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# European Community and Member States greenhouse gas emission trends 1990-1998

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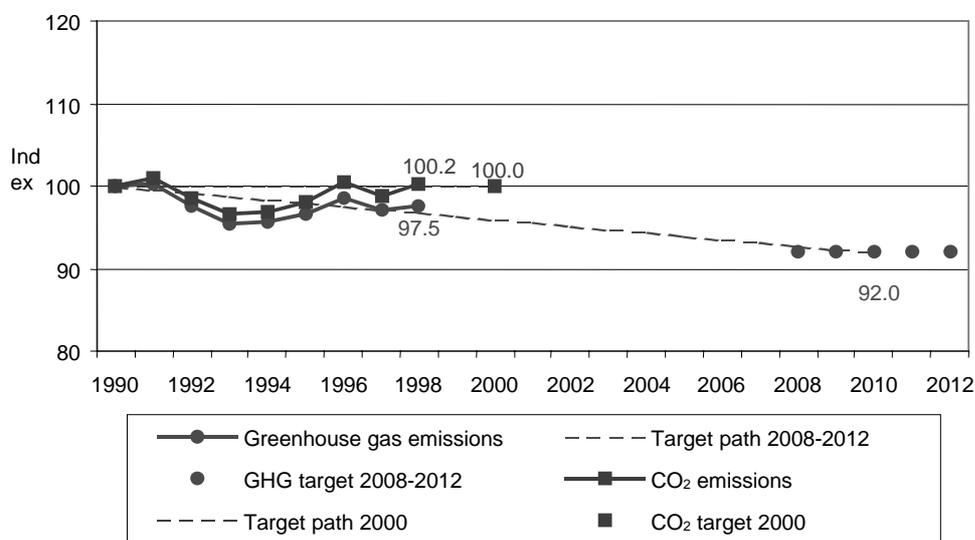
# 1. Executive summary

The purpose of this report is to contribute to the evaluation of progress of the European Community and its Member States towards meeting their greenhouse gas commitments under the UNFCCC and the Kyoto Protocol. The report aims at performing a consistent and comparable assessment of the contribution of each Member State towards meeting greenhouse gas targets of the EC as a whole. It does not aim at evaluating compliance of Member States with their targets but at evaluating their contribution to the EC greenhouse gas emissions in 1998. The progress evaluation is carried out by comparing 1990-1998 greenhouse gas emission data of the EC and its Member States with two (hypothetical) linear target paths: (1) the UNFCCC target path for 2000; and (2) the Kyoto target path for 2008-2012. By calculating the deviations from these target paths in 1998, a measure of actual progress of the EC and its Member States in 1998 is established.

## *Progress of the European Community*

Greenhouse gas emissions in the European Union were 4,046 Tg in 1998; they decreased by 104 Tg or 2.5 % between 1990 and 1998 (Figure A and Table A). About 82 % of EU15 greenhouse gas emissions are CO<sub>2</sub> emissions; CH<sub>4</sub> and N<sub>2</sub>O emissions account for about 9 % each. CO<sub>2</sub> emissions almost stabilised between 1990 and 1998 and were 3,328 Tg in 1998 (+7 Tg or +0.2 %). CH<sub>4</sub> and N<sub>2</sub>O emissions were 364 Tg and 354 Tg of CO<sub>2</sub> equivalents respectively in 1998, which was a decrease by 16.5 % and 9.9 % respectively between 1990 and 1998. Therefore, in 1998, the European Union as a whole was only slightly above its linear target paths for 2000 and 2008-2012. However, actually achieving the targets for 2008-2012 will still be difficult and require large efforts, as GDP and energy consumption are expected to grow in the next decade.

**Figure A: EU15 Greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and Land use change and forestry)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the EC with its greenhouse gas targets in 2008-2012, but aims at evaluating overall EC greenhouse gas emissions in 1998.

