energy research is a logical element of the Federal Government’s overarching energy-policy aim of introducing a sustainable energy supply, without nuclear power, that is free of subsidies in the long term. One of the energy research programme's top priorities is to harmonise the need for long-term energy-supply reliability with solutions to problems in the areas of environmental and climate protection. Through this programme, the Federal Government is supporting research and development (R&D) carried out by companies, research institutions and universities.

a) From 1974 to 2000, the Federal Government provided a total of DM 11 billion in funding for non-nuclear energy research; approximately DM 1.8 billion have been earmarked for such research for 2001 to 2006. Additional funding, the amount of which is not recorded in detail, is provided by companies, research institutions and the Länder. The funding emphases include the development of technologies for reducing energy consumption, for enhancing energy efficiency and for making renewable energies more cost-effective. Key areas of support and funding include:

- Reduced energy requirements

  = In the building sector, model projects regarding energy-efficient designs, demonstration objects for energy-optimised building renovation and modernisation and R&D for new thermal insulation methods are supported. Thanks to public-sector research funding, solar-thermal systems for heating and hot water are very close to cost-effectiveness.

  = In order to promote economical and rational use of energy in industrial processes, commonly used technologies – e.g. melting, drying, separating, grinding – are being studied with a view to improvements in terms of energy technology.

- Increasing energy efficiency in energy conversion

With the aim of increasung energy efficiency – for example, to obtain more electric power per unit of coal – the following two emphases in development of new energy conversion technologies are being supported:

= Improved combustion methods and high-efficiency power plant concepts hold great potential for reducing emissions of gases with adverse effects on climate. Further important issues include: materials and measuring methods, pressurised coal-dust combustion and high-performance combined cycle (gas-and-steam) power stations. Leaps in efficiency amounting to 2 percent are expected to be achieved shortly; efficiency increases of 5 percent are expected in the medium term.

= Development of fuel cells has been well funded in the past. The next important step is to bring them to maturity (for the market) by developing new production methods and testing them in demonstration projects. The aim is to pave the way for fuel cells to become a cost-effective energy technology and establish a competitive industry.

- Increasing the economic efficiency of renewable energies

In order to achieve a substantial medium and long-term increase in renewable energies' share of the energy mix, research is being supported that is aimed at making relevant systems and methods more cost-effective, so that these technologies can become more cost-effective overall.

= In the area of photovoltaic systems, funding is targeted at industrial methods designed to lower the manufacturing costs of solar cells and modules, at increasing the efficiency of solar cells and at measures to reduce the high ancillary costs for inverters, assembly and installation.

= In the area of wind-energy systems, support and funding are focused on the development of offshore facilities. The Federal Government has developed a strategy for the use of offshore wind power, whereby in an initial stage lasting until 2006, and under current conditions, total capacity of 500 MW could be installed on offshore sites currently expected to be available for this use. According to the strategy's medium-term projections – up to the year 2010 – 2000 to 3000 MW of capacity could be installed. In the long term, i.e. until 2025 to 2030, approximately 20,000 to 25,000 MW of installed power would be possible, assuming the systems were cost-effective by then. To these ends, investors in offshore wind parks and the electricity industry must create the basis for transporting such quantities of electric power generated offshore. Offshore wind-energy use on this scale would represent 15% of total power consumption, in comparison with 1998.

= Support and funding in the area of geothermal energy is aimed at using geothermal facilities to generate a virtually unlimited amount of electric power and heat on an economic, CO_2-free basis. The main obstacles to a market launch consist of the high prospecting risk and the ensuing high drilling costs. Two methods are being developed: the hot dry rock method, which would be used for electricity generation, and development of cleft/porous storage horizons not used to date. The hot dry rock method used in a European project in Soultz is now at the beginning of a stage aimed at construction of a pilot facility for generation of electric power. Additional funding is to be provided in order to accelerate development of the other method, e.g. by funding demonstration projects.

b) In view of the political aim of phasing out nuclear power in Germany, activities in the area of nuclear-energy research focus on safety aspects. In addition to provision of assistance in phase-out operations and investigation of long-term safety in the disposal of radioactive waste, respective activities include co-operation with Western partners, and with Central and Eastern European countries, in order to enhance the level of safety in reactors located in Central and Eastern Europe. The Federal Government allocates funds amounting to approx. DM 150m per annum for nuclear-safety and final-disposal research. Such funds also ensure that Germany will still be able to participate in international research projects to maintain and enhance nuclear safety and apply German expertise effectively in international negotiations.

c) Nuclear fusion research aims at providing proof that large-scale power generation in fusion reactors, via controlled nuclear fusion, is basically possible from a technical point of view. Research work in fusion energy is focused on plasma physics (maintaining and containing burning plasmas), on improving and adapting typical components (such as superconducting magnets, high-performance high-frequency generators (gyrotrons), systems for keeping plasmas clean, diagnostics) and on developing materials that can withstand the particular stress factors of fusion reactors (ion and neutron shooting) for sufficient periods of time and which exhibit low tritium absorption and activation. These ambitious research objectives can only be achieved through long-term international co-operation and by combining resources. International efforts (EU, Canada, Russia, Japan) are targeted at implementing the ITER project. ITER is to provide initial proof of the technical feasibility of a fusion reactor with burning plasma and a tenfold energy increase. In Germany, fusion research is concentrated in three centres: the Max Planck Institute for Plasma Physics (IPP), the Karlsruhe Research Centre (FZK) and the Jülich Research Centre (FZJ). German fusion research is integrated into the European fusion programme and is co-funded by EURATOM on a pro-rata basis. Currently, the largest project in German fusion research is the new large Wendelstein 7-X stellerator in Greifswald. Its completion is expected in 2006.

VIII.4.3 Mobility research

The new "Mobility and transport" research programme, adopted by the Federal Government in March 2000, marks a clear orientation of transport research towards the objective of sustainability. Transport is still among the main causes of CO_2 emissions. Due to the ever-increasing traffic load, CO_2 transport-related emissions have increased by an additional 15% since the early 1990s. According to all available projections, this tendency will last even beyond the year 2010. Taking into account that the transport sector is a top economic priority, it is quite evident that this is a key area in which it must prove possible to harmonise ecological and economic requirements on a permanent basis.

The research field entitled "Acting responsibly in health, environment and resource issues" forms the basis for research activities to reduce ozone precursor substances, soot particles, CO_2, other greenhouse gases and noise. Natural areas and landscapes are to be preserved and the quality of life in conurbations is to be enhanced. Therefore, funding emphases include development of alternative vehicle and power concepts and optimisation of conventional vehicles and power systems. In optimisation of conventional vehicles, energy is to be saved through technology transfer from projects pertaining to the materials research programme of the Federal

Ministry of Education and Research (BMBF). Another important area for action involves the introduction of modes of transport that run on renewable fuels.

Via research in other areas, focusing on measures such as traffic prevention, reorganisation and public awareness, "indirect reduction" of emissions is also being promoted.

In the "intelligent traffic network" telematic is used to optimise road, rail, air and ship transports and to link different modes of transport effectively. It must become possible, in both passenger and goods traffic, to select optimal modes of transport. Travel times are to be shortened and resources conserved. New solutions are being sought, in the research field entitled "Against the trend: more goods by rail and ship", in order to counter the growing quantity of goods traffic on the road. The response to growing pollution from goods transports on roads is to consist of improved utilisation of railway and waterway capacities, of improved vehicle utilisation and of optimised routing and internal logistics. The funding emphasis entitled "Flexible transport chains" is to show potential for reducing road traffic.

In the action field entitled "Rail and bus – faster, more comfortable, more environmentally friendly", operational and organisational innovations combined with new transport and switchover technologies are to increase the efficiency and attractiveness of local public transport, thereby making traffic more environmentally friendly and less prone to traffic jams. Research under the heading of "A deeper understanding of mobility" includes studies in the area of recreational and holiday traffic, which now accounts for some 50% of total private automobile transports (in terms of passenger-kilometres). Furthermore, new ways of controlling recreational traffic are to be identified.

In the context of promoting traffic-reducing structures and substitutions for physical traffic, the links between housing, workplaces, sites for leisure activities and shopping areas are to be enhanced. Support for strategies to reduce and prevent traffic focuses on the original causes of traffic – and it can make a substantial contribution to climate protection. This aspect gives rise to links with the research programme entitled "Building and housing".

VIII.5 General data on the subject of "systematic monitoring"

VIII.5.1 Detailed summary

The Global Climate Observing System (GCOS) was set up in 1992. GCOS pursues the objective of making observations and information required to tackle issues pertaining to climate available to all users. GCOS is a system jointly funded by the World Meteorology Organisation (WMO), the Intergovernmental Organisation for Oceanography (IOC) of UNESCO, the United Nations Environment Programme (UNEP) and the International Council for Sciences (ICSU). GCOS is intended as a permanent, user-controlled system for climate monitoring. GCOS is expected to help reveal climate changes and their underlying causes, to facilitate assessments concerning the impacts of climate changes and climate variability and to facilitate research aimed at improving understanding of the climate system and relevant predictions.

In Germany, competences for systematic long-term observation of various variables for describing the climate system are distributed among a number of different Federal Ministries. These include the Federal Ministry of Transport, Building and Housing (BMVBW) and its subordinate authorities German Weather Service and the German Maritime and Hydrographic Agency (BSH); and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and its subordinate authorities, the Federal Environmental Agency (UBA) and the Federal Agency for Nature Conservation (BfN). The Alfred Wegener Institute (AWI) is also contributing to these efforts.

Moreover, Germany contributes significants to European space-based observation systems operated by the European Space Agency (ESA) and EUMETSAT (the European Organisation for the Exploitation of Meteorological Satellites).

In fall 1993, a national GCOS Secretariat was established at German Weather Service, in Offenbach, to carry out national co-ordination of co-operation among the institutions involved. The BSH operates a national GOOS Secretariat.

The present report is the first report of the Government of the Federal Republic of Germany about systematic climate monitoring in Germany. Part of the 3rd National

Report stipulated by the United Nations Framework Convention on Climate Change (UNFCCC), it contains descriptions of a broad range of observation and monitoring systems for which information has been provided. Although it is evident that this report is incomplete to some extent, it still represents the most comprehensive overview of climate observation systems in Germany.

For additional information on environment observation systems operated by the Federal Government in general, please refer to the Federal Environmental Agency (UBA, 1998).

VIII.5.2 National programmes for systematic atmospheric monitoring

VIII.5.2.1 The legal basis

The Federal Republic of Germany has set forth its obligations to carry out systematic (climate) monitoring in various national laws (e.g. Environmental Information Act, Act on the German Weather Service).

The German Weather Service (DWD)[17], the national meteorological service of the Federal Republic of Germany, is legally bound to carry out meteorological observations (Act on the German Weather Service of 11 November 1952, as amended on 1 January 1999). The DWD thus fulfils the obligations arising from the Framework Convention on Climate Change in the area of systematic monitoring of meteorological variables.

In fall 1993, a national GCOS Secretariat[18] was set up at the German Weather Service. Since its establishment, this Secretariat has played an active role in developing the GCOS programme. Since August 2001, the national GCOS Secretariat has also been in charge of completing the national report on systematic climate monitoring, the first edition of which has now been published.

Meteorological variables are also measured by other authorities at national or Länder level.

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[17] http://www.dwd.de
[18] http://www.dwd.de/research/klis/internat/gcos/

The air-quality monitoring network originally established by Deutsche Forschungsgemeinschaft had the task of monitoring air quality throughout Germany. To this end, it sampled the air both at clean-air sites and in conurbations. When monitoring responsibilities were assumed by the Länder and, subsequently, the Länder measuring networks were built, the DFG's air-quality measuring network confined itself to measuring the background pollution at selected clean-air sites. When the UBA was established in 1974, it assumed responsibility for this network.

Air-quality measurements are carried out in accordance with a range of laws and protocols:

- Protocols pertaining to the UN/ECE Convention on Long-Range Transboundary Air Pollution: SO_2 Protocol, NOx Protocol, VOC Protocol, 2nd Sulphur Protocol, Protocol on Heavy Metals, POP Protocol, Multicomponent Protocol.
- European Monitoring and Evaluation Program (EMEP)
- International Cooperation Program Integrated Monitoring (ICP IM)
- International Cooperation Program Mapping (ICP M)
- HELCOM
- OSPARCOM
- GAW (successor of BAPMon, GO_3OS[19])

VIII.5.2.2 National plans and organisational structures

National plans pertaining to meteorological observations are developed and updated by the German Weather Service in accordance with the basic legal texts. There is no national plan for climate monitoring.

The German Weather Service is in charge of carrying out meteorological observations on the territory of the Federal Republic of Germany. The German Weather Service is a public institution, with partial legal capacity, within the sphere of action of the Federal Ministry of Transport, Building and Housing (BMVBW). Its tasks pertaining to systematic monitoring, as set forth by the Act on the German Weather Service, are as follows:

[19] GO_3OS = Global Ozone (O_3) Observation System

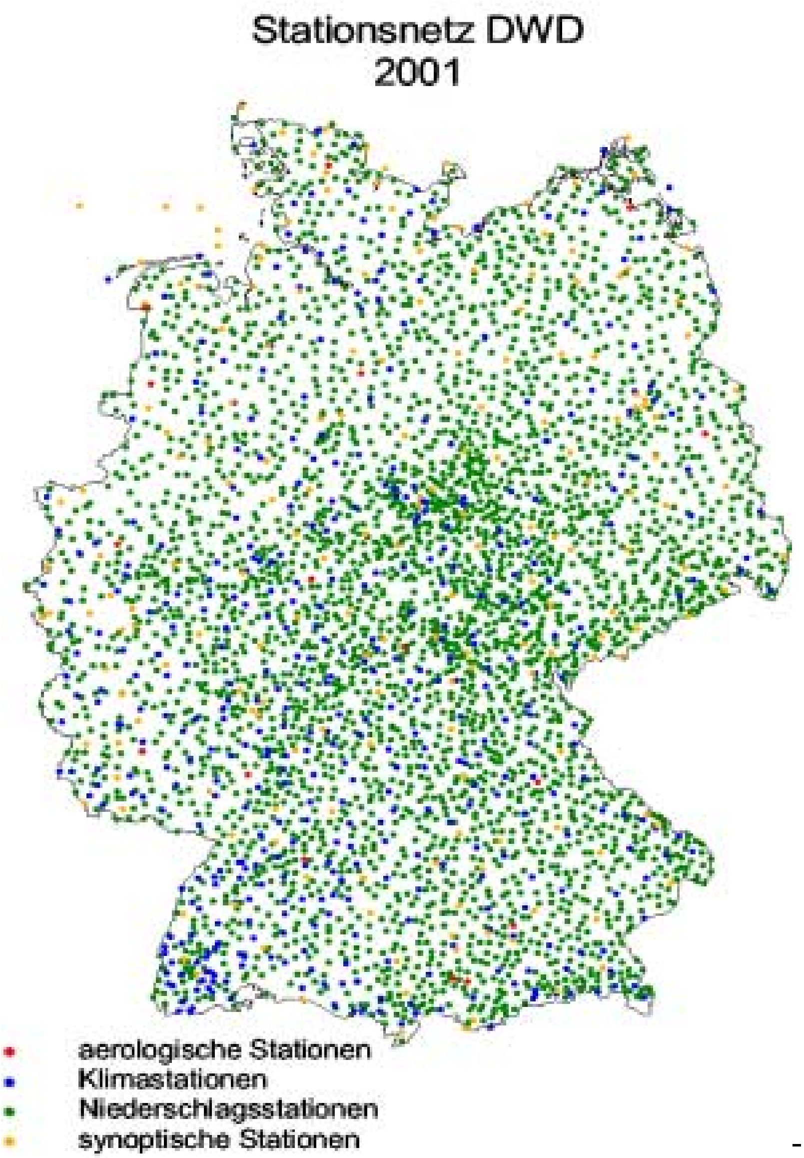
- Short-term and long-term recording, monitoring and assessing of meteorological processes, and of the structure and composition of the atmosphere,
- Monitoring of the meteorological interactions between the atmosphere and other parts of the environment,
- Operating the required measuring and observation systems in order to fulfil the tasks named above, and
- Storing, archiving and documenting meteorological data and products.

This figure shows the geographic distribution of the stations belonging to the various networks operated by the German Weather Service.

Fig. VIII.5.2.2.1 Station network of the German Weather Service, 2001

Legend Fig. VIII.5.2.2.1

Stationsnetz DWD	DWD station network
aerologische Stationen	aerological stations
Klimastationen	climate stations
Niederschlagsstationen	precipitation stations
synoptische Stationen	synoptic stations



In order to update and modernise measuring networks and to achieve further savings, the future equipment of stations, their geographic distribution and their measuring programmes were redefined within the framework of a large-scale project entitled "measuring network 2000". The results gained in this project have begun to be implemented. Further information is available both from the German Weather Service on request and on the Service's Website.

In order to fulfil its tasks, the DWD operates several measuring networks. Their respective numbers of stations are in keeping with relevant requirements and meteorological parameters.

Fig. VIII.5.2.2.1 provides an overview of the station density in the German measuring networks operated by the German Weather Service. The stations operated by the German Weather Service are listed in "station information" tables of the Service (KLIS[20]).

In some Länder, the density of stations is further increased by regional measuring networks operated by the Länder in question. Besides measuring precipitation, such measuring networks also record air temperature and wind velocity and direction. Recently, privately operated measuring networks have also appeared. However, their measuring standards only partly meet the criteria established by the German Weather Service, and their data is normally not made available to the German Weather Service for the purposes of international. For this reason, such networks are not discussed in the present report.

The measuring network of the Federal Environmental Agency (UBA) can be subdivided into 5 task-specific areas:

- Immissions measuring network
- Deposition measuring network
- Solar UVB monitoring – BfS/UBA
- Programme for monitoring airborne chemicals, in the framework of Global Atmosphere Watch

[20] http://www.dwd.de/research/klis/daten/

- Contributions to environmental observation

As far as their station sites are concerned, the immission measuring network and the deposition measuring network are largely identical. A map containing all sites of the air measuring network operated by the UBA is available at:
http://www.umweltbundesamt.de/uba-info-daten/daten/mblage.htm

With the addition of the Zugspitze/Hohenpeißenberg GAW station, the number of manned measuring stations has been increased to a total of nine, whereas the number of automatic measuring stations has been reduced to 14. The UVB measuring network consists of 3 UBA-operated sites, situated in Zingst, Langen and Schauinsland. All are associated with the BfS' Neuherberg station.

Besides measuring air pollution, the stations also record meteorological data. The GAW global station (Zugspitze/Hohenpeißenberg) of the WMO/UNEP programme is currently set up, and experimental measurements have begun. This enhances measurements of climate gases (CO_2 since 1972, CH_4 since 1993). Moreover, two stations now measure N_2O and SF_6 (Zugspitze, Schauinsland).

The radioactivity measuring formerly carried out within the IMIS measuring network was discontinued in 1999.

Measuring parameters and sampling: The parameters of each station are described in detail at:
http://www.umweltbundesamt.de/uba-info-daten/daten/mbback.htm

The measuring data is available on request from the Langen branch office of the Federal Environmental Agency (UBA). No public access to this data is provided. At present, ozone data is available on the Internet, together with relevant data of the Länder.