Note (2) For the preparation of this report, EC greenhouse gas inventories as compiled under the EC Monitoring Mechanism and submitted by the Member States to the European Commission until 1 April 2000 have been used. Differences between data used in this report and Member States submissions to the UNFCCC secretariat after 1 April 2000 might occur. Note that greenhouse gas emission data, as referred to in this report, neither includes industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from land use change and forestry (LUCF). In addition, no adjustments for temperature variations or electricity trade are made for the EC as a whole. However, for some Member States: (1) additional information is given on greenhouse gas emissions including F-gases (when complete time series 1990-1998 for these gases were submitted); (2) emission data corrected for temperature variations or electricity trade is used (when targets refer to corrected data and data was submitted). Based on other information (several studies commissioned by the Commission, DG ENV) EU15 total Fgas emissions in 1995 were indicatively estimated to be 70 Tg (CO<sub>2</sub> equivalents). This corresponds to 1.6 % of the total EU15 emissions of the three gases considered in this report (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O). The main conclusions of this report are not expected to change significantly if emissions of F-gases were included.

**Table A: Greenhouse gas emissions and CO<sub>2</sub> emissions in the EU in Gg of CO<sub>2</sub> equivalents (excl. industrial F-gases and LUCF)**

MEMBER STATE	Total greenhouse gas emissions			CO <sub>2</sub> emissions		
	1990	1998	Trend 90/98	1990	1998	Trend 90/98
Austria	75,452	78,548	4.1%	62,130	66,604	7.2%
Belgium	136,014	144,622	6.3%	113,997	121,975	7.0%
Denmark (1)	69,567	75,603	8.7%	52,894	60,125	13.7%
Finland	72,586	76,020	4.7%	59,300	63,950	7.8%
France	538,539	543,691	1.0%	387,590	412,860	6.5%
Germany	1,201,117	1,011,653	-15.8%	1,014,500	886,499	-12.6%
Greece	103,912	119,503	15.0%	85,249	100,324	17.7%
Ireland	53,496	63,728	19.1%	31,575	40,028	26.8%
Italy	514,665	538,171	4.6%	429,694	458,327	6.7%
Luxembourg	14,114	5,872	-58.4%	13,300	5,179	-61.1%
Netherlands (1)	208,936	225,969	8.2%	161,400	181,400	12.4%
Portugal	62,614	73,753	17.8%	43,132	53,891	24.9%
Spain	301,919	360,481	19.4%	226,057	273,017	20.8%
Sweden	69,467	70,291	1.2%	55,443	56,953	2.7%
United Kingdom	727,110	657,727	-9.5%	584,220	546,390	-6.5%
<b>EU-15</b>	<b>4,149,509</b>	<b>4,045,632</b>	<b>-2.5%</b>	<b>3,320,481</b>	<b>3,327,520</b>	<b>0.2%</b>

(1) Non-adjusted data; for adjusted data see corresponding Member States section.

### *CO<sub>2</sub> emissions*

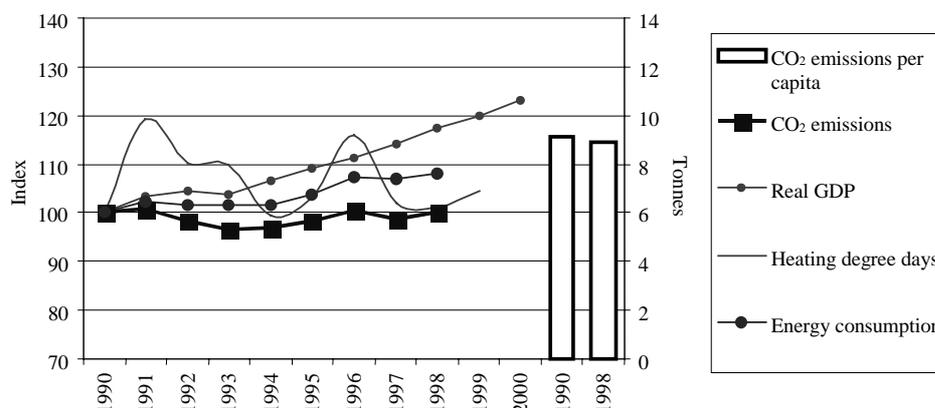
Table A shows that there are large variations in CO<sub>2</sub> emission trends between Member States. Only three Member States reduced their emissions: Luxembourg (61.1 %), Germany (12.6 %) and UK (6.5 %). Together, they accounted for a reduction of 174 Tg, while in all other Member States emissions increased during the same period by 181 Tg. The largest absolute decrease in CO<sub>2</sub> emissions occurred in Germany (128 Tg) and the United Kingdom (38 Tg). The largest relative increases occurred in the cohesion States Ireland (+26.8 %), Portugal (+24.9 %) and Spain (+20.8 %). The largest increases in absolute terms were in Spain and Italy with 47 Tg and 29 Tg respectively.

**Driving forces of CO<sub>2</sub> emissions:** Fossil fuel energy consumption is the main driving force of CO<sub>2</sub> emissions. Two factors strongly influence energy consumption: economic growth and outdoor temperature (i.e. cold or mild winters).

CO<sub>2</sub> emissions decreased in the early 1990s due to slow economic growth throughout all Member States and due to large reductions in Germany and the United Kingdom. Emissions were highest in 1991 and 1996 – the two coldest years in the 1990s – thus illustrating the influence of temperature variations on CO<sub>2</sub> emissions. In recent years, temperature corrected CO<sub>2</sub> emission trends appear to be rising again: in 1998, CO<sub>2</sub> emissions were third highest in the 1990s, but with relatively mild temperatures (Figure B).

Carbon intensity of GDP and of energy consumption decreased considerably as GDP increased by 17.4 % and gross inland energy consumption grew by 8.2 % between 1990 and 1998 (compared to a 0.2 % growth of CO<sub>2</sub> emissions). The main reasons for the decarbonisation were: (1) large energy efficiency improvements after the German unification and the related economic restructuring in the new Länder; (2) the switch from coal to gas in the UK electricity generation; (3) a general switch from coal to gas, renewable energies and nuclear power.

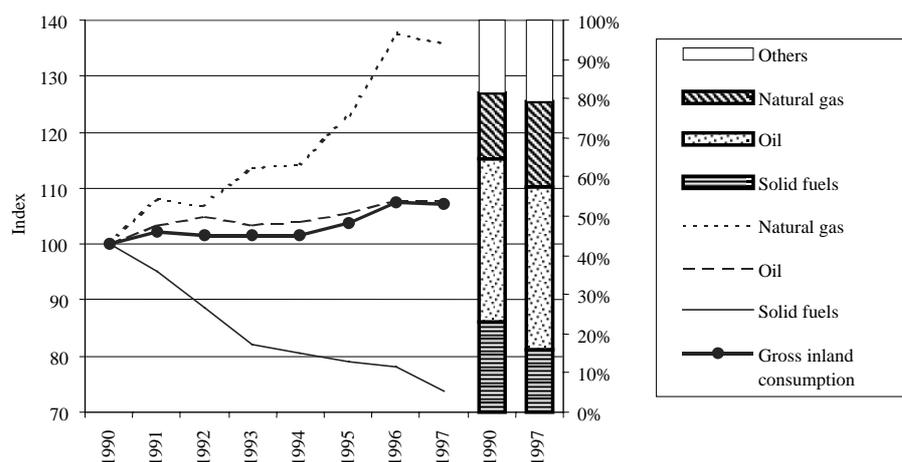
**Figure B: EU15 CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days<sup>1</sup> and energy consumption)**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption (also referred to as 'energy consumption' in this report) as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were taken from EC (2000).

**Fossil fuel combustion** is the main driving force of CO<sub>2</sub> emissions. The reliance on fossil fuels still is high. Figure C shows that their share in gross inland energy consumption declined slightly from 81 % in 1990 to 79 % in 1997 (oil: 42 %, gas: 21 %, solid fuels: 16 %). Nuclear power accounts for approx. 15 % and renewable energies for approx. 6 % of gross inland energy consumption in 1997. The EU target of 12% of energy supply by renewables in 2010 will require significant additional efforts.