The results obtained from the measuring network are integrated into the following products:

- Federal Environmental Agency intranet pages
- Monthly reports from the measuring network

- Annual report
- Data provided to international organisations
- German-wide ozone projection and description of the actual situation

VIII.5.2.3 Participation in remote-sensing programmes

In the area of space-based observations, Germany is a member of the European Space Agency (ESA) and EUMETSAT (European Organisation for the Exploitation of Meteorological Satellites). The German Weather Service represents the Federal Republic of Germany's interests to EUMETSAT. Participation in shaping the Integrated Global Observing Strategy (IGOS) takes place under similar arrangements.

VIII.5.2.4 International data exchange and data policy

DWD data are exchanged internationally according to WMO rules (WMO Resolution 40). Thus, data and products selected by the German Weather Service to support WMO programmes are available internationally. Other data and products are available by the German Weather Service on request. The terms of use in such cases are contractually defined in accordance with the national data policy.

In 1999 the German Weather Service, acting in cooperation with the Japanese Meteorological Service, began setting up the GCOS Surface Network Monitoring Centres (GSNMC) with the goal of improving the availability and quality of climate data provided by the GSN stations. Since the international availability of climate data depends, inter alia, on use of error-free transmission formats, reports on detected formal errors are submitted every six months. Such errors can hamper, or even preclude, use of transmitted climate data. Reporting also covers the quality of transmitted data on monthly precipitation and monthly average temperature. Data collected through this system is transferred once a month to the ICSU World Data Centre A for Meteorology (WDC-A) and thus is available through the network of World Data Centres.

VIII.5.2.5 Activities to support developing countries

The Federal Ministry for Economic Cooperation and Development (BMZ) is responsible for planning and implementing the Federal Government's development policy. The Ministry focuses on the following areas:

- Shaping of global framework conditions,
- Development of bilateral and multilateral support strategies,
- Supporting development programmes and projects in the partner countries,
- Supporting cooperation of non-governmental organisations in development policy,
- Monitoring of success and control of the use of resources.

The Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, which has carried out activities in international development cooperation since 1975, also runs projects. GTZ has more than 10,000 staff members in more than 120 countries worldwide and is thus the largest undertaking of this kind in Germany.

Since 1993 the Federal Republic of Germany has supported the implementation of the United Nations Framework Convention on Climate Change in developing countries. In a first and second phase, the German Climate Protection Programme "Measures to implement the UNFCCC" has worked to support developing countries in collecting national data about GHG emissions and possible GHG reductions.

The third phase focuses on implementing the Kyoto Protocol.

The Federal Government provides a range of different types of development assistance. In addition to technical cooperation, which is implemented mainly by the GTZ, the spectrum includes financial cooperation (KfW Group (Kreditanstalt für Wiederaufbau), and Germany's contributions to international organisations (multilateral cooperation).

The German Weather Service has neither the legal possibilities nor the financial means to take part in technical cooperation. However, the German Weather Service may directly cooperate with meteorological organisations in partner countries and convey knowledge and skills and support such organisations so that they are able to better fulfil their national and international tasks.

VIII.5.2.6 Deficits

As a rule, the German Weather Service observes the 10 Climate Monitoring Principles (Chapter XII).

Dismantling of precipitation stations within the scope of the German Weather Service has been partly compensated for through use of regional precipitation networks of the Länder and through radar measuring by the German Weather Service radar network.

At present the German Weather Service is considering whether outstanding, climatologically valuable stations could be given a special protective status.

VIII.5.3 National programmes for the systematic observation of the oceans

VIII.5.3.1 Legal basis

The Federal Republic of Germany is obliged by law to systematically monitor the marine environment. According to the Federal Maritime Responsibilities Act as amended on 18 September 1998 the Federal Maritime and Hydrographic Agency (BSH) must monitor changes to the marine environment, support shipping and fisheries with scientific research and carry out nautical and hydrographic services. The obligation to carry out maritime meteorological observations is set forth, inter alia, in the Act on the German Weather Service of 11 November 1952, as amended on 1 January 1999, in the International Convention for the Safety of Life at Sea (SOLAS) of 1974, and including its corresponding amendments and the Protocol of 1978, as well as in numerous international conventions relating to the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission, IOC.

Moreover, by participating in the Global Ocean Observing System (GOOS) the Federal Government has integrated monitoring within its international activities, as required, and approved the establishment of the national GOOS Secretariat within the Federal Maritime and Hydrographic Agency (BSH). The national GOOS Secretariat cooperates closely with the German GCOS Secretariat at the German Weather Service. Many of the measuring systems depicted in Chapter X.4. Oceanographic observations form part of the national contribution to GOOS.

VIII.5.3.2 National plans and organisational structures

The MARNET measuring network has been elaborated and developed in the national oceanographic sector on the basis of a concept submitted to the Federal Ministry of Transport, Building and Housing (BMVBW). At present two stations are being set up, in the North Sea and the Baltic Sea, to extend this measuring network. In all likelihood, in early 2002 the station "*Nordseeboje II"* will be moored close to the position of the former "*Forschungsplattform Nordsee*" and will be commissioned, while the station "*Arkona Becken*" will begin operations during the first three months of 2002 (see chapter VIII.7 Oceanographic observations for stations plan). No further stations are planned at present. However, it is intended to introduce new measuring methods and to improve the measuring equipment in the interest of best possible data quality and data availability. In this context, attempts are being made, within the framework of the "European workshop on fixed monitoring networks in the North Sea region" (SeaNet), to achieve a relevant consensus of the European countries, in cooperation with the "European Association for the Global Ocean Observing System" (EuroGOOS). The Federal Maritime and Hydrographic Agency (BSH) actively participates in international oceanographic data collection on merchant ships (Ships of Opportunity Programme, SOOP).

In Germany, as already mentioned, the German Weather Service (DWD) is responsible for carrying out meteorological observations and thus also for maritime meteorological observations. See the relevant section for details on the Service's tasks and organisational structure.

The German Weather Service uses the national network of voluntary observing merchant ships, research vessels and fishing fleets, operating worldwide, to collect marine meteorological in situ data close to the sea surface. This effort is embedded in the international VOS Scheme, which is coordinated within the WMO and to whose establishment, maintenance and evaluation the German Weather Service contributes substantially.

EGOS (European Group on Ocean Stations) co-ordinates the deployment of drifting and moored meteorological buoys in the North Atlantic. At present, a German Weather Service staff member holds the position of chairman of the management committee. The German Weather Service, which provides drifting buoys (inter alia) for this programme, is planning to continue its in this effort.

The German Weather Service runs maritime meteorological measuring systems situated in the foreshores of Germany, partly in cooperation with the Federal Maritime and Hydrographic Agency (BSH).

In maritime meteorology, it is necessary to study the marine atmosphere up to high altitudes. For this reason, the German Weather Service has set up a series of mobile automated aerological stations on sea vessels [from where ascents are performed], and it is participating by this means in the international Automated Shipboard Aerological Programme, ASAP.

As to organisation, the German Weather Service's maritime meteorological activities are integrated in the field of maritime data management and climate control.

VIII.5.3.3 Participation in remote sensing programmes

Chapter X.2.2.3 reports on the participation of the German Weather Service in remote sensing programmes.

On a routine basis, the satellites of NOAA, EUMETSAT and ESA monitor the sea surface, collect data on sea ice and surface temperatures and conduct environmental monitoring. Programmatic interests are represented through participation in national preparatory meetings, in the meetings of the relevant bodies of ESA and EUMETSAT and in national and international user groups.

VIII.5.3.4 International data exchange and data policy

SeaNet applied for, and carried out, an EU project "SeaNet Data Interface" (SNDI), aimed at simplifying, and making more secure, exchange of operational oceanographic data. This project facilitates data exchange with Europe, initially in only 6 countries. SeaNet's data policy provides for authorities and research institutions to be able to use measuring-network data free of charge, whereas commercial use is subject to charges, in keeping with the national provisions of the country providing the data. A reduced set of MARNET data is made globally available to the WMO through the GTS.

Ultimately, national data policy in the oceanographic field will be oriented to the policy of GOOS, which favours the unrestricted release of observation data.

The national data collected by the Ship of Opportunity Programme (SOOP) will be forwarded to the Global Surface Data Centre.

In Germany, international exchange of maritime meteorological data is carried out by the German Weather Service. This takes place on the basis of international agreements and commitments within the framework of the WMO – e.g. within the VOS Scheme, which uses the GTS of the WMO, or within the Marine Climatological Summaries Scheme, MCSS. Resolution 40, adopted on the occasion of the 12th WMO Congress, is an important guideline for policies for exchange and dissemination of maritime meteorological data.

VIII.5.3.5 Activities to support developing countries

In actions restricted to specific periods and mostly within or in connection with development projects funded by the Federal Ministry of Education and Research (BMBF) or the EU, the Federal Maritime and Hydrographic Agency (BSH) provides scientific / technical advising if developing countries show an interest in deploying and purchasing oceanographic observation systems resulting from relevant projects (e.g. China and Indonesia in connection with the "MERMAID" and "CANVAS" projects, etc. run by the Federal Ministry of Education and Research, (BMBF). In-depth and more extensive activities require additional resources.

VIII.5.3.6 Deficits

If GOOS and EuroGOOS are to become effective operational instruments, so that the defined objectives can be achieved, the declarations of intent provided by the Länder must be followed by the provision of appropriate funds. The measuring network components already in place are a start. However, in the view of the enormous need for data such components can only be the beginning of a considerably enlarged overall system.

VIII.5.4. National programmes for systematic terrestrial climate-related observations

VIII.5.4.1 The legal basis

VIII.5.4.1.1 Land use

In 1979, as an action following the CSCE Final Act of 1975, the Convention on Long-range Transboundary Air Pollution, UN/ECE-CLRTAP, was signed in Geneva by the then 34 Member States of the UN Economic Commission for Europe (as of 1998, following the political restructuring processes in Europe, a total of 43 of the 53 Member States had joined the Convention) and by the European Community. This was the first internationally binding instrument to address the problems of air pollution on a broad basis. "Besides establishing the general principles for international cooperation to control air pollution, it has created a framework for institutionally combining research and policies" (UN/ ECE 1996, unofficial translation). Implementation is carried out by Executive Body, which is supported by 3 working groups and the European Monitoring and Evaluation Programme (EMEP)[21]. The working groups are supported by special working groups staffed with experts from the Member States.

VIII.5.4.1.2 Biota

As regards nature conservation-oriented biotic information (biological diversity, species distribution), there is no legal basis at present for nationwide observations. The amendment of the Federal Nature Conservation Act currently in progress

[21] http://www.unece.org/env/lrtap/conv/lrtap_o.htm

provides for integrated environmental monitoring to be legally enshrined as a task to be carried out by the Federal Government and the Länder. It also provides for mutual support and coordination. Detailed provisions concerning such integrated environmental monitoring are not yet available. The Länder are responsible for surveys in the field of nature conservation.

EU Directive 2001/18/EC provides for the monitoring of releases and the placing on the market of genetically modified organisms. To determine relevant ecological impacts, data on species and their distribution is to be collected. Relevant monitoring concepts are being developed at present. It is not foreseeable whether such efforts can be expected to produce climate-relevant data. The EU Directive is to be implemented into German law by October 2002 (Genetic Engineering Act).

VIII.5.4.2 National plans and organisational structures

VIII.5.4.2.1 Land use

The German contribution to the International Co-operative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems refers to several components.

- Federal Environmental Agency (UBA): International Cooperative Programme on Integrated Monitoring of Air Pollution Effects on Ecosystems (ICP Integrated Monitoring)
- Federal Agricultural Research Centre (FAL): International Cooperative Programme on Effects of Air Pollutants and other Stresses on Crops and Non-wood Plants (ICP Crops)
- Bavarian National Heritage (*Bayerisches Landesamt für Denkmalpflege*:) Programme on Effects of Air Pollution on Materials, Including Historic and Cultural Monuments (ICP Materials)
- Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL): International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forest)
- International Cooperative Programme on Assessment and Monitoring of Rivers and Lakes (ICP Freshwater)

Integrated monitoring begins by assessing the status quo of ecosystems and their changes under the influence of anthropogenic pollutants. For this purpose, concentrations and depositions of air pollutants are determined. In addition, the interactions of substances deposited from the atmosphere with different sub-compartments of the investigated ecosystems are examined – in this context, the soil or groundwater and surface water and biota, for example.

In order to differentiate between ecosystem changes brought about by the impact of anthropogenic air pollutants and those occurring naturally, it is necessary to carry out long-term monitoring of plants and animals (biomonitoring) in direct connection with collection of physical and chemical environmental data (i.e. monitoring and data collection at the same monitoring sites, and at the same times). Such studies are currently being carried out at 50 monitoring sites, located in 27 Europeand and Northern American countries[22].

Sweden is coordinating this programme; the International Programme Centre is located in Helsinki, Finnish Environment Institute. See
http://www.vyh.fi/eng/intcoop/projects/icp_im/datatabl1.htm.
for an overview of the meta data of all participating countries. Germany is participating in the programme with one monitoring site:
Location: Bavarian Forest (size: 0.64 km^2), observation started: 1989, until 1992 as pilot programme, since 1992 permanent measuring programme.

The monitoring site has been mapped completely, and all its flora and fauna have been inventoried. The monitoring programme, including 90 subprogrammes per year, collects data on over 10,000 measured/observed parameters. Subprogrammes are divided into compulsory programmes and optional programmes. Apart from climate and air chemistry they also include monitoring on soils, leachage and groundwater, forest damage and vegetation.

[22] http://www.vyh.fi/eng/intcoop/projects/icp_im/im_map.htm

The data provided by the German programme is forwarded, in the prescribed formats, to the data centre in Finland. There, joint reports are drawn up. Annual international reports are available at the following address:
http://www.vyh.fi/eng/orginfo/publica/electro/fe_427/fe_427.htm
Further information is available at the following address:
http://www.vyh.fi/eng/intcoop/projects/icp_im/im.htm
This site also provides further information regarding the manual and links to other programmes, etc. The GTOS Website also has a link to this programme.

VIII.5.4.2.2 Soil

In the context of the implementation of the Federal Soil Protection Act and the Soil Protection Ordinance of 1999 soil examinations are carried out in the area of the UBA air measuring network. At 17 measuring and sampling sites, the soil has been mapped for land use. Apart from data on soil chemical and physical properties, soil index data is also collected, for determination of such factors as carbon content, cation exchange capacity, pH values and the organic substance. Such data collection within the UBA air measuring network forms an integrated part of the data collection at the approximately 700 permanent monitoring areas of the Länder. Standards for the relevant methods and study parameters were prepared in connection of implementation of the Federal Soil Protection Act.

VIII.5.4.2.3 Biota

There are no national plans for nature-conservation-oriented integrated environmental monitoring. At the expert level, the competent regional authorities and the Federal Agency for Nature Conservation have developed a concept for nature-conservation-oriented environmental monitoring. No decision on implementing this concept has yet been taken. The Länder carry out surveys in keeping with their own relevant plans, and in their respective areas. As a rule, it is not possible to combined such results at the national level, since these surveys differ in their subjects, criteria and intervals.

VIII.5.4.3 Participation in remote sensing programmes

The EU CORINE Programme – **C**o-**or**dination of **In**formation on the **E**nvironment – was initiated in 1985 and mainly focuses on:

- Protection of habitats
- Control of air pollution
- Protection of the environment in the Mediterranean .

On the basis of satellite data, an inventory of land cover was drawn up in Germany for the first time in 1990, including both natural land cover and human land uses. This inventory is known as the "CORINE Land Cover". The European programme provided for a national survey on the basis of a harmonised "Technical Guide" and a collection of the data to form a European, harmonised data set.

In 1991 the UBA commissioned the Federal Statistical Office to carry out the survey for Germany. After the establishment of the European Environmental Agency (EEA) this task was continued in the EEA project Land Cover – Ecological Monitoring.
The European Topic Centre Land Cover (ETC/CL) was founded in 1995 as an international coordinating body, within the EEA, in order to coordinate the LC Ecological Monitoring Project. National Reference Centres (NRC) were established in the Member States of the EEA, functioning as national contact points. During the initial survey carried out in Germany the Federal Statistical Office functioned as NRC Germany.

Method:
The internationally binding nomenclature includes a total of 44 land cover classes for Europe and takes account not only of the main categories of the land cover/land use such as artificial areas, agricultural land, forests and water surfaces but also of classes that are substantially significant for nature conservation and landscape protection. 36 classes are relevant for Germany. The scale of the output product was fixed at 1:100.000. The smallest surfaces mapped correspond to 25 hectares (500 m x 500 m) and linear features, such as rivers and roads, less than 100 m in width are not included. The method is explained in detail in the "Technical Guide", which is available in German and includes additional information on digitalisation.

EUROSTAT compiled the international surveys within the GISCO information system. The data is available upon request at EEA – ETC CORINE Land Cover; upon establishment of the new ETCs, from 2001 onwards, it is available from the ETC Terrestrial Environment.

Information about international activities are available at the following addresses:
http://etc.satellus.se/index.htm
http://etc.satellus.se/the_project/about_etc/index.htm
This set of data is to be used for ecological random surface sampling (Ökologische Flächenstichprobe).

The Authoritative Topographic Cartographic Information System (ATKIS) run by the Länder surveying agencies uses a similar description of land use as its topographic basis, but it has a higher resolution (starting from 1:25.000). In order to meet the need for standard types of surveying data, this system uses conventional land-use classes of the sort expected on basic topographic maps. AKTIS cannot be considered an alternative for complete-coverage studies of Germany, due to its higher resolution and the enormously large data volumes and high costs that would arise if such resolution were extended to the entire country.

Schedule:
In 2000, the first updates of land-use changes, in relation to the initial survey, were begun on the basis of current images. The update is being carried out within an EU / EEA Community project in cooperation with the Member States. Planning, which was prepared in cooperation with EEA, calls for the Member States to finish the updating by the end of 2004. This will mean that the update for the entire surface of Germany will also be completed by 2004. This project has been divided into two subprojects:

IMAGE2000: Activities in connection with satellite collection and processing,
CLC2000: Activities in connection with the interpretation and mapping of land-cover changes.

Whereas Part I of the activities on behalf of the EU/EEA is being centrally managed and coordinated, for all Member States, by the Joint Research Centre in Ispra, the Member States will be responsible for Part II (interpretation and mapping of land-use changes).

The inclusion key and the methods are the same as those used in the initial survey. Changes covering a minimum surface of 5 hectares are to be detected and mapped on the basis of the satellite scenes processed in the IMAGE2000 Project and in comparison to the data from the initial survey.