**Figure C: EU15 gross inland energy consumption by fossil fuel type**



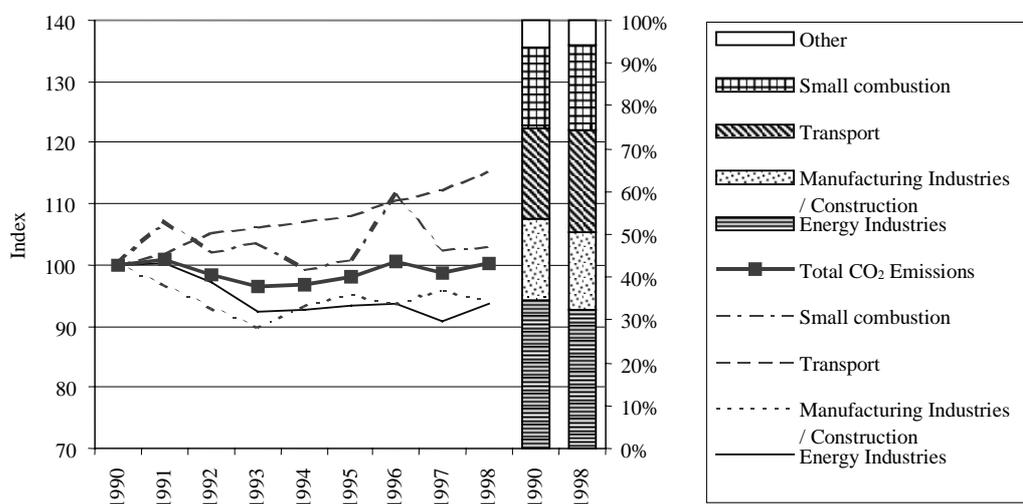
Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include nuclear power, renewable energy sources and net electricity imports.

**Sectoral breakdown of CO<sub>2</sub> emissions:** More than 90 % of CO<sub>2</sub> emissions come from fossil fuel combustion. Figure D shows that energy industries is the largest

<sup>1</sup> Heating degree days are a measure for temperature variations. They are the sum of temperature differences between a certain constant indoor temperature and the daily average of outdoor temperature. Therefore, lower average temperatures lead to higher heating degree days.

CO<sub>2</sub> emitting sector accounting for 32 % of total CO<sub>2</sub> emissions in 1998. Second was transport with 24 % after considerable growth in the 1990s. Small combustion and manufacturing industries account for 20 % and 18 % respectively. In general, a shift from energy and manufacturing industries to transport and small combustion can be observed.

**Figure D: Sectoral breakdown of EU15 CO<sub>2</sub> emissions (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

CO<sub>2</sub> emissions from **energy industries** decreased by 6.2 % between 1990 and 1998. Most of the reductions were achieved by 1993; since then emissions stabilised. The major driving force of CO<sub>2</sub> emissions from energy industries is thermal power production which accounts for 51 % of gross electricity generation. The main reasons for declining CO<sub>2</sub> emissions from energy industries were:

- energy efficiency improvements in the German energy industry;
- the fuel switch from coal to gas in the power industry (especially in UK).

CO<sub>2</sub> emissions from **manufacturing industry (and construction)** reduced by 5.7 % from 1990 to 1998 with an absolute low in 1993. Since 1993, CO<sub>2</sub> emissions from industry increased slightly. The most important reasons for the decline in the early 1990s were:

- the industrial restructuring in the new Länder after German unification;
- reduced GDP growth in almost all Member States.

CO<sub>2</sub> emissions from **transport** increased by 15.3 % from 1990 to 1998 as a consequence of rising road traffic in all Member States (see Table C – Luxembourg's decline is due to methodological reasons). Spain, Germany and France show the largest increases in absolute terms. Only Finland and the United Kingdom had singledigit growth rates of CO<sub>2</sub> emissions between 1990 and 1998. Emissions in all other Member States grew at 10 % or more, with especially high rates in the cohesion countries ranging from 77 % (Ireland) to 29 % (Greece). As

car ownership ratios are still much lower in the cohesion states, transport is expected to continue to grow at a fast pace in these countries.