Further information is available at:
http://etc.satellus.se/I&CLC2000/download.htm

VIII.5.4.4 International data exchange and data policy

VIII.5.4.4.1 Soil

Data exchange with the Länder is governed by the Administrative Agreement on Environmental Data Exchange, which defines the subject and extent of data (e.g. basic soil data, background values, site parameters). The Federal Agency for Geological Sciences and Raw Materials (Bundesanstalt für Geowissenschaften und Rohstoffe, BGR) contributes substantially to the establishment of a national information system, since individual special information systems of the Federal Agency for Geological Sciences and Raw Materials (e.g. pedology) make available important information necessary for the work of the Federal Environmental Agency.
The Federal Environmental Agency is currently setting up the Federal Soil Information System. Continuous provision of data from the Länder to the Federal Government is expected to begin in coming years.

VIII.5.4.4.2 Biota

Information is provided to the international level within different international conventions and on the grounds of EU Directives. These include the:

- Habitats Directive
- Bird Directive
- Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)
- Agreement on the Conservation of Bats in Europe (EUROBATS)
- Agreement on the Conservation of Small Cetaceans of the Baltic and North Sea (ASCOBANS)

- Agreement on the Conservation of Seals in the Wadden Sea
- Ramsar Convention
- Bern Convention
- Helsinki Convention
- Alpine Convention

The Länder provide the information, and the Federal Government prepares some summaries or draws up national reports. There are no standard provisions at the federal level as regards the collection methods or the measuring networks. However, the Habitats Directive and the Birds Directive include legally binding provisions that have to be completed and standardised by the Länder in cooperation with the Federal Agency for Nature Conservation (Bundesamt für Naturschutz, BfN).

VIII.5.4.5 Deficits

VIII.5.4.5.1 Soils

Results of the permanent monitoring areas from the past exhibit a high degree of heterogeneity, and comparison is therefore only partly possible. In the past, specifications regarding standards for setting-aside permanent monitoring areas, for sampling and for analysis were inadequate. As a result, the compatibility of "historic" data is limited. Ordinances and implementing regulations pursuant to the Federal Soil Protection Act will accelerate this process of harmonisation of data collection.

VIII.5.4.5.2 Biota

Deficits are mainly found in coordination and standardisation of biotic surveys. For this reason, it is not possible to prepare nationwide overviews. Monitoring of biological diversity, as required pursuant to Article 7 of the Convention on Biological Diversity, still remains to be implemented in Germany. Existing Länder surveys focus almost exclusively on protected, endangered and valuable species and habitats. Therefore the information the provide covers only subsets of biological diversity and only a small proportion of the surface of Germany. And yet monitoring of compliance with the overarching sustainability principle, and climate-relevant monitoring, requires information that can support representative conclusions regarding all of Germany's territory.

VIII.6 Meteorological and atmospheric observations

VIII.6.1 General

Relevant climatological requirements – for example, relative to the networks operated by the German Weather Service (DWD) – have always been given careful attention, since both real-time applications and climatological applications benefit from the precision required for climatological purposes. For this reason, the German Weather Service recognises and respects the principles applied to climate monitoring (Karl et al., 1995. see Chap. X.3). Nonetheless, the German Weather Service no longer operates a full-time measuring network oriented solely to climatological purposes.

In fall 1993, the German Weather Service established a national GCOS Secretariat. This Secretariat has assumed responsibility for coordinating national activities relative to climate monitoring. In cooperation with the Japanese weather service, it also monitors the availability and quality of reports provided by the GSN's stations, and it operates a GSN Monitoring Centre (GSNMC) to this end. The German Weather Service also participates actively in the GCOS Surface Network (GSN), GCOS Upper Air Network (GUAN) and Global Atmosphere Watch (GAW).

The Global Precipitation Climatology Centre (GPCC), which is also operated by the German Weather Service, represents yet another contribution to GCOS. It is a German contribution to international climate-analysis and climate-research activities, as well as a component of the Global Precipitation Climatology Project (GPCP), which is integrated in the Global Energy and Water Cycle Experiment (GEWEX) of the World Climate Research Programme (WCRP).

VIII.6.2 Contributions to the GCOS networks

Table VIII.6.10.1 presents an overview of the German contributions to GCOS.

VIII.6.3 Contributions to the GCOS Surface Network (GSN)

A total of 3 of the German Weather Service's stations in Germany have been selected for the GCOS Surface Network (GSN):

- Hamburg-Fuhlsbüttel (WMO-No. 10147),
- Lindenberg (10393) and
- Hohenpeißenberg (10962).

Additional stations could be made available for any regionalisation and / or addition to the GSN.

The Hamburg-Fuhlsbüttel station is an aviation-weather station that was established in 1891 as an observatory. In 1955, it was moved about 270 m to the west, and it is now located on the grounds of Hamburg Airport. In 1995, the station was moved again – this time, about 700 m to the south-west. In that same year, a transition was made to semi-automatic operation, and since then the station automatically measures air temperature, at heights of 2 m and 5 cm, ground temperature, humidity, air pressure, wind direction and wind speed, precipitation and sunshine duration.

The Lindenberg Meteorological Observatory was established in 1905 by Richard Assmann, the discoverer of the stratosphere, and it began making measurements in the same year. In each of the years 1956 and 1971, the observation/measurement site was moved by about 200 m. Semi-automatic operation began in 1992. Like the Hamburg-Fuhlsbüttel station, this station automatically measures air temperature at heights of 2 m and 5 cm, along with ground temperature, humidity, air pressure, wind direction and wind speed, precipitation and sunshine duration.

The station is slated to become a National Reference Station. This means that all of its conventional measurements and observations will be continued in parallel with automatic data collection.

Measurements at the Hohenpeißenberg Meteorological Observatory (Fig. VIII.6.3.2) began in 1781, within the framework of the *Societas Meteorologica Palatina*. Until 1932, short interruptions in observations repeatedly occurred. No further interruptions in observations and measurements have occurred since then. This station made the transition to semi-automatic operation in 1993. Since then, the station has automatically been recording air temperature, at heights of 2 m and 5 cm, along with ground temperature, humidity, air pressure, wind direction and wind speed, precipitation and sunshine duration.

This station is also slated to become a National Reference Station. This means that all of its conventional measurements and observations will be continued in parallel with automatic data collection.

These stations largely conform to the 10 principles of climate monitoring. The following Table VIII.6.3.1 shows how the GSN stations conform to the 10 principles (where relevant data was available):

Tab. VIII.6.3.1 Conformance of GSN stations with 10 principles

#	Hamburg-Fuhlsbüttel	Lindenberg	Hohenpeißenberg
1	NE	NE	NE
2	No	Yes	Yes
3	NE	NE	NE
4	Yes	Yes	Yes
5	NE	NE	NE
6	Yes	Yes	Yes
7	NE	NE	NE
8	NE	NE	NE
9	NE	NE	NE
10	Yes	Yes	Yes

The effects of introduction of new measuring systems, and of changes in existing systems, are checked via parallel measurements at selected stations within the German Weather Service's measuring network.
Protection of the stations is guaranteed by virtue of their status (one aviation-weather station and two meteorological observatories).

Fig. VIII.6.3.2 The German Weather Service's Hohenpeißenberg Meteorological Observatory

VIII.6.4 Contributions to the GCOS Upper Air Network (GUAN)

For the *GCOS Upper Air Network* (GUAN), one station of the German Weather Service and one AWI-operated station were selected:

Fig. VIII.6.4.1 GAW – Schauinsland regional station of the Federal Environmental Agency

- Stuttgart-Schnarrenberg (10739),
- Neumayer (89002).

The Stuttgart-Schnarrenberg station sends aloft UTC radio probes (at 12 a.m., 12 p.m. and 6 p.m.) to carry out high-altitude wind measurements, in a practice dating from January 1957. Since February 1995, it has been managed as a GUAN station. Shortly after it was nominated as a GUAN station, it was converted for automatic weather-station operation, including automatic launches of radio probes.

VIII.6.5 Contributions to Global Atmosphere Watch (GAW)

Germany contributes to the *Global Atmosphere Watch* (GAW) with the following stations:

- Zugspitze/Hohenpeißenberg,
- Neumayer station (Antarctic, operated by AWI),
- The Schauinsland and Neuglobsow regional stations.

The Zugspitze/Hohenpeißenberg GAW station consists of 2 platforms: one in the Zugspitze environmental research station and one in the German Weather Service's Hohenpeißenberg Meteorological Observatory.

Hohenpeißenberg Meteorological Observatory has a long tradition of meteorological measurements and chemical measurements of the atmosphere. Its series of uninterrupted meteorological observations dates from 1781. In 1967, a now-extensive ozone-measurement programme began. In 1994, installation of the GAW station began, and the Observatory's measurement programme was considerably expanded. In keeping with the GAW requirements for global stations, measurements include reactive trace gases, physical and chemical properties of aerosols, substances in precipitation and a range of auxiliary data needed to interpret chemical data for the atmosphere (Fig. VIII.6.4.1).

At the Zugspitze location, the German Weather Service and Federal Environmental Agency share responsibilities for carrying out measurements for GAW: the Federal Environmental Agency measures reactive and climate-relevant trace gases, while the German Weather Service measures meteorological components, aerosol concentrations and various radionuclides. The Zugspitze/Hohenpeißenberg global station also co-ordinates and cooperates closely with observatories on the Hoher Sonnblick in Austria and the Jungfraujoch in Switzerland.

The Zugspitze/Hohenpeißenberg GAW station largely fulfills the 10 principles for climate monitoring.

VIII.6.6 Other networks for monitoring weather and atmospheric composition

In addition to the stations in the global monitoring networks (GAW; GUAN; GSN), the German Weather Service operates several national networks of stations that regularly collect meteorological data in Germany. Their data is subjected to quality assurance measures and then archived chronologically in a climate database. Most of the chronological series begin in the 1940s, although some date from the 19th and 18th centuries.

Since the mid-1970s, the German Weather Service has routinely transferred all meteorological data from its station networks to storage media, checked the data for quality and then archived it. It has also been transferring earlier data, some of it on paper or (since the 1950s) on punch cards, to magnetic tape, and it has been adding this data to the climate database as well.

Data gathered by the former GDR's Meteorological Service, until 1990, has also been similarly processed (although the details have varied) and compiled in a suitable data archive (Einheitlicher Meteorologischer Datenspeicher (EMDS); standardized meteorological data-storage medium). To the greatest possible extent, this data archive has been integrated within the German Weather Service's climate database, in a process that was completed in 1992. Because data was processed in different ways in the old and new Federal Länder prior to 1990, the data sets from the two areas differ in form and content, to some extent.

Since 1997, new climate data has been placed in a relational database system – the MIRAKEL database. In addition, the earlier database has been migrated (largely) to MIRAKEL, with the result that the aforementioned climate data is now archived in a relational database system that greatly facilitates its use.

The entire climate database has been divided into data sets, defined in terms of data elements and chronological density of data. The German Weather Service's station networks now serve as the sources for the data sets (figures: as of 2000):

- About 230 synoptic-climatological reporting stations ("weather stations") with technical personnel serving as observers and/or with automatic function;
- About 530 climate stations with comprehensive measuring programmes carried out by non-professionals;
- About 3500 precipitation stations with restricted measuring programmes carried out by non-professionals;
- About 260 stations that measure ground temperature;
- Additional analyses of analog measurements taken at selected stations, and of hourly measurements made by automatic equipment (wind, temperature, humidity and sunshine duration)
- About 230 automatic stations for 10-minute data (including about 50 that measure only wind parameters);
- About 20 aerological stations (including 12 with a complete measuring programme).

About 130 synoptic reporting stations are also climate stations (synoptic-climatological reporting stations), and all climate stations are also precipitation stations. Analyses of analog measurements has now given way almost completely to calculation of hourly figures on the basis of 10-minute readings taken by automatic stations.

Information about the observation stations within the various measuing networks is also administrated in the MIRAKEL database and can be accessed via the Internet.

Relevant details have been compiled in Table VIII.6.10.1. Tabelles VIII.6.10.2 to VIII.6.10.7 list the homogeneous chronological data series available in the German Weather Service's database.

The German Weather Service also participates in other global measuring networks. Its Lindenberg Meteorological Observatory is integrated within the BSRN (*Baseline Surface Radiation Network*)[17] and thereby contributes to global monitoring of atmospheric radiation. In addition, the Meteorological Observatory is being expanded into a reference station for the GVaP (GEWEX-Global Water Vapor Project of the WCRP).

Fig. VIII.6.6.1 "LAP – 16000" tropospheric wind profiler / RASS at the Lindenberg Meteorological Observatory (German Weather Service)

The "vertical probe" measuring systems listed in Tab. VIII.6.10.4 are wind-profiler radar systems with radioacoustic sensors (RASS). These systems carry out high-resolution chronological and spatial monitoring of wind-vector profiles and virtual temperatures at altitudes ranging from about 0.5 to a maximum of 18 km. A prototype has been in quasi-operational service since July 1996 at the Lindenberg Meteorological Observatory (Fig. VIII.6.6.1). The following Table IX.7.6.2 shows the main characteristics of this 482-MHz wind profiler and the 482-MHz BRAGG RASS and summarises the types of measurements (wind-vector and virtual temperature profiles) concerned.

[17] http://bsrn.ethz.ch/

Tab. VIII.6.6.2 Characteristics of the remote-monitoring system for wind and temperature profiles [482 MHz wind-profiler radar (WPR), coupled with a radio-acoustic sounding system (RASS)]

	482 MHz WPR	**482 MHz Bragg-RASS**
Operating frequency	482.0078 MHz	1000 – 1150 MHz
Peak output	16 kW	4 x 20 W
Effective antenna area	140 m^2	2.5 m^2
Antenns gain (on-axis gain above isotropic)	35 dBi	25 dBi
One-way half power	3°	about 12°
Number of radiation directions	max.: 5	4 x 1
Angle of inclination	75°	-
Vertical resolution	250 ... 500 m	250 m
Vertical range	Low Mode (250 m): 0.5 – 8 km High Mode (500 m): 3 – 18 km	0.5 – 4 km
Averaging interval	25 min	5 min

Within the framework of the "Measurement Network 2000" project, the German Weather Service is planning to supplement the operational radio-sounding network with three 482-MHz wind-profiler/RASS systems. In connection with the existing measuring system at Lindenberg Meteorological Observatory, this will mean that operational high-resolution systems for monitoring vertical wind and temperature distribution will be in place at 4 selected locations in Germany.

Installation of this German Weather Service remote monitoring network is planned for 2002-2004. Its locations will include the Lindenberg site, 2 sites in northern Germany and one site in southern Germany.

As shown in Table VIII.6.10.2, the German Weather Service operates a weather-radar network comprising a total of 16 locations. Within the framework of the "RADOLAN" project supported by the Länder Working Group on Water (Länderarbeitsgemeinschaft Wasser – LAWA), operations as of 2003 are to provide hourly precipitation data with 1 km^2 resolution. Currently, a procedure is being developed for routine online calibration of radar precipitation data, with the help of automatic ground-based precipitation-measuring stations. While raw data for radar reflectivity has been available for some locations since 1991, complete coverage of

Germany did not begin until 2001. Further information is available from the German Weather Service's KLIS system in the Internet.

In Germany, the Alfred Wegener Institut for Polar and Ocean Research[18] (AWI) also contributes to global monitoring of atmospheric and oceanographic variables. To this end, it operates 2 stations in polar regions: the Koldewey station, in Ny Ålesund on Spitzbergen, and the Neumayer station on the Ekström Shelf Ice in Atka Bay, in the north-eastern region of the Weddell Sea in Antactic. It also operates the "Polarstern", a research and supply ship that is the most important tool of German polar research.

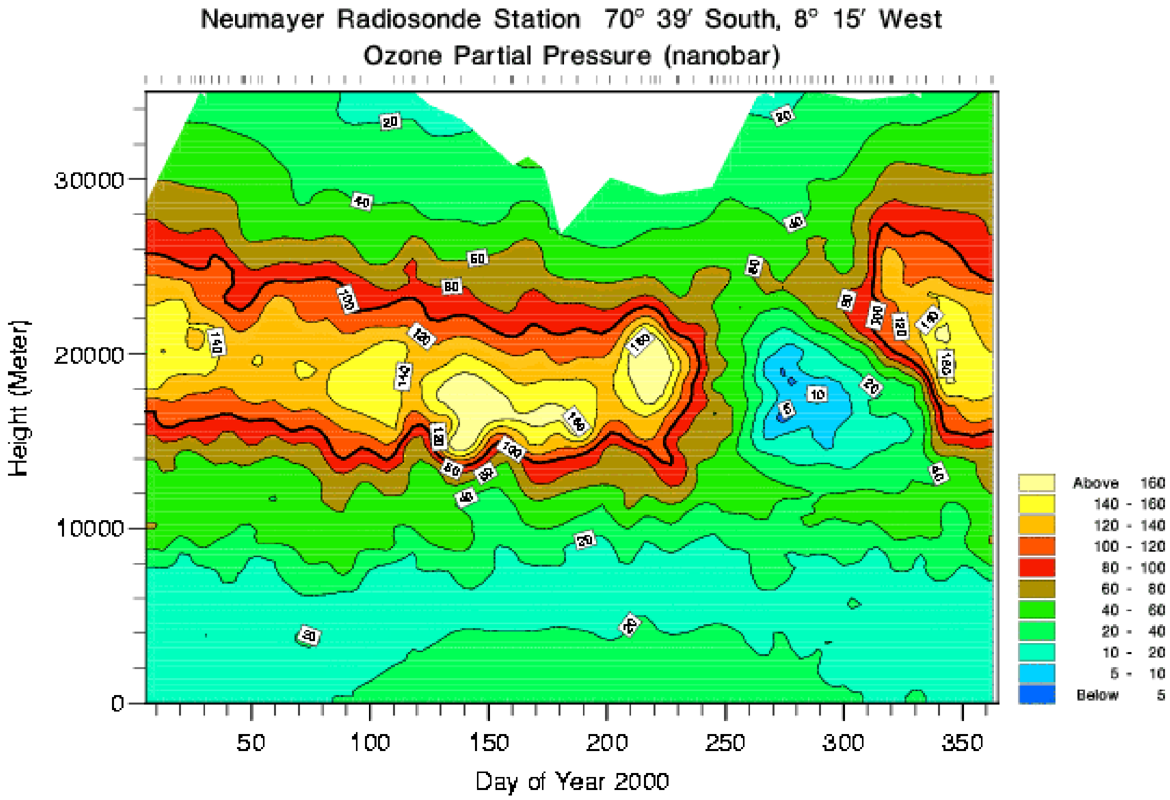


Fig. VIII.6.6.3 Annual course of ozone concentrations above the Neumayer station

[18] http://www.awi-potsdam.de/www-pot/index-d.html

Fig. VIII.6.6.4 Launch of a radio probe at the Neumeyer station

The first "Georg von Neumayer" Antarctic station was established in 1981, on the Ekström Shelf Ice, as a scientific observatory for geophysics, meteorology and atmospheric chemistry and as a logistics base for summer expeditions. The station's namesake, Georg von Neumayer, was an important pioneer of German south-pole research.

By the early 1990s, the station facility was in such poor condition, after having weathered stresses from ice movements and snowpacks, that it had to be rebuilt. The new Neumayer station facility was completed in March 1992, at a location only ten kilometres from the original site. Since then, the station's research and measuring programme has been continually expanded, and it now includes measurements of atmospheric ozone (Fig. VIII.6.6.4). Its atmospheric-chemical measurements are carried out in co-operation with the German Weather Service, the University of Heidelberg's Institute for Environmental Physics and the University of Mainz[19]. The Neumayer station also contributes to the GUAN and GAW.

The Alfred Wegener Institute has had scientists working in Ny-Ålesund since 1988. This polar location received yet another facility in August 1991, when Germany's "Koldewey" research station. Koldewey provides research facilities for scientists working the areas of biology, chemistry, geophysicas and atmospheric physics. Since 1992, the Koldewey station has been part of the *"Network for Detection of*

[19] http://www.awi-bremerhaven.de/GPH/SPUSO.html

Stratospheric Change" (NDSC), a global network that studies long-term changes in the stratosphere. It provides important long-term data that scientists need in order to better understand the stratosphere's chemical and physical processes. The stratospheric measuring programme is being carried out by AWI, in cooperation with the University of Bremen and the Norwegian Institute for Atmospheric Research (NILU). The meteorological and aerological data collected by the station is regularly reported to the WMO.

All data is validated, post-processed and archived by the "Meteorological Information System of the Alfred Wegener Institute" (MISAWI)[20]. Measurements in Ny-Ålesund are made in close co-operation with the Norweigian weather service and the Norsk Polarinstituut. Radiation measurements are made within the framework of the WCRP's BSRN.

The AWI's two stations are included in Tables VIII.6.10.2. VIII.6.10.4 and VIII.6.10.6.

VIII.6.7 Reorganisation of the German Weather Service's ground-based measuring network (Measuring Network 2000 project)[21]

The German Weather Service is planning to reorganise and modernise its network of full-time and part-time ground-based measuring stations by about 2007. Its aim in this connection is to establish a National Basic Measuring Network (NABAM) that will be operated jointly by the country's civil and military weather services (the latter is the German Armed Forces' Geophysical Consultation Service – Geophysikalischer Beratungsdienst), will integrate volunteer stations and be operated in accordance with standard principles and a coordinated network configuration.

Reasons for the network reorganisation:

In light of applicable criteria relative to data quantity, quality and cost-effectiveness, existing measuring and monitoring networks are no longer able to meet growing requirements with regard to supply of data for numeric models, provision of information and expert opinions, climate monitoring, supply of data for operational

[20] http://www.awi-bremerhaven.de/MET/
[21] Additional information about the "Measuring Network 2000“ project is available at the German Weather Service's Website: http://www.dwd.de/general/projects/mn2000/mn2000.html

warning and forecasting services and provision of measurements and monitoring data to customers.

Deficits in the main network:

- Stations of the civil and military weather services use a number of different automatic, semi-automatic and manual data-collection and transmission systems, with differences in hardware, software and instruments. Some of the technical equipment is obsolete.
- The civil and military weather services differ in terms of their equipment and the extent of the data collection.
- Not all stations provide data with high chronological resolution.
- The stations' data-transmission procedures are not standardized (some are automatic, some are manual).
- The potential for automating data-collection processes has not been fully exploited.
- A large percentage of the stations are manned stations (with 3 to 6 observers), and thus the network's operation is extremely expensive.

Deficits in the volunteer network:

- All data is collected conventionally (manually). As a result, the error rate is relatively high.
- All data is transmitted off line; in some cases, electronic data-storage media are used, but in most cases data is recorded in paper tables.
- The data is not available for real-time use.
- Data is collected only at 3 climate-oriented times, 6:30 a.m., 1:30 p.m. and 8:30 p.m. UTC; high-resolution data is not available.
- It is becoming increasingly difficult to gain volunteer observers.

Deficits in data processing:

- The differences in transmission pathways, and the high level of manual overhead, generate unreasonably large amounts of manual work in data checking and processing for follow-on routines.
- Availability of non-real-time products is often subject to considerable delays.

The reorganisation is expected to achieve the following:

- Real-time or near-real-time availability of high-quality data sets obtained in keeping with standardized methods, and derivative products with high levels of chronological and spatial density, for operation and non-operational applications.
- All full-time and volunteer stations within the civil weather service, and the stations of the military weather service (NABAM), will use standardized methods and all will have the same (or compatible) equipment (IT and measuring systems).
- The NABAM includes volunteer-operated measuring stations for climate, precipitation and wind data. This will considerably increase the spatial density of data available in real time.
- All stations shall send their data, which will have high chronological resolution, in real time or near-real-time to headquarters. State-of-the-art data-transmission processes will be used – in the interest of earlier availability for non-operational applications.
- All NABAN stations will use modern, largely automated data-checking procedures – this will improve the quality of the climate database.
- The civil and military weather-service networks will have interoperable configurations.
- Full use will be made of potential for automation of measurements and visual observations, in keeping with the state of the art – this will permit personnel reductions.
- Automation of key data-collection and data-checking components, as described above, will substantially enhance cost-effectiveness of network operation.

VIII.6.8 Basic principles of meteorological and atmospheric observations

The German Weather Service, Germany's national meteorological service, carries out meteorological observations throughout all of Germany. The legal basis for the German Weather Service's operations consists of the Act on the German Weather Service (DWD-Gesetz). This act calls for the German Weather Service to carry out the following tasks:

1. Provision of meteorological services for the general public, and individual customers and users, especially with regard to the areas of transport, industry, agriculture and forestry, construction, public health, water-resources management, environmental protection and nature conservation and science,
2. Provision of reliable meteorological data for air and maritime transport,
3. Provision of warnings about weather conditions that could threaten public safety and order,
4. Short-term and long-term recording, monitoring and assessment of meteorological processes, and of the structure and composition of the atmosphere,
5. Study of the meteorological interactions between the atmosphere and environmental sectors,
6. Weather forecasting,
7. Monitoring of the atmosphere with regard to radioactive trace substances, and forecasting regarding their movements,
8. Operation of the measuring and monitoring systems necessary for performing the tasks listed under numbers 1 through 7 and
9. Archiving and documentation of meteorological data and products, and provision of such data and products as needed.

VIII.6.9 Data exchange and data policy

As the national meteorological service of the Federal Republic of Germany, the German Weather Service cooperates internationally in the area of meteorology and fulfills its commitments relative to such cooperation. For example, it shares the data of the aforementioned stations internationally. It also transmits metadata and historical station data to the responsible data centres.

VIII.6.10 Quality assurance

The German Weather Service carries out quality-assurance procedures for all its data from measurements and observations. Such procedures differ depending on the variables and data sets concerned.

The German Weather Service's tasks include safe storage of collected data, for future applications, and provision of such data as necessary. For this reason, all collected data, along with their descriptive metadata, is stored in a relational database that provides optimal access and enhances both uses and quality assurance. The database includes indexes that indicate what quality-assurance measures have been carried out. "Quality bytes" describe the the quality status for individual elements.

Describing the quality of data collected prior to the introduction of automatic quality-assurance procedures poses a problem. While such historical data normally underwent manual quality-assurance procedures, it still needs to be subjected to standardized quality-assurance methods.

Non-climatological disruptions of measurements, especially those resulting from changes in measuring and analysis procedures, changes in stations' surroundings and changes of stations' locations, are identified by means of homegeneity tests. Where possible, stations' measurement series are homogenised to harmonise them with the latest applicable measurement and site conditions.

A number of monthly indexes have been homogenised for the two long measurement series of the Hohenpeißenberg and Hamburg stations. These include daily mean temperature, mean daily maximum and minimum temperatures, total precipitation and the numbers of days that exceed certain thresholds (frost days, summer days, days with at least 1 mm precipitation, etc.). A number of chronological series have been homogenised with respect to these parameters (Table VIII.6.10.3). Similar homogenisation is planned for the Lindenberg station.

A number of the German Weather Service's stations have compiled very long series of observations. Among these are the 19 stations listed in Table VIII.6.10.3. In addition to these stations, which contribute to the GSN, GUAN or GAW systems, other stations have also compiled long series of near-ground and aerological data. These long series of meteorological observations and measurements available within the German Weather Service system are a unique cultural heritage – at least on the national level – and are thus especially valuable and worthy of protection.

Table VIII.6.10.1 provides a short overview of the numbers of stations with which the Federal Republic of Germany contributes to global networks for climate monitoring.

Tab. VIII.6.10.1 Contribution to global climate-monitoring systems

	GSN	**GUAN**	**GAW**	**BSRN***
For how many stations is the party responsible?	3	1	4	3
How many of these stations are currently in operation?	3	1	4	3
How many are operated in keeping with GCOS standards?	3	1	4	3
How many are expected to be in operation in 2005?	3	1	4	3
How many provide data to international data centres?	3	1	3	3

*Basic Surface Radiation Network of the WCRP

Tab. VIII.6.10.2 Near-ground atmospheric monitoring systems for climate

Systems	Climate parameters (for example, temperature, precipitation, other)	Total number of stations[22]	Suitable for characterising national/regional climate? (Please check one box)			Chronological data series # stations/platforms (# data digitised)			Adequate quality assurance? (Please check one box)			Available metadata Total # stations (%digitised)
			fully	partly	not suited	30-50J	50-100J	>100J	yes	partly	no	
Stations suitable for national climate monitoring	air pressure	191		X		10	69	0	x			191 (100%)
	cloud cover/ cloud elevation, type	628		X		122	266	12	X			628 (100%)
	humidity	628		X		122	266	12	X			628 (100%)
	precipitation (liquid)	4022		X		1145	2565	60	X			4022 (100%)
	precipitation (solid)			X		122	266	12	X			
	precipitation (radar)	16	X			0	0	0		X		16 (100%)
	global radiation (satellite measurement)	grid, METEOSAT resolution	X			0	0	0	X			(100%)
	global radiation	44[23]	X			11	2	0	X			44 (0%)
	diffuse sunshine	30		X		4	1	0	X			30 (0%)
	thermal radiation from the atmosphere	13		X		0	0	0	X			13 (0%)
	sunshine duration	380		X		666	132	4	X			380 (100%)
	temperature (2 m)	628[24]		X		122	266	12	X			628 (100%)
	visibility	628		X		122	266	12	X			628 (100%)
	wind speed and direction	298		X		89	18	2	X			298 (100%)
Internationally distributed station reports	air pressure	191				10	69	0	X			
	cloud cover/ cloud elevation, type	147				10	69	0	X			
	humidity	191				10	69	0	X			
	precipitation (liquid)	189				10	69	0	X			
	precipitation (solid)											
	global radiation	44				11	2	0	X			

22 Including 19 stations of the German Armed Forces (future NABAM stations) and the AWI's Ny Ålesund and Neumayer stations.
23 Plus 16 synoptic stations whose data is neither checked nor archived!
24 Of these, about 50 stations are only automatic

Systems	Climate parameters (for example, temperature, precipitation, other)	Total number of stations[22]	Suitable for characterising national/regional climate? (Please check one box) fully	partly	not suited	Chronological data series # stations/platforms (# data digitised) 30-50J	50-100J	>100J	Adequate quality assurance? (Please check one box) yes	partly	no	Available metadata Total # stations (%digitised)
	diffuse Sonnenstrahlung	30				4	1	0	X			
	thermal radiation from the atmosphere	4				0	0	0	X			
	sunshine duration	172				10	69	0	X			
	temperature (2 m)	191				10	69	0	X			
	visibility	191				10	69	0	X			
	wind speed and direction	191				10	69	0	X			
Stations that report CLIMAT		119							X			
Reference Climate Stations (RCS)		3				0	0	3	X			

Tab. VIII.6.10.3 Available homogeneous data sets for near-ground meteorological observations

Name of data set	Climate parameters	# Stations or grid width and region	Time period	References
HOMDAT	temperature (mean daily maximum, average and minimum), precipitation (monthly total), water-vapour pressure (monthly mean); 21 derived parameters (number of days that meet certain conditions (for example, frost days))	19	Variable, beginning between 1870 and 1912. End in 1980 at the earliest. 15 still in operation today	German Weather Service Gerhard.mueller-westermeier@dwd.de
global radiation	global radiation (satellite measurement)	~8 km, Germany	04/1985 – continuous	http://www.dwd.de/research/satmet/global/index.html
3-hour synoptic ground observation	air pressure, cloud cover/cloud elevation/cloud type, humidity, temperature (2m), visibility, wind speed and wind direction, weather occurrences, course of weather	Neumayer Antarctic (70° 39' south, 8° 15' west)	beginning in 1981	http://www.awi-bremerhaven.de/ MET/Neumayer/obse.html gkoenig@awi-bremerhaven.de
Radiation-balance measurements	10-minute mean of global, reflex, against, off, air pressure, humidity, temperature (2m, 10m), wind speed and wind direction (2m, 10m)	Neumayer Antarctic (70° 39' south, 8° 15' west)	beginning in 1982	http://www.awi-bremerhaven.de/ MET/Neumayer/radiation.html gkoenig@awi-bremerhaven.de
Baseline Surface Radiation Measurements	5- minute mean of global, reflex, against, off, RG8. OG1. UV integral, UV spectral, solar photometry, air pressure, humidity, temperature (2m, 10m), wind speed and wind direction (2m, 10m)	Neumayer Antarctic (70° 39' south, 8° 15' west)	beginning in 1992	http://www.awi-bremerhaven.de/ MET/Neumayer/radiation.html gkoenig@awi-bremerhaven.de
Baseline Surface Radiation Measurements	5- minute mean of global, reflex, against, off, RG8. OG1. UV integral, UV spectral, solar photometry, air pressure, humidity, temperature (2m, 10m), wind speed and wind direction (2m, 10m)	Ny Ålesund Spitzbergen (78° 55' north, 11° 55' east)	beginning in 1992	http://www.awi-bremerhaven.de/ MET/NyAlesund /radiation.html gkoenig@awi-bremerhaven.de

Tab. VIII.6.10.4 Systems for observing the free atmosphere

Systems that are useful for national climate monitoring	Total number of stations	Suitable for characterising national/regional climate? (Please check one box)			Chronological data series # stations/platforms (# data digitised)				Adequate quality assurance? (Please check one box)			Available metadata Total # stations (%digitised)	Continuity # of stations/ platforms likely to be operated in 2005
		fully	partly	not suited	5-10J	10-30J	30-50J	>50J	yes	partly	no		
Radio sensing stations	15[25,26]	X			0	4	9	2	X			15 (100%)	15
Internationally used stations	15[26]				0	4	9	2	X				15
Stations that report CLIMAT TEMP	11[27]				0	2	0	0	X				14
ASAP stations	4				0	0			X			4 (100%)	4
Vertical probes*[28]	1				1	0			X			2 (100%)	4
Aircraft (instrument platforms of airlines)*[29]	48				0	0				X		48 (100%)	ca 60.
GPS	3				0				X			3 (100%)	12
Total network for observing the free atmosphere			X										

* Wet temperature and wind

VIII.6.10.5 Available homogeneous data sets from observations of the free atmosphere

Name of data set	**Climate parameters**	**# of stations or grid width and region**	**Time period**	**References**
Radio sensing, Neumayer station	Altitude profiles with high spatial resolution, for: temperature, humidity, wind speed, wind direction	Neumayer, Antarctic (70° 39' south, 8° 15' west)	beginning in 1983	http://www.awi-bremerhaven.de/MET/ gkoenig@awi-bremerhaven.de

[25] Of these, 3 are stations of Federal Armed Forces
[26] Including 3 AWI stations: Ny Ålesund, Neumayer and Polarstern
[27] Including 2 AWI stations: Ny Ålesund and Neumayer
[28] Wind, temperature
[29] Temperature, pressure, wind

Name of data set	Climate parameters	# of stations or grid width and region	Time period	References
Ozone sensing, Georg Forster station	Main pressure areas for: temperature, humidity, wind speed, wind direction, ozone	Georg Forster, Antarctic (70°46' south, 11°41'east)	1985 – 1992	http://www.awi-bremerhaven.de/MET/ gkoenig@awi-bremerhaven.de
Ozone sensing, Neumayer station	Altitude profiles with high spatial resolution, for: temperature, humidity, wind speed, wind direction, ozone	Neumayer, Antarctic (70° 39' south, 8° 15' west)	beginning in 1992	http://www.awi-bremerhaven.de/MET/ gkoenig@awi-bremerhaven.de
Ozone sensing, Ny Ålesund	Altitude profiles with high spatial resolution, for: temperature, humidity, wind speed, wind direction, ozone	Ny Ålesund, Spitzbergen (78° 55' north, 11° 55' east)	beginning in 1991	http://www.awi-bremerhaven.de/MET/ gkoenig@awi-bremerhaven.de

Table VIII.6.10.6 Monitoring systems for climate-relevant trace gases

Trace gas	Total number of stations	Suitable for characterising national/regional climate? (Please check one box)			Chronological data series # stations/platforms (# data digitised)				Adequate quality assurance? (Please check one box)			Available metadata Total # stations (%digitised)	Continuity # of stations/ platforms likely to be operated in 2005
		fully	partly	not suited	5-20 J	20-30 J	30-50 J	>50 J	yes	partly	no		
Ozone (ground level)	4		X		1	0	2		X			4 (100%)	4
Ozone (column)	4	X			1	0	2			X		4 (100%)	3
Ozone (profile)	4	X			0	0	2		X			4 (100%)	4
Atmospheric water vapour	1		X		1	0	0			X		1 (100%)	1
NO_2 (column)	1			X	1	0	0			X		1 (100%)	1
Aerosols	2			X	1	0	0			X		2 (100%)	2
Optical thickness of aerosol	5		X		3	0	0		X			5 (100%)	5

Table VIII.6.10.7 Available homogeneous data sets for climate-relevant trace gases

Name of data set	Trace gas	# of stations or grid widte and region	Time period	References
Hohenpeißenberger ozone column	Ozone (column)	1	1968 – today	Arbeitsergebnisse der Abteilung Forschung im DWD, Nr. 31
Hohenpeißenberger ozone profile	Ozone (profile)	1	1968 – today	Köhler, U., and H. Claude, 1996
Lindenberg, AERO	Water vapour (profile)	1	1961-ongoing	Leiterer,U., Dier,H. and Naebert,T.,1998

Name of data set	Trace gas	# of stations or grid widte and region	Time period	References
Lindenberg, RSASAEULE	Water vapour (column)[30]	1	1993-ongoing	
Lindenberg SPECTROMETER	Aerosol optical depth	1	1986 – ongoing	Weller,M. et al. 2000
Lindenberg	Ozone (profile)	1	1975-ongoing	
Lindenberg, 0_3 DICKEN	Ozone (column)	1	1993 – ongoing	Tagesmittel-Werte (Brewer 078)
Ozone sensing, Georg Forster station	Main pressure areas of: temperature, humidity, wind speed, wind direction, ozone	Georg Forster, Antarctic (70°46' south, 11°41' east)	1985 – 1992	http://www.awi-bremerhaven.de/MET/ gkoenig@awi-bremerhaven.de
Ozone sensing, Neumayer station	Altitude profiles with high spatial resolution, for: temperature, humidity, wind speed, wind direction, ozone	Neumayer, Antarctic (70° 39' south, 8° 15' west)	beginning in 1992	http://www.awi-bremerhaven.de/MET/ gkoenig@awi-bremerhaven.de
Ozone sensing, Ny Ålesund	Altitude profiles with high spatial resolution, for: temperature, humidity, wind speed, wind direction, ozone	Ny Ålesund, Spitzbergen (78° 55' north, 11° 55' east)	beginning in 1991	http://www.awi-bremerhaven.de/MET/ gkoenig@awi-bremerhaven.de
Solar photometry measurements (Georg Forster)	Optical thickness of aerosol in 350 – 1050 nm spectral range	Georg Forster, Antarctic (70°46' south, 11°41' east)	1988 – 1992	aherber@awi-bremerhaven.de
Solar photometry measurements (Neumayer station)	Optical thickness of aerosol in 350 – 1050 nm spectral range	Neumayer, Antarctic (70° 39' south, 8° 15' west)	beginning in 1992	aherber@awi-bremerhaven.de
Solar photometry measurements (Ny Ålesund)	Optical thickness of aerosol in 350 – 1050 nm spectral range, vertical profile from airborne measurements	Ny Ålesund, Spitzbergen (78° 55' north, 11° 55' east)	beginning in 1991	aherber@awi-bremerhaven.de
Aerosol lidar profiles	Aerosol in troposphere and stratosphere (backscattering coefficients)	Ny Ålesund, Spitzbergen (78° 55' north, 11° 55' east)	beginning in Jan. 1989, and then always in winter months	
FTIR measurements of trace gases in Ny-Ålesund[31]	$CO_{2.}$ N_2O, $CH_{4.}$ CFCs-12. CFCs-22. HCl, HF	Ny Ålesund, Spitzbergen (78° 55' north, 11° 55' east)	beginning in 1992	http://www.awi-potsdam.de/www-pot/ftir jnotholt@awi-potsdam.de
FTIR measurements from FS Polarstern[31]	$CO_{2.}$ N_2O, $CH_{4.}$ CFCs-12. CFCs-22. HCl, HF	Polarstern research ship (80°N to 70°S)	1994.1996.1999	http://www.awi-potsdam.de/www-pot/ftir jnotholt@awi-potsdam.de
Near-ground ozone Ozon	Continuous in situ measurements of near-ground ozone; chronological resolution: 3 minutes	Neumayer, Antarctic (70° 39' south, 8° 15' west)	beginning in 1983	rweller@awi-bremerhaven.de
Condensation cores (CN)	Continuous in situ measurements of	Neumayer, Antarctic	beginning in 1983	rweller@awi-bremerhaven.de

[30] Reference data for microwave radar and GPS sensing within the sphere of the Lindenberg GvaP station

[31] Absorption measurements were carried out, with the help of the sun (during the polar night, with the moon), in the infrared spectral range. The spectra yield the total concentrations of 20-30 atmospheric trace gases. The most important climate-relevant trace gases are listed.