CO<sub>2</sub> emissions from **small combustion** grew by 3 % between 1990 and 1998. They fluctuate considerably according to temperature variations and the related need for heating in households. CO<sub>2</sub> emissions from small combustion peaked in 1991, 1993 and 1996 because of cold winters. The largest absolute decreases occurred in Germany. Also the Nordic countries Denmark, Finland and Sweden reduced their CO<sub>2</sub> emissions from small combustion, whereas all other Member States increased theirs.

#### *CH<sub>4</sub> emissions*

CH<sub>4</sub> emissions decreased almost steadily and were 16.5 % below 1990 levels in 1998. The main sources of CH<sub>4</sub> emissions are agriculture (enteric fermentation and manure management), waste (mainly waste disposal in landfills) and fugitive emissions from fuels (e.g. in the gas distribution networks).

CH<sub>4</sub> emissions from agriculture were reduced by 6 % but their share in CH<sub>4</sub> emissions increased to 49 % in 1998. Emissions from waste decreased by 24 %; their share in CH<sub>4</sub> emissions declined to 30 % in 1998. Fugitive emissions from fuels accounted for 17 % of CH<sub>4</sub> emissions in 1998. The most important reasons for declining CH<sub>4</sub> emissions are emission control from landfills (collection for flaring or power generation), leak reductions in gas distribution systems and reductions in coal mining.

There are large variations in CH<sub>4</sub> emission trends in the Member States (Table B): whereas Finland and Germany reduced their CH<sub>4</sub> emissions by 42 % and 36 % respectively, Spanish CH<sub>4</sub> emissions grew by 26 %. In absolute terms, Germany, UK, France, and the Netherlands achieved the largest reductions, whereas Spanish CH<sub>4</sub> emission increases were the highest.

**Table B: CH<sub>4</sub> and N<sub>2</sub>O emissions in the EU in Gg of CO<sub>2</sub> equivalents (excl. LUCF)**

MEMBER STATE	CH <sub>4</sub> emissions			N <sub>2</sub> O emissions		
	1990	1998	Trend 90/98	1990	1998	Trend 90/98
Austria	11,289	9,648	-14.5%	2,033	2,297	13.0%
Belgium	12,658	12,205	-3.6%	9,360	10,442	11.6%
Denmark	5,848	6,024	3.0%	10,825	9,454	-12.7%
Finland	7,520	4,352	-42.1%	5,766	7,719	33.9%
France	61,390	52,155	-15.0%	89,559	78,675	-12.2%
Germany	116,990	74,655	-36.2%	69,626	50,499	-27.5%
Greece	9,209	9,755	5.9%	9,455	9,424	-0.3%
Ireland	12,836	13,631	6.2%	9,085	10,069	10.8%
Italy	39,727	41,317	4.0%	45,245	38,528	-14.8%
Luxembourg	504	480	-4.8%	310	214	-31.0%
Netherlands	27,138	22,373	-17.6%	20,398	22,196	8.8%
Portugal	13,364	13,332	-0.2%	6,118	6,531	6.8%
Spain	34,626	43,615	26.0%	41,236	43,849	6.3%
Sweden	5,964	5,376	-9.9%	8,060	7,962	-1.2%
United Kingdom	77,212	55,354	-28.3%	65,677	55,983	-14.8%
<b>EU15</b>	<b>436,276</b>	<b>364,271</b>	<b>-16.5%</b>	<b>392,753</b>	<b>353,841</b>	<b>-9.9%</b>

## *N<sub>2</sub>O emissions*

N<sub>2</sub>O emissions were almost 10 % below 1990 levels. The main sources of N<sub>2</sub>O emissions are agriculture (soils and fertiliser use) and industrial processes (mainly adipic and nitric acid production). Agricultural N<sub>2</sub>O emissions reduced only slightly (2 %), but emissions from industrial processes declined by 36 % between 1990 and 1998. Accordingly, the share of agriculture in N<sub>2</sub>O emissions increased to 61 % in 1998, whereas the share of industrial processes declined to 20 %. A small but rapidly increasing source of N<sub>2</sub>O emissions almost doubling between 1990 and 1998 is the transport sector after the introduction of the catalytic converter.

Large percentage reductions of N<sub>2</sub>O emissions were achieved by Luxembourg (31 %) and Germany (27.5 %), whereas N<sub>2</sub>O emissions in Finland increased by 33.9 % between 1990 and 1998. In absolute terms, Germany, UK, France, and Italy achieved the largest reductions, whereas Spain and Finland increased most. A large share of German reductions were achieved in 1998 after new N<sub>2</sub>O emission reduction methods have been introduced in two adipic acid plants.

## *Progress of the Member States*

Table C gives an overview of the variations of greenhouse gas emissions of the EC as a whole and of each Member State between 1990 and 1998. It illustrates that CH<sub>4</sub> and N<sub>2</sub>O emissions decreased in several Member States, whereas non-adjusted CO<sub>2</sub> emissions declined only in three Member States (Germany, Luxembourg and UK). All other Member States had rising (non-adjusted) CO<sub>2</sub> emissions between 1990 and 1998.

**Table C: Variations of greenhouse gas emissions 1990-1998 of EU15 and the Member States in percent (excl. industrial F-gases and LUCF)**

	EU15	AT	BE	DK	FI	FR	DE	GR
Greenhouse gases <sup>(1)</sup>	-2.5%	+4.1%	+6.3%	+8.7% (-6.8%)	+4.7%	+1.0%	-15.8%	+15.0%
CH <sub>4</sub>	-16.5%	-14.5%	-3.6%	+3.0%	-42.1%	-15.0%	-36.2%	+5.9%
N <sub>2</sub> O	-9.9%	+13.0%	+11.6%	-12.7%	+33.9%	-12.2%	-27.5%	-0.3%
CO <sub>2</sub> <sup>(1)</sup>	+0.2%	+7.2%	+7.0%	+13.7% (-6.7%)	+7.8%	+6.5%	-12.6%	+17.7%
Energy industries	-6.2%	-5.9%	-14.4%	+20.2%	+16.3%	+3.6%	-17.9%	+15.9%
Manufacturing industries	-5.7%	+9.6%	+19.4%	+4.2%	+8.4%	+0.7%	-25.0%	+7.0%
Transport	+15.3%	+23.5%	+20.1%	+15.6%	+3.4%	+13.8%	+11.4%	+29.4%
Small combustion	+3.0%	+11.6%	+22.3%	-6.7%	-8.8%	+9.6%	-6.0%	+30.0%
	IE	IT	LU	NL	PT	ES	SE	UK
Greenhouse gases	+19.1%	+4.6%	58.4%	+8.2%	+17.8%	+19.4%	+1.2%	-9.5%
CH <sub>4</sub>	+6.2%	+4.0%	-4.8%	-17.6%	-0.2%	+26.0%	-9.9%	-28.3%
N <sub>2</sub> O	+10.8%	-14.8%	-31.0%	+8.8%	+6.8%	+6.3%	-1.2%	-14.8%
CO <sub>2</sub> <sup>(1)</sup>	+26.8%	+6.7%	-61.1%	+12.4% (+10.4%)	+24.9%	+20.8%	+2.7%	-6.5%
Energy industries	+36.1%	+9.2%	96.5%	+11.3%	+17.8%	+5.9%	+9.9%	-17.1%
Manufacturing industries	+2.2%	+2.0%	74.8%	+5.7%	+15.1%	+23.0%	-6.5%	-6.3%
Transport	+76.8%	+15.2%	56.2%	+21.6%	+41.9%	+35.1%	+13.3%	+5.3%
Small combustion	+2.5%	+2.4%	+49.3%	+2.1%	+34.0%	+16.7%	-9.9%	+5.6%

(1) For Denmark and the Netherlands adjusted data is given in brackets. If for Denmark the electricity trade correction is only taken into account for the year 1990 the adjusted Danish greenhouse gas emissions decreased by 0.3% from 1990 to 1998 and the adjusted CO<sub>2</sub> emissions increased by 1.6%.