Name of data set	Trace gas	# of stations or grid widte and region	Time period	References
	condensation cores (ø > 10 nm), chronological resolution: 1 minute	(70° 39' south, 8° 15' west)		

VIII.7 Oceanographic monitoring

VIII.7.1 General information

Monitoring climate changes in the marine sphere requires use of specially coordinated systems that monitor both the atmosphere and the ocean. Energy and substance flows at the interface between ocean and atmosphere create strong links between the two systems.

The ocean plays a central role in the earth's climate. Because water can store some 3,100 times as much heat as air can, ocean currents can transport enormous amounts of heat over long distances and thus bring about regional climate shifts. The North Atlantic current for example, moderates Europe's climate throughout a region extending to north Scandinavia, to northern latitudes that in Canada and Siberia are covered with permafrost and which thus harbour few people. Another consequence of the large thermal carrying capacity of water is that the ocean tends to dampen rapid, strong climate changes in the atmosphere. Monitoring of thermal transport by the ocean's current system thus plays an important role in study and prediction of climate changes.

Another key property of the ocean is its ability to store carbon dioxide (CO_2) and other greenhouse gases. While the atmosphere is presumed to contain only about 700 gigatonnes (Gt) of CO_2, the ocean is thought to contain some 40,000 Gt of bound CO_2. Deep-reaching convection regions in northern parts of the North Atlantic and in the Weddell Sea transport carbon dioxide and other greenhouse gases into the ocean's depths, where they remain out the atmosphere's reach for long periods of time. And upward convection currents in the ocean – for example, off the west coasts of Africa and South America, can release large amounts of CO_2. The rates of CO_2 exchange between the atmosphere and ocean, and the processes by which such exchange occurs, are not yet well understood.

Because such a large percentage of the earth's surface is covered by water, the maritime atmosphere plays a key role in global climate. And because the two spheres are coupled, as mentioned above – especially because of atmospheric feedback on to the ocean, the present chapter covers the relevant maritime meteorological monitoring systems.

VIII.7.2 The Voluntary Observing Ships (VOS) network

The German Weather Service currently has been able to gain over 700 commercial and research ships for its voluntary meteorological observing service.

Most of the data these ships gather is sent via satellite links, in near real-time, into the Global Telecommunication System (GTS), a global meteorological data network, where it supports current weather forecasting and a broad range of meteorological services. The ships also store the data on back-up media (diskettes/log books) and have it taken off board regularly by their ports' meteorological services.

For use in climatological studies, the data is carefully reviewed and archived by the German Weather Service's National Archive for Maritime Data (NAMD). In addition, the entire database is shared with other countries worldwide, within the framework of the MCSS (Marine Climatological Summaries Scheme). To this end, the German Weather Service and the British weather service, acting under commission to the WMO, each operate a Global Collecting Centre (GCC) for ships's weather reports.

Fig. VIII.7.2.1 Typical container ship in voluntary maritime meteorological observing service

On a quarterly basis, the MCSS member countries [about 40 "Contributing Members" (CM)] send all of the meteorological observation data from their voluntary observing ships to the GCCs. The data is checked for compliance with minimum quality standards and then forwarded, in a standard quality format, to 8 sub-centres ["Responsible Members" (RM)] that archive the data and subject it to climatological analysis pursuant to the JCOMM agreement.

This VOS system is continually being improved with regard to climatological quality requirements (VOS Climate Project), and it thus provides a reference for other data sources (remote satellite sensing and model data).

VIII.7.3 Buoys

Fig. VIII.7.3.1 Typical type FGGE meteorological drift buoy

To measure climate-relevant variables (such as temperature, salt concentrations and ocean currents), oceanographers rely on research ships (as described above) and on automatic reporting platforms: anchored measuring platforms, bodies drifting on the ocean's surface and, in recent research, profiling deep drifters. Surface drifters are equipped with meteorological and oceanographic sensors that gather data from the water layer near the surface.

The Voluntary Observing Ships (VOS) system is supported by a system of drifting meteorological buoys that, unlike most oceanographic buoys, are equipped with special meteorological measuring instruments. They are placed in areas outside of shipping routes, where little data is normally gathered, so that they can enhance spatial coverage in meteorological data-gathering.

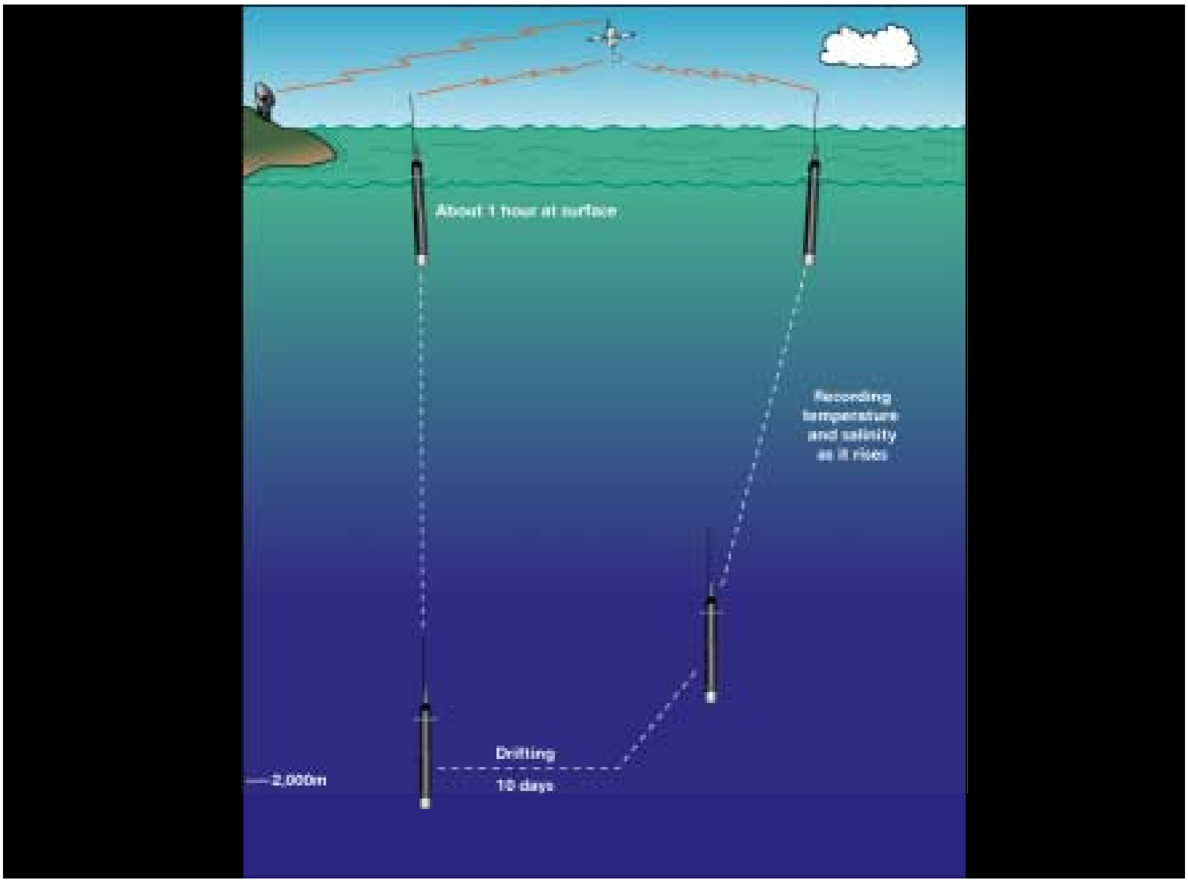
In the EGOS framework, the German Weather Service is contributing to these efforts with its own drift buoys. EGOS (European Group on Ocean Stations) is a group of 9 European countries (currently) that is working to optimise operation of drifting and anchored buoys. By cooperating in sharing relevant tasks and resources, the group's members reduce their individual workloads. As a result of the group's efforts, some 2 – 6 German buoys are permanently operational. Quality assurance is carried out by the EGOS' own monitoring system, while relevant archiving is carried out by NAMD.

Fig. VIII.7.3.2 ASAP launch

VIII.7.4 Deep-drifting buoys

Germany (Institute for Marine Research at the University of Kiel – IfM Kiel) is participating in the ARGO programme, with profiling deep-drifting buoys, within the framework of the EU-financed GYROSCOPE project. In ARGO, drift buoys are allowed to float (inactively) in ocean currents at depths of about 2000 meters. Every two weeks they rise to the surface, measuring temperature and salinity en route, transmit their data to receiving stations via satellite, and then drop back down to their operating depths.

Fig. VIII.7.4.1 Functional principle for profiling deep-drifting buoys (NOAA diagram)



Germany has not yet decided whether or not to participate in ARGO with a nationally funded contribution.

VIII.7.5 The Automated Shipboard Aerological programmes (ASAP)

In maritime studies, meteorologists gather data not only near the ocean's surface, but also from the sea-air interface layer and the free atmosphere. Such data is being gathered, for example, within the framework of the Automated Shipboard Aerological Programme (ASAP), in which the German Weather Service maintains up to 4 operational units. Data from this programme is also disseminated, checked for quality and archived via the GTS.

VIII.7.6 The Ships of Opportunity Programme (SOOP)

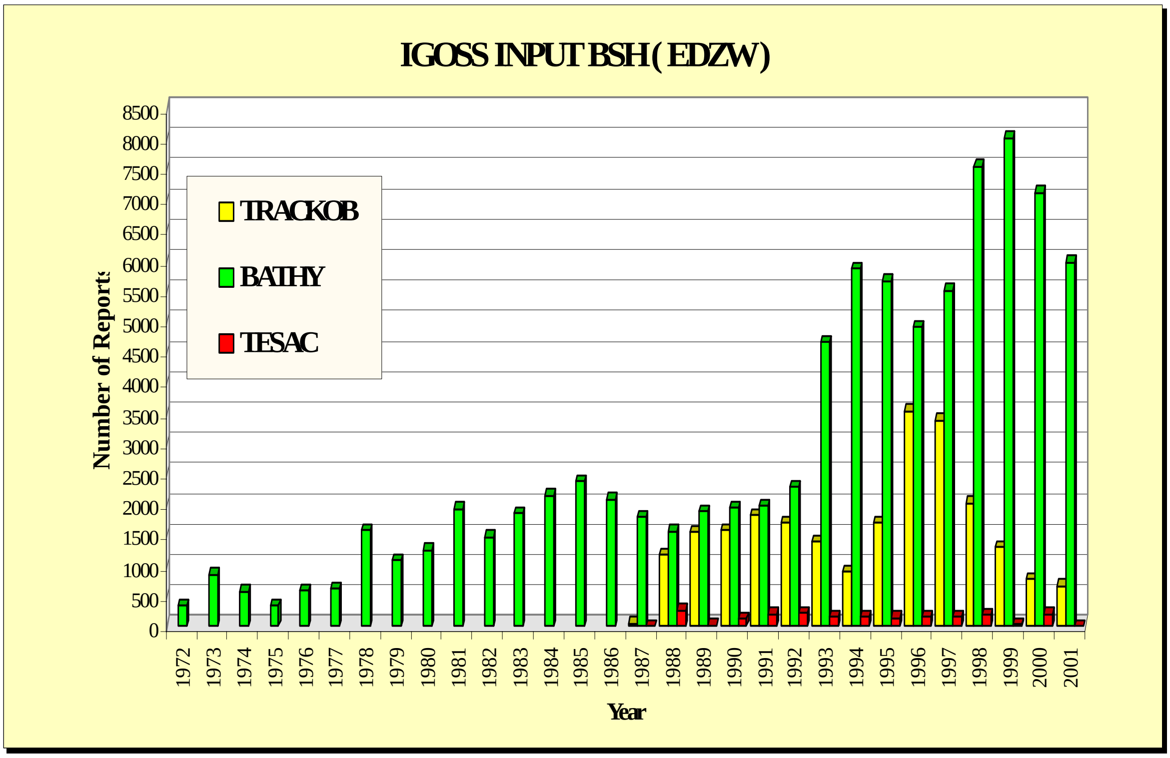
Germany has been participating in the Ships of Opportunity Programme (SOOP) since the programme's inception. The German Maritime and Hydrographic Agency

(BSH) maintains 2 SOOP lines, in the Atlantic Ocean, on which commercial ships use XBTs to measure temperature distribution at depths to 1100 metres. These lines include: are (a) the AX-11 line, from the mouth of the English Channel to Rio de Janeiro and (b) the AX-3 line, from the English Channel to the west coast of the U.S.. Some German research ships – including the Meteor, Polarstern, Gauss and Walther Herwig – have also been participating in SOOP, from time to time, with XBT measurements.

Numerous commercial ships have also been equipped with contact thermometers that measure water temperatures near the ocean's surface.

All measurements are distributed worldwide via the GTS, in near-real-time, in a system that uses the following codes: BATHY (vertical temperature profiles), TESAC (vertical temperature and salinity profiles) and TRACKOB (surface temperatures and salinity).

Fig. VIII.7.6.1 Statistics on German SOOP measurements, as provided to the GTS, for the period 1972 to 2001.



VIII.7.7 Sea-level measurements

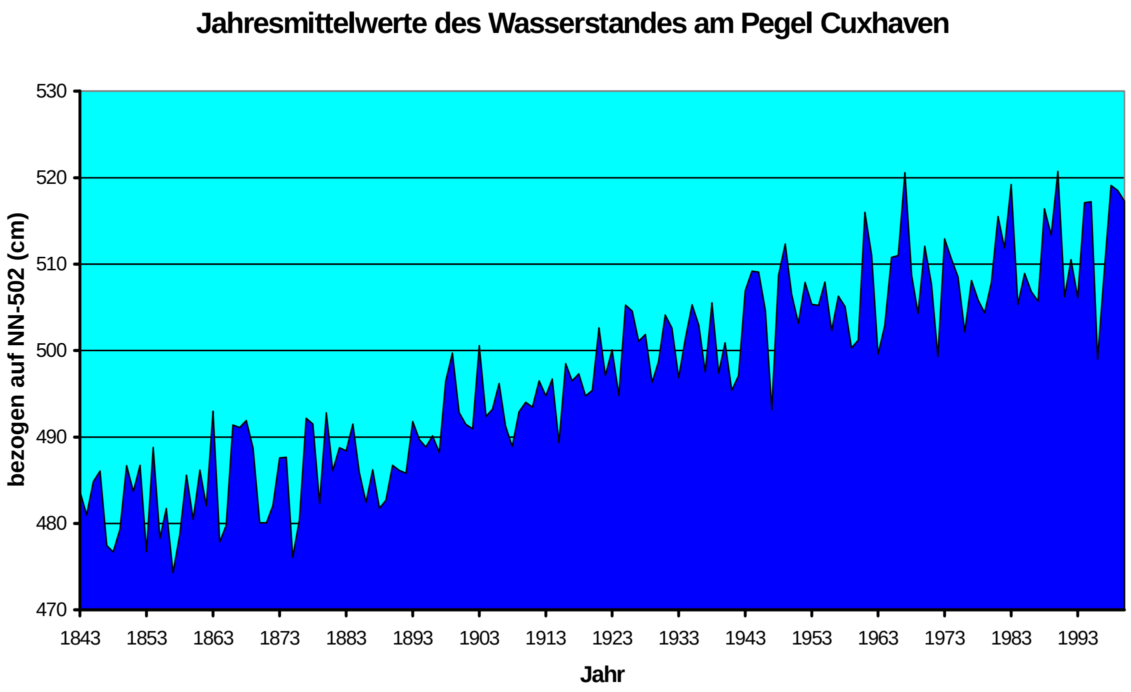
Tidal levels along German coastlines are measured by administrative bodies for water quality and shipping. The German Maritime and Hydrographic Agency (BSH) uses such tidal-level measurements for its water-level forecasts. Water-level data for Borkum (Fischerbalje), Cuxhaven (Steubenhöft) and Amrum (Wittdün) is sent annually to the Permanent Service for Mean Sea-Level (PSMSL) in Birkenhead (UK).

The data series extend back to the following years:

at Borkum	to 1963
at Cuxhaven	to 1843
at Amrum	to 1963

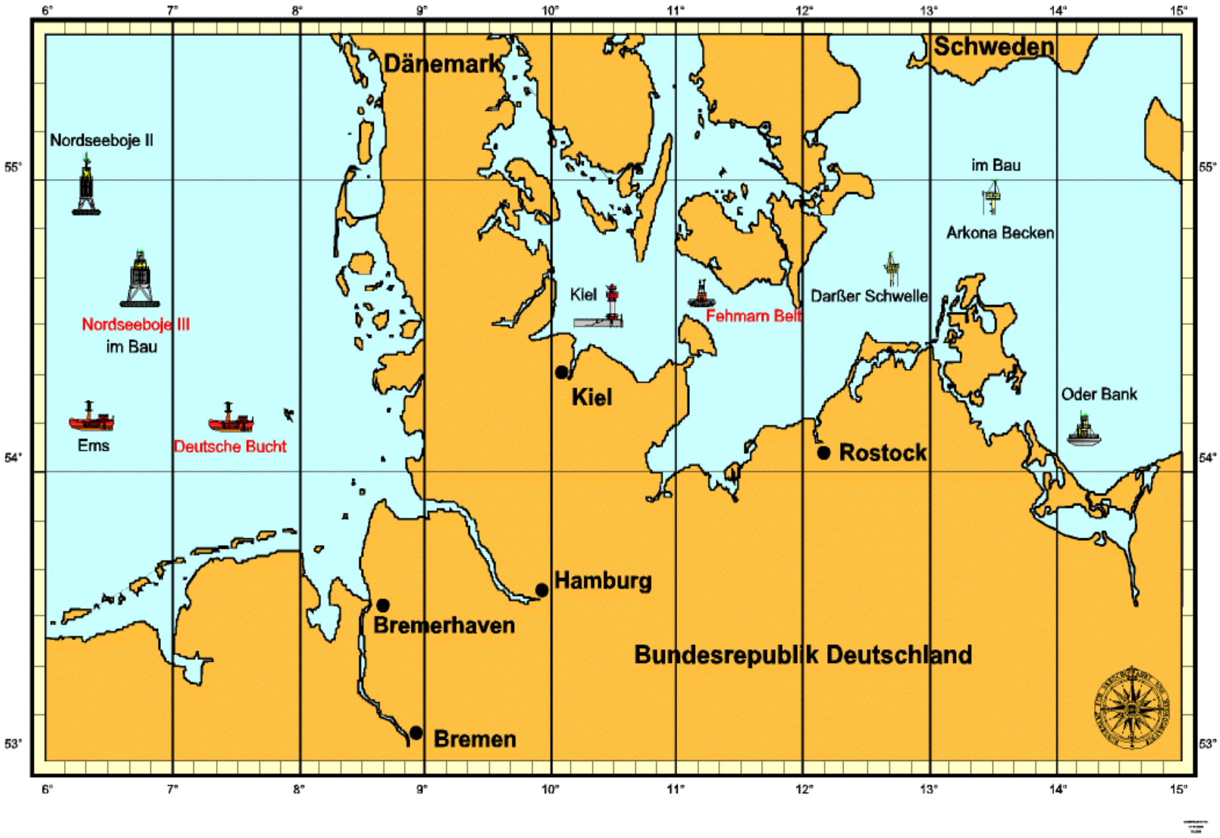
The PSMSL's Website provides comprehensive information for the three stations regarding changes, over the years, in data such as tide gauge zero[32].

Fig. VIII.7.7.1 Changes in annual mean water levels at Cuxhaven station (oriented to sea level of 502 cm)



[32] http://www.pol.ac.ak/psmsl/

Fig. VIII.7.7.2 The BSH's automatic marine-environmental measuring stations in the North Sea and Baltic Sea.

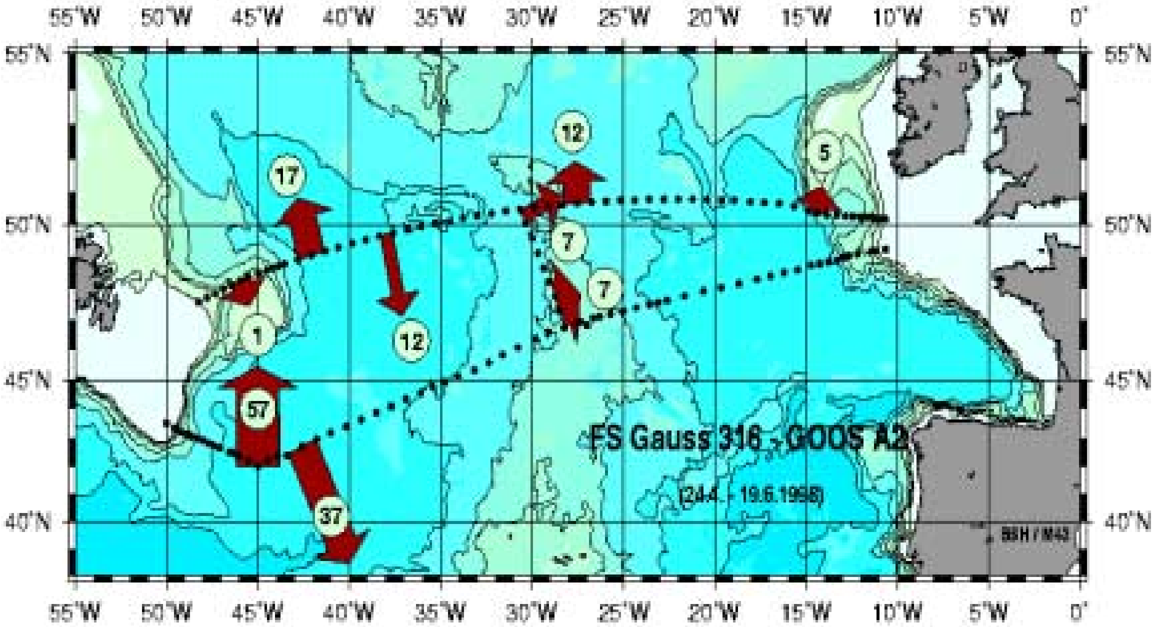


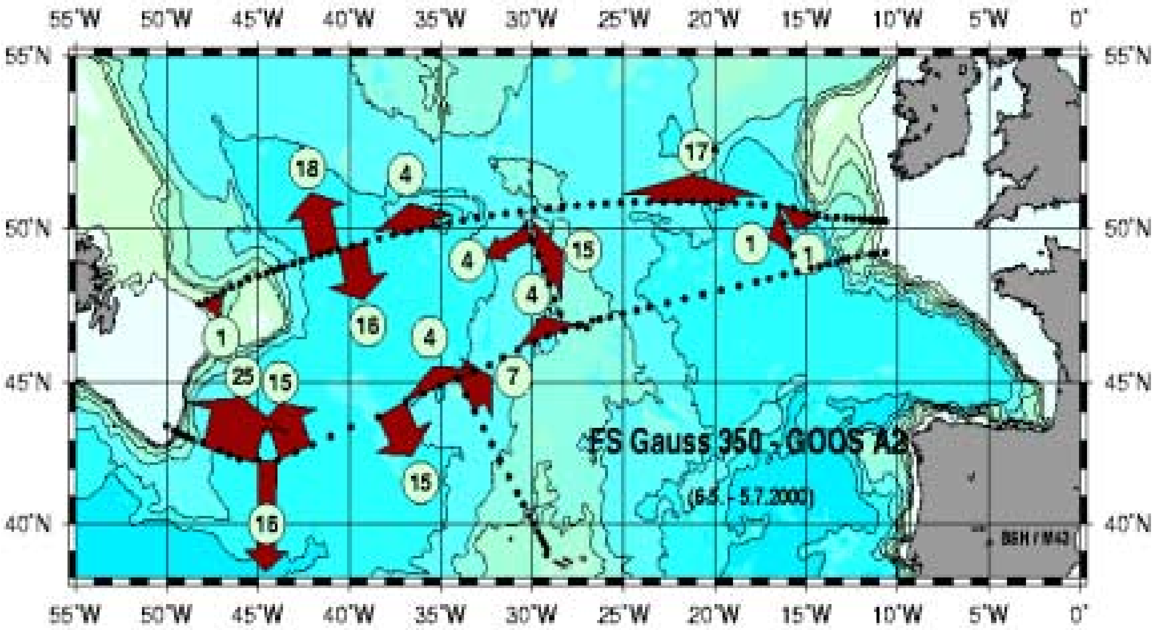
VIII.7.8 Other oceanographic measuring networks

In the North Sea and west Baltic Sea, the German Maritime and Hydrographic Agency (BSH) operates its MARNET marine-environmental measuring network, which currently consists of 7 measuring stations and which will be expanded to 9 stations by the end of 2002 (Fig. VIII.7.7.2). The MARNET's stations take hourly measurements for the following variables: air temperature, air pressure, wind direction and wind speed. At several water depths, they also measure temperature, salinity, oxygen content and gross gamma radiation. Two of the stations also measure nutrient levels. The meteorological measurements and water-temperature and salinity data are uploaded to the GTS at the four main meteorological times, i.e. four times a day[33].

[33] http://www.bsh.de/Meeresumweltschutz/MARNET/MARNET.html

Fig. VIII.7.8.1 Main current arms, with their transport rates in Sv (106 m^3/s), through the periphery of hydrographic boxes. The current arrows' surface areas are volume-transport equivalents. a) Gauss voyage 316, 1998; b) Gauss voyage 350, 2000.





The AWI also archives oceanographic data of relevance to global climate monitoring. Table VIII.7.8.2 provides an overview.

Tab. VIII.7.8.2 Oceanographic data archived at the AWI

Data	Time period	Total	North-polar region	South-polar region	Access
CTD	Nov. 1983 to Jan. 2001	4280	1217	3063	www.awi-bremerhaven.de/OZE/index.html
Anchorings	Sep. 1986 to Jan. 2001	1104*	508	596	www.awi-bremerhaven.de/OZE/index.html
XBT	Oct. 1984 to Sep. 1998	3549	-	-	www.awi-bremerhaven.de/OZE/index.html

Last revision: Sept. 2001

Unprocessed thermosalinograph (surface temperature and salinity) data, dating from May 1993, is archived in the meteorological database. This data has not yet been processed – i.e. checked for measuring errors – and thus it is not yet available from the relevant AWI Website[34] (neither is it listed). The first data records from this group will be processed by the beginning of next year, and processing will continue for the remaining data records. Thanks to changes in processing routines, future data processing will be faster, and data will thus be available almost immediately after it is collected.

VIII.7.9 Hydrography programme

In a continuation of its North-Atlantic activities within the WOCE (World Ocean Circulation Experiment), and as part of its participation in GOOS, since 1998 the BSH has been carrying out a modified measuring programme in the transition zone between sub-tropical and sub-polar circulations. Along two hydrographic sections from the English Channel to the banks of Newfoundland (A2 corridor), measurements are being taken, throughout entire water columns, of temperature, salinity, oxygen concentrations and nutrients. The complete hydrographic, quasi-synoptic boxes formed by the stations' locations permit improved assessments of geostrophic transport rates – and thus of the oceanic thermal transport relevant for the European climate system. This programme is being supported by XBT measurements taken by commercial ships, within the SOOP framework (AX-3) and at two-monthly intervals, in the A-2 corridor's dynamic cover layer.

Tab. VIII.7.9.1 Participation in global ocean-monitoring systems

	VOS	SOOP	TIDE GAUGES	SFC DRIFTERS	SUB-SFC FLOATS	MOORED BUOYS	ASAP
For how many platforms is the party (country) responsible?	725[35]	2 (XBT) 5 (SST)	3	2-6	28	7	4
How many of these platforms make their data available to international data centres?	725 [1]	2 (XBT) 5 (SST)	3	2-6	28	7	4
How many of these are expected to be in operation in 2005?	about 600	2 (XBT) 5 (SST)	3	2-6	58	9	4

[34] http://www.awi-bremerhaven.de/MET/Polarstern/met.html
[35] Not including Federal Armed Forces

Tab. VIII.7.9.2 Oceanographic monitoring system for climate

System component	Total # stations/ sections	Suitable for characterising national/regional climate? (Please check one box)			Chronological data series # stations/platforms (# data digitised)			Adequate quality assurance? (Please check one box)			Available metadata Total # stations (%digitised)	Continuity # of stations/platforms expected to be in operation in 2005
		fully	partly	not suitable	30-50 Y	50-100 Y	>100 Y	yes	partly	no		
SOOP:												
- TRACKOB[36]			X						X			X
- XBT[37]	AX-3:140 sections		X					X			8000 stat. digital	X
	AX-11: 76 sections		X					X			4000 stat. digital	X
MARNET (moored oceanogr. stations in North Sea and Baltic Sea)[38]	7		X		1 digital	2 digital			X		7 stat.	9 stat.
Surface drift buoys												
Profiling deep-drift buoys	18		X					X			18 100 %	?[41]
	22[40]			X								
- GYROSCOPE[39]	10		X					X			10 drift buoys	40 drift buoys

[36] TRACKOB: SST measurements on irregular routes in North Sea and Baltic Sea
[37] XBT: on 2 SOOP lines (AX-3 aund AX-11) of the BSH
[38] MARNET: Information about the BSH' marine environmental measuring network in North Sea and Baltic Sea is available at http://www.bsh.de/Meeresumweltschutz/MARNET/MARNET.html or http://www.bsh.de/Marine_Environment/MARNET/MARNET.html.
[39] GYROSCOPE is an EU-financed project that is contributing to ARGO; the Institute for Marine Research at the University of Kiel is participating in it.
40 Institute for Marine Research at the University of Kiel, Kiel: a) deep-drift buoys in CLIVAR – tropical and subtropical interactions (15 buoys)
b) deep-drift buoys in SFB 460 – TP A4 subpolar North Atlantic (7 buoys); data is provided to GTS.
[41] Application submitted to BMBF for joint-research project (AWI – BSH – IfM Kiel), as a contribution to ARGO. Support funding unknown as yet. For this reason, no estimate of the number of deep-drift buoys in 2005 can be provided.

System component	Total # stations/ sections	Suitable for characterising national/regional climate? (Please check one box)			Chronological data series # stations/platforms (# data digitised)			Adequate quality assurance? (Please check one box)			Available metadata Total # stations (%digitised)	Continuity # of stations/platfo rms expected to be in operation in 2005
		fully	partly	not suitable	30-50 Y	50-100 Y	>100 Y	yes	partly	no		
Current measurements	2 moorings 15[42] 6 moorings[43]	 X	X					X X			2 moorings 50 % X	X 6
Atlantic hydrographic section (48° N) - WOCE-A2[44] - A2 corridor[45]	 4 sections 4 sections	 X X						 X X			 4 sections 4 sections	 0 sections 2 sections
"Helgoland Reede"Long-term data series (T,S, nutrients, meteorol.)	1	X					digital		X		Methods description s, 50% digital	1
Annual Autumn Groundfish Survey round Greenland	140	X			digital			X				140
Water levels	3		X		2 digital		1 digital	X			3 digital	3
Meteorological observations (for example, temperature, air pressure, wind)	725		X		X[46]			X			725 (100%)	Ca. 600

[42] Institute for Marine Research at the University of Kiel: a) Current-measuring arrays in the Labrador Sea (11 moorings)
b) Current-measuring arrays off the coasts of Brazil (4 to 5 moorings)
[43] Institute for Marine Research, Hamburg: Denmark Strait Overflow & East Greenland Current Freshwater content.
[44] In 1993, 1994, 1996 and 1997, work was conducted on the WOCE-A2 hydrographic section, within the framework of the World Ocean Circulation Experiment (WOCE).
[45] In 1998 and 2000, the BSH added to the WOCE-A2 section another more northerly section, chosen so that the two sections form a corridor (A2 corridor).
[46] To this end, a sea region measuring about 5°x5°, for which data series of sufficient duration could be formed, was considered.

System component	Total # stations/ sections	Suitable for characterising national/regional climate? (Please check one box)			Chronological data series # stations/platforms (# data digitised)			Adequate quality assurance? (Please check one box)			Available metadata Total # stations (%digitised)	Continuity # of stations/platforms expected to be in operation in 2005
		fully	partly	not suitable	30-50 Y	50-100 Y	>100 Y	yes	partly	no		
Other programmes (if necessary, described in greater detail in notes)		X[47]						X			X	

[47] Ireland-Greenland Atlantic hydrographic section, two-year intervals.

VIII.7.9.3 Available homogeneous data records for oceanographic observations (oceanographic contribution)

Integrated data records; Name and short description	Climate parameters	# platforms and/or grid width and region	Time period	References
"Deutsche Bucht"	wind direction, wind speed, sea state, water temperature, salinity, oxygen content, radioactivity	54° 10‘ N, 07° 27‘ E	1969 – 1988. 1989 – 2001	Archived in the BSH's German Oceanographic Data Centre (Deutschen Ozeanographischen Datenzentrum – DOD)
"Fehmarnbelt"	wind direction, wind speed, sea state, water temperature, salinity, oxygen content, radioactivity, air temperature, wind direction, wind speed, air pressure	54° 36‘ N, 11° 09‘ E	1924 – 1945. 1947 – 1984. 1984 – 1996. 2001	Archived in the BSH's German Oceanographic Data Centre (DOD)
"Kiel"	wind direction, wind speed, sea state, water temperature, salinity, air temperature, radioactivity	54° 30‘ N, 10° 16‘ E	1936 – 1945. 1947 – 1967. 1969 – 2001	Archived in the BSH's German Oceanographic Data Centre (DOD)
"Ems"	water temperature, salinity, oxygen content, radioactivity	54° 10‘ N, 06°20.8‘ E	1989 – 2001	Archived in the BSH's German Oceanographic Data Centre (DOD)
"North Seaboje II"	water temperature, salinity, oxygen content, air temperature, wind direction, wind speed, air pressure	55° 00‘ N, 06° 20‘ E	1991 – 1998; 2001	Archived in the BSH's German Oceanographic Data Centre (DOD)
"Darsser Schwelle"	water temperature, salinity, oxygen content, pressure, air temperature, wind direction, wind speed, air pressure, humidity, solar radiation, rainfall, radioactivity	54° 41.9‘ N, 12° 42‘ E	1993 – 2001	Archived in the BSH's German Oceanographic Data Centre (DOD)
"Oderbank"	water temperature, salinity, oxygen content, pressure, air temperature, wind direction, wind speed, air pressure, humidity	54° 04.6‘ N, 14° 09.6‘ E	1996 – 2001	Archived in the BSH's German Oceanographic Data Centre (DOD)
"Elbe"	wind direction, wind speed, sea state, water temperature, salinity, oxygen content, radioactivity	54° 00‘ N, 08° 06.5‘ E	1924 – 1939. 1945. 1947 – 1988. 1989 – 1999	Archived in the BSH's German Oceanographic Data Centre (DOD)
SOOP section AX-3	water temperature (XBT) spatial resolution: 30 sm	North Atlantic: corridor from English Channel to Newfoundland	1988 – 2001	BSH reports (Berichte aus dem BSH): ISSN 0936-0298; ISSN 0936-0298; ISSN 0946-6010
SOOP section AX-11	water temperature (XBT) spatial resolution: 60 sm	Atlantic: Route from English Channel to Rio de Janeiro	1990 – 2001	
Pegel Borkum	water level	53° 33.48‘ N; 06° 44.91‘ E	1963 – 2001	
Pegel Cuxhaven	water level	53° 52.08‘ N; 08° 43.17‘E	1843 – 2001	
Pegel Amrum	water level	54° 37.91‘ N; 08° 23.12‘ E	1963 – 2001	
Annual Autumn Groundfish Survey round Greenland since 1	temperature, salinity	East Greenland, West Greenland	1963 – 2001.	Archived in the BSH's German Oceanographic Data Centre (DOD)
"Helgoland Reede"	temperature, salinity, nutrients, meteorological variables	54° 11.18‘ N; 07° 54.00‘ E	1873 – 2001	Archived in the BSH's German Oceanographic Data Centre (DOD)
Denmark Strait Overflow	cold-water transport (temperature, salinity, current)	SE Greenland	1997-2001	
N Atlantic hydrographic section at 55° N	warm-water transport (temperature, salinity, current)	Ireland – Greenland	since 1991, at 2-year intervals	

Notes:

Deutsche Bucht: Manned fire-fighting ship from 1969 – 1988. 2 hourly values: wind direction, wind speed, sea state and current, water temperature and salinity, daily at 08:00 hours and at spring neap and mean tide.
Unmanned fire-fighting ship, since 1989 hourly measurements of water temperature at 7 depths, salinity and oxygen content at 2 depths; as of 1998 ammonia, nitrate and phosphate, as of 2001 radioactivity

Fehmarnbelt: Manned fire-fighting ship from 1924 – 1984. 2 hourly values: wind direction, wind speed, sea state and current, water temperature and salinity, daily at 08:00 hours and at spring neap and mean tide.
Unmanned ship, since 1984 since 1989 hourly measurements of water temperature at 6 depths (as of 2001, at 7 depths), salinity and oxygen content at 2 depths, air temperature, wind direction, wind speed and air pressure, radioactivity, as of 2001 ammonia, nitrate and phosphate.