If greenhouse gas emissions of the Member States are compared with their linear target paths for 2000 and 2008-2012, progress of Member States looks as follows: In 1998, only Germany, Luxembourg and the United Kingdom were well below their greenhouse gas emission target paths (Table D). Denmark was below its CO<sub>2</sub> emission target path for 2000 and near to its linear Kyoto target path (taking into account adjustments for temperature and electricity trade). France and Sweden were near to their linear Kyoto target paths. All other Member States were well above their greenhouse gas emission limitation and reduction paths. Ireland, Spain and the Netherlands were more than 10 index points above their linear Kyoto target paths in 1998.

**Countries well below their emission target paths:** In 1998, **Germany**, as the largest emitter of the EU, was 7.4 index points below the linear target path for 2008-2012. The main reason for this were large emission reductions after the German unification. **Luxembourg** was 47.2 index points below the Kyoto target path mainly due to reduced coke use in metal industry and higher electricity imports. The **United Kingdom** was 4.5 index points below the linear Kyoto target path in 1998. The bulk of the UK greenhouse gas emission reduction was achieved through the fuel switch from coal to gas in the power producing sector.

**Table D: Progress of EU15 and of the individual Member States in 1998**

	CO <sub>2</sub> emission target path for 2000	Greenhouse gas emission target path for 2008-2012
EU15	☺	☺
Austria	☹	☹
Belgium	☹	☹
Denmark	☹	☹
Finland	No target	☹
France	No target	☺
Germany	No target	☺
Greece	☹	☹
Ireland	☹	☹
Italy	☹	☹
Luxembourg	☺	☺
Netherlands	☹	☹
Portugal	No target	☹
Spain	☹	☹
Sweden	☹	☺
United Kingdom	☺	☺

Note: The progress assessment procedure consists of four steps (see Chapter 2.2 for details):

1. Plotting the 1990-1998 greenhouse gas emission index against the index of the linear target path.
2. Calculating the hypothetical, interpolated, value on the linear target path index in 1998.
3. Calculating the deviation of the emission index value in 1998 from the value on the target path.
4. Awarding smileys according to the achievements with the following ratings:
  - ☺ more than 2 index points below linear target path (positive contribution to EC trend)
  - ☹ more than 2 index points above linear target path (negative contribution to EC trend)
  - ☺ in a range of plus/minus 2 index points of linear target path (some positive contribution to EC trend)

## 2. Introduction

The year 2000 marks an important milestone in European Community climate policy, as many targets for greenhouse gas emissions refer to this year. Firstly, the Council of Ministers agreed in 1990 on the objective to stabilise EU carbon dioxide (CO<sub>2</sub>) emissions by 2000 at 1990 levels. This commitment was repeated when the United Nations Framework Convention on Climate Change (UNFCCC), signed in Rio de Janeiro in June 1992, committed Annex I Parties (including the European Community (EC) and all EC Member States) to aim at returning their anthropogenic CO<sub>2</sub> and other greenhouse gas emissions to 1990 levels by the year 2000. Finally, most EC Member States have adopted national limitation and reduction targets for greenhouse gas emissions for the year 2000, which are linked but not dependent on the entry into force of the relevant international agreements.

At the third Conference of Parties (COP3) to the UNFCCC, held in Kyoto (Japan) in December 1997, the Parties adopted the Kyoto Protocol to the UNFCCC, which sets different binding greenhouse gas emission targets for Parties listed in Annex B of the Protocol. The Protocol aims at reducing aggregated emissions by these Parties of six greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, SF<sub>6</sub>) by at least 5 % from 1990 levels during a first commitment period from 2008-2012. The EC and its Member States face a common reduction target of 8 %, which they intend to achieve jointly. For this purpose, the Council of Ministers agreed on the so-called EC burden sharing agreement in June 1998, redistributing different emission limitation and/or reduction targets for each EC Member State. The Kyoto Protocol is not yet in force, but the Parties aim at concluding vital negotiations at COP6 in The Hague in November 2000, in order to allow for early ratification and the Protocol's entry into force by 2002.