Kiel: Manned fire-fighting ship from 1936 – 1967. 2 hourly values: wind direction, wind speed, sea state and current, water temperature and salinity, daily at 08:00 hours and at spring neap and mean tide.
Kiel lighthouse, since 1969 hourly measurements of water temperature at 6 depths, salinity at 2 depths, air temperature, radioactivity.

Ems: Unmanned fire-fighting ship, since 1989 hourly measurements of water temperature at 7 depths, salinity and oxygen content at 2 depths, radioactivity.

North Seaboje II: Large unmanned buoy, since 1991 hourly measurements of water temperature at 7 depths (as of 2000 at 8 depths), salinity and oxygen content at 2 depths, air temperature, wind direction, wind speed and air pressure.

Darsser Schwelle: Unmanned measuring mast, since 1993 hourly measurements of water temperature at 6 depths, salinity at 4 depths and oxygen content at 2 depths, pressure, air temperature, wind direction, wind speed, air pressure, humidity, solar radiation and rainfall, radioactivity.

Oderbank: Large unmanned buoy, since 1996 hourly measurements of water temperature at 2 depths, salinity at 2 depths and oxygen content at 2 depths, pressure, air temperature, wind direction, wind speed, air pressure, humidity.

Elbe: Manned fire-fighting ship from 1924 – 1988. 2 hourly measurements: wind direction, wind speed, sea state and current, water temperature and salinity daily at 08:00 hours and at spring neap and mean tide.
Unmanned fire-fighting ship, since 1989 hourly measurements of water temperature at 5 depths, salinity and oxygen content at 2 depths, radioactivity, as of 1998 ammonia, nitrate and phosphate.

SOOP line AX-3: Commercial ships of Hapag-Lloyd shipping company ("Köln Express" and "Bonn Express") and the research ships "Gauss", " Meteor", "Prof. Multanovsky"

SOOP line AX-11: Commercial ships of Hamburg-Süd shipping company ("Monte Rosa" and " Cap Finisterre")

VIII.8 Terrestrial observations

VIII.8.1 General information

The German Weather Service carries out a range of monitoring programmes that can be considered contributions to terrestrial observation systems (Fig. VIII.8.6.2.1). It particular, it supports the GTN-H facility.

VIII.8.2 Participation in GTN-P

By virtue of geographic location, Germany has no permafrost soils.

VIII.8.3 Participation in GTN-G

Only a few university institutes are participating in worldwide monitoring of glaciers. There are no significant glaciers on Germany's territory.

VIII.8.4 Participation in GTN-H

As part of its meteorological monitoring tasks, the German Weather Service operates its own precipitation-measuring network. This network represents a contribution to the hydrological component of GTOS. Relevant details are provided in Chapter VIII.5.

This measuring network also measures snowpacks (absolute and new snow), in water equivalents.

VIII.8.5 Participation in FLUXNET

Within the framework of FLUXNET, a global network of stations that is studying exchange of CO_2, water vapour and energy between the atmosphere and terrestrial ecosystems, CarboEurope[48] is developing a prototype of a reliable, continually operating monitoring system expected to produce a comprehensive carbon balance sheet for Europe. The European network comprises over 30 stations that are carrying out *in situ* measurements of carbon and energy flows in boreal, temperate and Mediterranean forests. FLUXNET was established in spring 2000 and now consists of 69 research institutions in 15 European countries.

Germany is participating in the network with two stations – in Tharandt and Bayreuth. A third station is currently being established in Solling. An overview of the locations in Europe, with descriptions of the involved stations, is available in the Internet[49].

VIII.8.6 Other terrestrial monitoring networks

VIII.8.6.1 Ground temperature

Many of the German Weather Service's stations measure ground temperatures at various depths, including a maximum depth of 100 cm. One station (Potsdam) has been measuring ground temperature for over 100 years at a depth of 12 m.

Ground-temperature data is exchanged on the basis of bilateral agreements.

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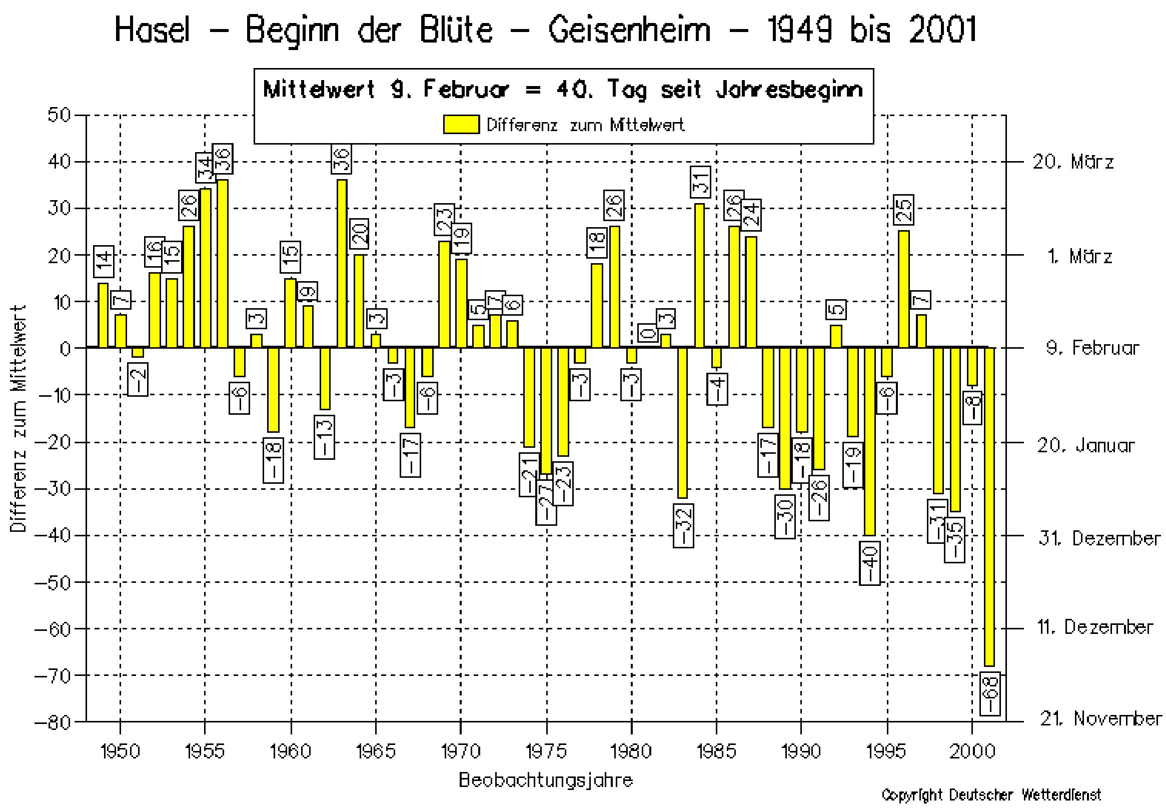
[48] http://www.unitus.it/dipartimenti/disafri/progretti/eflux/euro.html

VIII.8.6.2 Biota

The German Weather Service's phenological monitoring data (Fig. VIII.8.6.2.1) is not exchanged internationally, since no agreements are in place for exchange of such data between weather services. In addition, such monitoring is carried out in only a few countries. In the 1950s, the International Phenological Gardens (IPG) network was founded as a means of obtaining a basis for such comparisons. This network was supported until 1995 by the German Weather Service. In 1996, the German Weather Service transferred this responsibility to Humboldt University in Berlin, in order to reduce its costs; the German Weather Service does not consider IPG operation to be one of its central tasks.

Additional information about the German Weather Service's phenological monitoring is available from the service's climate information system (KLIS) in the Internet.

Fig. VIII.8.6.2.1 Data series covering long periods of time show how the commencement of certain phenological phases changes:



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49 http://www.unitus.it/dipartimenti/disafri/progetti/eflux/euromap2.html

[Beginning of hazel bloom at Geisenheim, 1949 to 2001; mean value of 9 February = 40th day since the beginning of the year; different from the mean value; observation years]

Legal framework: ICP Forests is a joint programme of the European Union and the United Nations that was established on the basis of EC Council Regulation (EEC) No 3528/86. This programme monitors and assesses the condition of forests on the basis of various indicators. It comprises the following study areas in Germany:

- Annual surveys on a systematic sampling network (with about 420 points in a 16 x 16 km grid, with some areas of higher density sampling) that covers all of Germany's forested areas; surveys include assessment of trees' crown condition. This forest-damage survey (known as Waldschadenserhebung, WSE, in Germany) has an intensity level referred to as "level I".
- Level I also includes the soil-condition survey (known as Bodenzustandserhebung, BZE, in Germany), which to date has been carried out once (in the 1987 to 1993 period), on an 8 x 8 km grid (with some areas of higher density sampling) with about 1800 points. This survey covers foliar nutrient status as well as soil chemistry and capacity and intensity parameters. Current plans call for repeating this survey every 10 to 15 years.
- Level II includes observations on 89 permanent observation plots, carried out at intervals ranging from weeks to years (some observations are also continuous). Level II surveys gather data (in addition to that collected in Level I) on deposition of air pollutants via precipitation, substance movements in groundwater and meteorological data.

The surveys are carried out and evaluated by the Länder. The Federal Government coordinates the work and prepares national summaries.

Regular monitoring of changes in the ranges of plants and animals can provide indications of climate changes. The great majority of relevant studies focus only on individual species, however. The Federal Agency for Nature Conservation maintains a database of monitoring data on vascular plant populations (FLORKART) and a similar database on butterfly populations (LEPIDAT). It remains to be determined whether this information is suitable for range-monitoring studies – since the information is based on reports of volunteers, it thus cannot be updated at precise yearly intervals.

Ecological Random Area Sampling (Ökologische Flächenstichprobe – ÖFS) provides methods and concepts for surveying distribution of biotopes and species. Applied at five-year intervals, the methods would detect changes in factors such as species and structural diversity, and yield results that would be representative of all of Germany. A decision on implementation of this monitoring method has not yet been taken. The UK has been applying a similar method (Countryside Survey) for some time now. In 2001, Switzerland also launched a biodiversity-monitoring (BDM) programme that collects species-diversity throughout a sampling grid. It is still unclear whether a standardized biodiversity-monitoring programme will be introduced on a European-wide basis.

In reporting obligations under the FFH Directive and the EC Bird Directive, countries are required to gather information on the condition of NATURA 2000 areas. While in Germany this area network includes only a selection of valuable natural areas, it is being expanded throughout Europe – presumably under common quality standards.

Changes in the migratory behaviour of migratory animal species can also be used to verify climate changes. No long-term series of relevant nationwide-monitoring data are available. It remains to be determined whether findings from bird-migration research of various universities and of the Radolfzell bird station[50] could be applied to such studies. Possibly, surveys carried out with regard to reporting obligations under the Bird Directive and the Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA) might be applicable in this regard in future.

VIII.8.7 Hydrological measurements in surface waters

In Germany, hydrological measurement networks are operated by the water-resources administrations of the Länder and, along federal waterways, by the Federal Government's waterway and shipping administration (Wasser- und Schifffahrtsverwaltung des Bundes – WSV). The "water-level regulation"

[50] http://vowa.ornithol.mpg.de/forschinf_d.html

(Pegelvorschrift), which was first issued in 1935, provides the basis for these networks. The 4th version of the regulation, in force since 1997, was prepared by the Länder Working Group on Water (Länderarbeitsgemeinschaft Wasser – LAWA) and the Ministry of Transport, Building and Housing (BMVBW).

Fig. VIII.8.7.1 Heldra hydrological measuring station along the Weser River

The legal basis for collection, evaluation and use of water-level data consists of the Federal Water Act, the water acts of the Länder and Federal Waterway Act, in their applicable versions. Germany's surface-waters measuring network comprises a total of 4379 water-level monitoring points. In addition to monitoring water levels, a total of 3019 measuring stations also measure rates of flow. The longest continuous series of monitoring data for daily rates of flow are those compiled by stations on the Rhine River (1802 Rees), Elbe River (1806 Dresden) and Weser River (1820 Vloto). On the Danube River, continuous records of water levels have been collected at the Passau point since 1876.

Some 1000 of these measuring stations are considered particularly important. This assessment is based on the stations' importance with regard to water-resources management, flood protection, waterway transports and planning, documentation and research. Monitoring data from these stations is published in the German Yearbook of Hydrology (Deutsches Gewässerkundliches Jahrbuch – DGJ), which has appeared since 1901. This work, which is divided into 10 volumes, covering different river basins, now contains monitoring data from 1032 hydrological measuring points. In addition to water-level data and rates of flow, the DGJ also publishes monthly mean levels for suspended particulates, as obtained from 50 measuring stations, and groundwater-level data obtained from about 200 selected measuring stations.

The Federal Government's waterway and shipping administration (WSV) operates 561 hydrological measuring stations of regional and supre-regional importance (this figures does not include the measuring points required simply for technical operation of facilities). A total of 161 of the WSV's measuring stations also register rates of flow. The DGJ publishes water levels from 190 WSV measuring stations and rates of flow from 78 WSV stations. In addition to collecting purely hydrological data, federal stations also measure a range of other parameters (drift, radioactivity, conductivity and various chemical parameters). Furthermore, about 250 stations also measure air and water temperature.

VIII.8.7.1 Hydrological water-level data in the DGJ

A range of different agencies review and archive water-level data runoff data independently, under their own responsibility. The only central agency among this group, the German Federal Institute of Hydrology (Bundesanstalt für Gewässerkunde – BfG), maintains a long-term database of runoff data – in the HYDABA hydrological database, which contains data series for federal measuring stations as well as historical data series for a number of Länder measuring stations.

Fig. VIII.8.7.1.1 " Online" measuring stations in ELWIS

Data exchange between the Länder, and between the Länder and the Federal Government, is regulated by administrative agreements. International data exchange with neighbouring countries is also regulated by agreements. Furthermore, Germany is actively involved in managing and updating data of the WMO's Global Runoff Data Centre (GRDC). A total of 94 German stations regularly provide the GRDC with updates of their runoff data. For several years, in an effort to meet the need for fast availability of environmental information, the Federal Government's waterway and shipping administration (WSV) has been operating the ELWIS electronic waterway information system (Fig. VIII.8.7.1.1). This system, which is accessible for all interested parties, shows the current hydrological situation on federal waterways. At present, current water levels for about 100 different measuring stations are shown in the Internet[51].

Tab. VIII.8.7.1.2 Participation in global terrestrial monitoring systems

	GTN-P	**GTN-G**	**FLUX NET**	**ICP IM**	ICP Forest/ Level II	ICP Vegetation/ Crops	ICP Materials	ICP Freshwater	**ICP Mapping**
For how many observation platforms is the party (country) responsible?	0	0	3	1	89	5	6	41	NE
How many of these platforms are currently in operation?	0	0	2	1	89	5	6	41	*
How many of these provide data to international data centres?	0	0	2	1	89	5	6	41	NE
How many are expected to be in operation in 2005?	0	0	3	2	89	5	6	?	NE

* Data from Länder measuring networks

[51] http://www.elwis.bafg.de

Tab. VIII.8.7.1.3 Terrestrial monitoring systems for climate

Systems suitable for national climate monitoring	Total # stations	Suitable for characterising national/regional climate? (Please check one box)			Chronological data series # stations/platforms (# data digitised)			Adequate quality assurance? (Please check one box)			Available metadata Total # stations (%digitised)	Continuity # of stations/plat-forms expected to be in operation in 2005
		yes	partly	no	30-50y	50-100y	>100y	fully	partly	not adequate		
Snow	4022		X		1145	2565	60	X			4022 (100%)	2100
Ground temperature (2, 5,10, 20, 50, 100 cm under the surface)	287		X		20	19	0		X		287 (100%)	315
Ground temperature (2, 3, 4, 5, 6, 7, 8, 9, 10, 12 m under the surface)	1			X	0	0	1		X		1 (100%)	1
CORINE: land use, ground cover (satellite data)	500x500 m		X		0	0	0	X			100 %	
UBA atmospheric measuring network: precipitation, temperature, wind direction and wind speed, relative humidity, air pressure, O_3, SO_2 (24); CO_2 (8)	24		X		0	0	0	X			24 (100%)	reduction planned
Permanent soil monitoring: land use, KAK, carbon and carbonate content	~700		X		0	0	0			X	700 (100%) but not all areas are digitised	X
Soil-condition surveys: carbon, organically dissolved humus, C/N and C/P relationships	16x16 km grid (about 1800)		X		0	0	0		X		X (at BMVEL)	Repetition planned
Runoff	3019	(X)	X		456	376	42	X			100%	?

Tab. VIII.8.7.1.4 Ecological monitoring systems for climate

Systems suitable for national climate monitoring	Total # stations	Suitable for characterising national/regional climate? (Please check one box)			Chronological data series # stations/platforms (# data digitised)				Adequate quality assurance? (Please check one box)			Available metadata Total # stations (%digitised)	Continuity # of stations/plat-forms expected to be in operation in 2005
		yes	partly	no	30-50y	50-100y	100-300y	>300y	yes	partly	not adequate		
Phenology	6400[52]		X		2000	4				X		9000 (70%)	1400
NDVI[53]	Grid, 1km resolution		X		0	0	0	0		X		X (100%)	X
Degree of vegetation cover[53]	Grid, about 7 km resolution		X		0	0	0	0		X		X (100%)	X

[52] Currently active: 1600
[53] Product derived from radiation data measured by satellites (NOAA).

VIII.9 Space-based monitoring programmes

VIII.9.1 General information

Under Germany's Act on transfer of space tasks (Raumfahrtaufgabenübertragungsgesetz – RAÜG), the German Aerospace Center (DLR) is responsible for designing the country's space programme, for implementing the programme and for maintaining international contacts, as the Federal Government's representative. In carrying out these tasks, the DLR cooperates closely with participating federal ministries, especially the Federal Ministry of Education and Research (BMBF) and the Ministry of Transport, Building and Housing (BMVBW). Via its Space Flight Committee and its programme committees (here: earth observation), the DLR consults regularly with federal ministries, including the Federal Ministry of Defence (BMVg), Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), Federal Ministry of Consumer Protection, Food and Agriculture (BMVEL) and Federal Ministry of the Interior (BMI); with scientists (for example, representatives of the National Committee for Global Change Research (NCGCR) of the Deutsche Forschungsgesellschaft (DFG) and the BMBF's committee of experts for global environmental aspects (Sachverständigenausschuss für Globale Umweltaspekte – SVGUA); and with industry. The activities of the Interministerial Committee for Geoinformation (IMAGI) include integration of remote-sensing data in GIS, for national applications. The DLR advises various organisations with regard to use of remote-sensing data – for example, the German Committee for Disaster Reduction (DKKV).

Within the sphere defined by the RAÜG, the DLR represents German interests in the European Space Agency (ESA). With regard to earth monitoring, this work involves contacts to the Earth Observation Programme Board (PB-EO) and the Data Operation Scientific and Technical Advisory Group (DOSTAG). The German contribution to ESA amounts to some 1040 million DM per year. Within this sum, Germany's contribution to various earth-observation programmes amounts to about 80 million DM per year. In addition, Germany pays contributions – i.e. the BMVBW pays contributions via EUMETSAT – to ESA, for development of the Second Generation Meteosat (MSG) and the MetOp polar-orbiting weather satellite.

VIII.9 .2 EUMETSAT

Europe's meteorological services coordinate their operational satellite activities via EUMETSAT (the European Organisation for the Exploitation of Meteorological Satellites). Because levels of contributions to EUMETSAT are based on gross domestic product, the Federal Republic of Germany, represented by the German Weather Service (DWD), is the largest contributor to EUMETSAT. In 2001, Germany paid over 68 million euros. The EUMETSAT programmes, which are the European contributions to the WMO and the space component of the Global Observing System (GOS), are highly significant for GCOS, for the following reasons:

- the long-term commitments of EUMETSAT programmes (especially important with regard to climate monitoring);
- the advantages of space-based observations over *in-situ* measurements:
    - different parts of the world can be observed with one and the same observation system,
    - collected information is largely complete-coverage information,
    - observations have high repetition frequencies.

It should be noted that the EUMETSAT Convention was expanded to cover tasks in the area of climate monitoring. Article 2 of the EUMETSAT Convention states: "*A further objective of EUMETSAT is to contribute to the operational monitoring of the climate and the detection of global climatic changes".*

With METEOSAT, EUMETSAT operates geosynchronous satellites; with the EUMETSAT Polar System (EPS), it is carrying out a programme for operational development of polar-orbiting meteorological satellites. The earliest METEOSAT data dates from 1977. The same METEOSAT system, now known as MTP (METEOSAT Transition Programme), will remain in operation until at least the end of 2003. The Meteosat Second Generation (MSG) programme, for which a firm decision has been taken, will provide operational data from the end of 2002/early 2003 to 2012/2014, while the EUMETSAT Polar System (EPS) will provide data from 2006 to approximately 2020.

MSG and EPS will carry certain instruments for climate monitoring and climate research. These include the the Geostationary Earth Radiation Budget (GERB) instrument, carried by MSG, and the GOME-2 (Global Ozone Monitoring Experiment), carried by METOP (ESA Meteorological Operational Programme) satellites in the context of EPS (EUMETSAT Polar System). In addition, all other instruments in the MSG and EPS/METOP payloads will provide valuable information of relevance to GCOS. Details about EUMETSAT, including its programmes, data and products, are provided on the EUMETSAT Website[54].

Within the framework of EUMETSAT's "Satellite Application Facilities" (SAF), the German Weather Service has agreed to function as the lead institution for the task of deriving climate-relevant parameters from a new satellite generation (MSG, EPS_METOP) and to establish the "SAF on Climate Monitoring". This unit is expected to enter its pre-operational phase in 2004.

VIII.9.3 Other satellite systems

Apart from operational meteorological satellites, the following other satellites are operated by Germany or co-financed by Germany, via its contribution to ESA. On the national level:

- BIRD (detection of high-temperature events such as fires, volcanoes; launched in 2001)
- CHAMP (CHAllenging Minisatellite Payload, for geoscientific and atmospheric research; since 2000)
- GRACE (Gravity Recovery And Climate Experiment; launch in 2002)
- MOS (mapping of ocean colour, chlorophyll and other water constituents and atmospheric aerosols; since 1996)
- SRTM (Global digital elevation models by single pass SAR interferometry, in 2000)
- TerraSAR (High-Resolution X-Band SAR for land observation, forestry, agriculture, regional planning, cartography, biomass; launch in 2005)

ESA:

[54] http://www.eumetsat.de/

- ERS-2 (Earth Remote Sensing Satellite – 2; since 1995)
- ENVISAT (Environmental Satellite; launch in 2002)
- GOCE (Gravity Field and Steady-State Ocean Circulation Explorer; launch in 2005)
- CRYOSAT (measurements of polar ice coverage, changes in sea level; launch in 2004)
- SMOS (Soil Moisture and Ocean Salinity; launch in 2006)
- Aeolus/ ADM (Atmospheric Dynamics Mission; launch in 2007)
- ACE – Atmospheric Profiling (Temperature and Humidity Soundings)
- SWIFT (on GCOM; 2006/2007)

To this list must be added the future Earth Explorer missions.

VIII.9.4 Data availability

The EUMETSAT Secretariat extracts geophysical parameters from METEOSAT data, archives them in its Meteorological Archiving and Retrieval Facility (MARF) and makes them available to interested parties. This data includes a number of products, such as climate data records, a precipitation index, a number of cloud products and sea surface-temperature data (SST product), that are of special interest for climate applications. Details about MARF and about how the archived data can be retrieved are available under http://www.eumetsat.de (click on "data, products and services" and then on "archived data retrieval service".

At the German Remote Sensing Data Centre (Deutsches Fernerkundungsdatenzentrum) in Oberpfaffenhofen, the DLR receives, processes, stores and provides satellite data. The data involved includes data from NOAA-AVHRR and -TOVS, from GOME on ERS-2 and, in future, data from MIPAS, GOMOS and SCIAMACHY on ENVISAT.

ESA provides data free of charge, within the framework of "Announcements of Opportunity", for scientific research. Outside of these announcements, data is provided for research purposes, upon application, at reduced rates (costs for fulfilling the user request). Full rates are charged for commercial/operational uses. Special terms for subscriptions or large-area coverage may be negotiated.

Similar policies also apply to the aforementioned projects in the national framework.

VIII.9.5 Conformance with GCOS standards

The primary requirement has to do with continuity of measurements. While this is always sought, with the aforementioned systems, it cannot always be achieved. In many cases, the missions concerned are for demonstration purposes or intended to help answer a specific question regarding the earth system. Thanks to close cooperation between ESA and EUMETSAT, a number of successful demonstrators have been transferred to routine regular operation, and this practice is to be continued in future where possible. With the Earthwatch programme, ESA has created the necessary organisation and programme framework for this purpose. And Global Monitoring for Environment and Security (GMES), a relevant programme element, has been contractually agreed via the European space strategy jointly defined by ESA and the EU.

The aforementioned GCOS standards for calibration/validation, quality assurance, chronological overlapping of old and new sensor data, archiving and access are all standards that are desired for all aforementioned satellite systems – and are met. One partly critical aspect involves delays between measurements and data delivery to users – delays which, depending on the amount and complexity of processing involved, can range up to several weeks.

IX List of abbreviations

AEWA	Agreement on the Conservation of African-Eurasian Migratory Waterbirds
ARGO	Array for real-time geostrophic oceanography
ASCOBANS	Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas
ASAP	Automated Shipboard Aerological Programme
AWI	Alfred Wegener Institute for Polar and Ocean Research
BAPMon	Background Air Pollution Monitoring Network
BATHY	GTS Code (temperature profile vs. depth)
BDM	Biodiversity Monitoring Programme of Switzerland
BfG	Federal Institute for Water Science (Bundesanstalt für Gewässerkunde)
BfN	Federal Agency for Nature Conservation (Bundesamt für Naturschutz)
BfS	German Federal Institute for Radiation Protection (Bundesamt für Strahlenschutz)
BMBF	Federal Ministry of Education and Research (BMBF) (Bundesministerium für Bildung und Forschung)
BMI	Federal Ministry of the Interior (Bundesministerium des Innern)
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit)
BMVBW	Federal Ministry of Transport, Building and Housing (Bundesministerium für Verkehr, Bau- und Wohnungswesen)
BMVEL	Federal Ministry of Consumer Protection, Food and Agriculture (Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft)
BMVg	Federal Ministry of Defence (Bundesministerium für Verteidigung)

BSH	German Maritime and Hydrographic Agency (Bundesamt für Seeschifffahrt und Hydrographie)
BSRN	Baseline Surface Radiation Network of the WCRP
BZE	Soil-condition survey (Bodenzustandserhebung)
CLIVAR	Climate Variability and Predictability
CORINE	Coordination de l'Information sur l'Environment
CTD	Conductivity/Temperature/Depth (measuring device)
DGJ	German Yearbook of Hydrology (Deutsches Gewässerkundliches Jahrbuch)
DOD	German Oceanographic Data Centre (Deutsches Ozeanographisches Datenzentrum)
DWD	German Weather Service (German Weather Service)
ECT/CL	European Topic Centre Land Cover
EEA	European Environmental Agency
EGOS	European Group on Ocean Stations
ELWIS	Electronic Waterway Information System (elektronisches Wasserstraßen-Informationssystem)
EMDS	Standardized Meteorological Database (Einheitlicher Meteorologischer Datenspeicher)
EMEP	European Monitoring and Evaluation Program
ENVISAT	Environmental Satellite, ESA
EPS	EUMETSAT Polar System
ERS-2	Earth Remote Sensing Satellite, ESA
ESA	European Space Agency
EUA	European Umweltagentur (European Environmental Agency)
EUMETSAT	European Organization for the Exploitation of Meteorological Satellites
EUROBATS	Agreement on the Conservation of Bats in Europe
FFH	EU Fauna, Flora and Habitat Directive
GAW	Global Atmosphere Watch
GCC	Global Collecting Centre
GCOS	Global Climate Observing system

GentG	Act on Genetic Engineering (Gentechnikgesetz)
GERB	Geostationary Earth Radiation Budget
GEWEX	Global Energy and Water Cycle Experiment
GHG	Greenhouse Gas
GMEA	Global Monitoring for Environment and Security
GOCE	Gravity Field and Steady-State Ocean Circulation Explorer, ESA
GOME	Global Ozone Monitoring Experiment (instrument to measure ozone profiles, ERS-2 and EPS satellites)
GOMOS	Global Ozone Monitoring by Occultation of Stars
GOOS	Global Ocean Observing system
GPCC	Global Precipitation Climatology Centre
GPCP	Global Precipitation Climatology Project
GPS	Global Positioning system
GRDC	Global Runoff Data Centre of WMO
GSN	GCOS Surface Network
GSNMC	GSN Monitoring Centre
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunication System of WMO
GTZ	Gesellschaft for Technische Zusammenarbeit GmbH
GVaP	GEWEX (tropospheric) Water-vapour Climatology Project
GZS	Global Collecting Centre (Globales Zentrum for Schiffswettermeldungen)
HELCOM	The Baltic Marine Environment Protection Commission (Helsinki Commission)
HYDABA	Hydrological Database (Hydrologische Datenbank)
ICP IM	International Cooperation Program Integrated Monitoring
ICP M	International Cooperation Program Mapping
ICSU	International Council for Science
IOC	Intergovernmental Oceanographic Commission of UNESCO
IfM	Institute for Marine Research (Institut für Meereskunde)
IGOS	Integrated Global Observing Strategy

IMIS	Integrated Measuring and Information System for Radioativity
IPG	International Phenological Garden
JCOMM	Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology
KLIS	The German Weather Service's climate-information system in the Internet
FCCC	Framework Convention on Climate Change
LAWA	Länder Working Group on Water (Länderarbeitsgemeinschaft Wasser)
MARNET	The BSH's Marine Environmental Measuring Network in the North Sea and Baltic Sea
MCSS	Marine Climatological Summaries Scheme of the WMO
METOP	ESA Meteorological Operational programmes
MISAWI	Meteorological Information System of the Alfred Wegener Institute
MSG	Meteosat Second Generation
NABAM	National Basic Measuring Network (Nationales Basismessnetz)
NAMD	The German Weather Service's National Archive for Maritime Data
NDSC	Network for Detection of Stratospheric Change
NOAA	National Oceanic and Atmospheric Administration, USA
ÖFS	Ecological Random Area Sample (Ökologische Flächenstichprobe)
OSPARCOM	Oslo-Paris Commission for the Protection of the North Sea
PSMSL	Permanent Service for Mean Sea-Level
RADOLAN	Radar Online Calibration (Radar-Online-Aneichung; official title of the project, translated: Routine procedures for online calibration of radar precipitation data with the help of automatic ground-based precipitation-measuring stations (ombrometers)
SCAPP	Scanning Pyrheliometer Pyranometer

SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Cartography
SFB	Special Research Area (Sonderforschungsbereich) of the Deutsche Forschungsgemeinschaft (DFG)
SNDI	SeaNet Data Interface
SOOP	Ship-of-Opportunity Programme
TESAC	GTS Code (Temperature, Salinity, Currents vs. depth)
TIROS	Television and Infrared Operational Satellite
TOVS	TIROS Operational Vertical Sounder
TRACKOB	GTS Code (along-track measurements)
UBA	Federal Environmental Agency (Umweltbundesamt)
UN-ECE	United Nations Economic Commission
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UTC	Universal Time Code
VOS	Voluntary Observing Ships
WCRP	World Climate Research programmes
WDC	ICSU World Data Centre
WMO	World Meteorological Organization
WSE	forest damage survey (Waldschadenserhebung)
WSV	Federal Government's waterway and shipping administration (Wasser- und Schiffahrtsverwaltung des Bundes
XBT	Expendable Bathythermograph

X The GCOS Standards

X.1 Best practices for GSN stations (Manual on Observations 2.10.3.19)

Long-term continuity should be provided for each GSN station. This requires the provision of the necessary resources, including well-trained staff, and keeping changes of location to a minimum.

In case of significant changes in sensor devices or station location, Members should provide for a sufficiently long period of overlap (at least one, but preferably two years) with dual operation of old and new systems to enable comparisons to be made and the identification of inhomogeneities and other measurement characteristics.

CLIMAT data should be provided in an accurate and timely manner. CLIMAT reports should be transmitted by the fifth day of the month but not later than the eighth day of the month.

Rigorous quality control should be exercised on the measurements and their message encoding. CLIMAT reports require quality control of the measurements themselves and their message encoding to ensure their accurate transmission to national, regional and world centres for their use. Quality control checks should be made on site and at a central location designed to detect equipment faults at the earliest stage possible. The Guide to Instruments and Methods of Observation (MO No 8) provides the appropriate recommendations.

The site layout should follow the recommended form (Guide on the GOS, WMO No 488).

The site and instruments should be inspected regularly and maintained according to WMO recommended practices (Guide to Instruments and Methods of Observation (WMO No 8). As part of the maintenance, the necessary calibration practices should be traceable to the standards provide by the Guide.

A national plan should be developed to archive daily data and metadata pertaining to each climate station. Metadata should include data concerning a station's establishment, subsequent maintenance, and changes in exposure, instrumentation and staff. The data and metadata should be in its original form as well as in digital format.

Detailed metadata and historical climate data for each GSN station should be provided to the GSN Data Centre. Both data and metadata should be up-to-date.

X.2 Best practices for GUAN stations (Manual on Observations 2.10.4.9)

Long-term continuity should be provided for each GUAN station. This requires the provision of the necessary resources, including well-trained staff, and keeping changes of location to a minimum.

Changes of bias caused by changes in instrumentation should be evaluated by a sufficient overlapping period of observation (perhaps, as much as a year) or by making use of the results of instrument intercomparisons made at designated test sites.

Soundings should preferably be made twice a day and should reach as high as possible, noting the GCOS requirements for ascents up to a height of 5 h Pa. Because climate data are needed in the stratosphere to monitor changes in the atmospheric circulation, composition and chemistry, every effort should be made to maintain soundings regularly up to a level as high as possible noting the above GCOS requirement.

CLIMAT TEMP data should be provided in an accurate and timely manner. CLIMAT TEMP reports should be transmitted by the fifth day of the month but not later than the eighth day of the month.

Rigorous quality control should be exercised at each GUAN site. Periodic calibration, validation and maintenance of the equipment should be carried out to maintain the quality of the observations.

Basic checks should be made before each sounding to ensure accurate data. Checks should also be made during and at the end of each sounding to assure corrections of incomplete soundings or errors before transmission.

Back-up radiosondes should be released in cases of failure in order to maintain the record from the GUAN station.

Detailed metadata should be provided. The batch identifier on the radiosondes should be logged for each flight, so that faulty batches can be identified and the data amended or eliminated from the climate records if necessary. Up-to-date records of metadata in a standard format should be provided to the GUAN Data Centres so that shifts in the data will not be mistaken for climate change. The metadata should include detailed information about the station such as location, elevation, operating instruments and their changes over time. Changes to operating and correction procedures should also be recorded. Both the corrected and uncorrected upper-air observation should be archived. Climate change studies require extremely high stability in the systematic errors of the radiosonde measurements.

X.3 Karl's Principles[55] (Karl et al., 1995)

1. Prior to implementing changes to existing systems, or introducing new observing systems, an assessment of the impacts of such changes on long [hard-] term climate monitoring should be standard practice.
2. Routine assessments of the long [hard-] term climate monitoring capability of existing systems should be standard practice.
3. Observing systems should be complete, possibly including both "low technology" and "high technology" components and ground truth validation.
4. The transition from research measurements to operational measurements for long [hard-] term climate monitoring must be planned in an orderly and systematic manner.
5. Knowledge of instrument, station, and/or platform history is essential and should be treated with as much care as the data themselves.
6. *In-situ* and other observations with long uninterrupted record should be given special consideration.
7. Calibration, validation and maintenance are critical to long [hard-] term climate monitoring.
8. Processing algorithms and changes in these algorithms must be well documented.
9. Data management, analysis and diagnostics are a key part of a relevant long [hard-] term climate monitoring system.
10. Data management systems must facilitate access (minimum cost).

[As published on the GOOS Website at http://ioc.unesco.org/goos/]

[55] S. auch http://www.gcrio.org/CONSEQUENCES/spring95/Climate.html.

XI Literature

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