**The purpose of this report:** The legal basis of this report is Council Decision 99/296/EC for a *Monitoring Mechanism of Community CO<sub>2</sub> and Other Greenhouse Gas Emissions*. This Decision establishes a mechanism for: (1) monitoring, in the Member States, all anthropogenic greenhouse gas emissions not controlled by the Montreal Protocol, and (2) evaluating actual and projected progress towards meeting commitments in respect of these emissions.

This report, prepared by the European Environment Agency and its European Topic Centre on Air Emissions, serves as input to the annual progress evaluation report of the European Commission to the Council and the European Parliament, as required under the Monitoring Mechanism. It focuses on actual progress by comparing 1990-1998 greenhouse gas emission data of the EC and its Member States with two (hypothetical) linear target paths: (1) the UNFCCC target path for 2000; and (2) the Kyoto target path for 2008-2012. By calculating the deviations from these target paths in 1998, an indicative measure of actual progress of the EC and its Member States in 1998 is established. Actual progress is further analysed by evaluating major driving forces and characteristics of greenhouse gas emission trends from 1990 to 1998.

**Outline of this report:** The report starts with a summary, providing the main conclusions on the assessment of the EC emission trends and the progress of the EC and its Member States towards achieving the UNFCCC and Kyoto Protocol targets.

Chapter 2 (Introduction) briefly characterises the provisions of the amended Monitoring Mechanism, methodological aspects and the data basis of this report. Chapter 3 evaluates progress of the Community as a whole towards fulfilling its greenhouse gas emission commitments and analyses trends and driving forces of greenhouse gas emissions in the EU. Firstly, greenhouse gas emission data for 1998 is compared with the hypothetical linear paths of emission targets for 2000 and 2008-2012. Then greenhouse gas emission trends 1990-1998 are described and analysed. Special focus is put on CO<sub>2</sub> emissions, because CO<sub>2</sub> emissions clearly dominate overall greenhouse gas emission trends (accounting for more than 80 % of all EC greenhouse gas emissions) and the reliability of CO<sub>2</sub> emission data is relatively high. CO<sub>2</sub> emission trends are presented against major driving forces, such as real GDP growth, outdoor temperature and energy consumption. In addition, sectoral characteristics of the CO<sub>2</sub> emission trends are analysed. Finally, energy consumption and electricity production patterns in the EU are characterised briefly.

Chapter 4 aims at evaluating the contribution of each Member State to the fulfilment of the Community's commitments. First the greenhouse gas emission targets of the Member States are presented. Then, greenhouse gas emission trends and characteristics are analysed for each individual Member State and driving forces are examined (energy consumption, electricity generation).

The Annex includes short summary tables of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions for the EC and its Member States. Detailed tables of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions and emission data on HFCs, PFCs and SF<sub>6</sub> for the EC and its Member States have been compiled by EEA and its ETC/AE in the EEA technical report – ‘Annual European Community Greenhouse Gas Inventory 1990-1998, submission to UNFCCC’ (May, 2000). The report and the data is also available on the EEA web site (<http://www.eea.eu.int/>).

## 2.1. The EC Monitoring Mechanism

After having signed the UNFCCC in 1992, the European Community adopted Council Decision 93/389/EEC<sup>2</sup> for a *Monitoring Mechanism of Community CO<sub>2</sub> and other Greenhouse Gas Emissions* in June 1993. The purpose of this Decision was to establish an instrument to monitor and assess regularly progress towards stabilisation of CO<sub>2</sub> emissions by 2000 at 1990 levels in the European Community. The European Community subsequently ratified the UNFCCC in December 1993. By signing the Kyoto Protocol in April 1998, the European Community as a whole as well as all of its Member States individually agreed upon an 8% reduction of their anthropogenic greenhouse gas emissions by 2008-2012 relative to 1990 emission levels. In the Council Conclusions on the EC burden sharing arrangement (June 1998), the Member States politically agreed on an EU internal redistribution of the common 8% reduction target. This agreement envisages different emission targets for each Member State according to different economic circumstances with the ultimate goal to assure fulfilment of the EC commitments in the Kyoto Protocol. It is the intention to notify the burden sharing agreement upon ratification by the EC and all Member States according to Art 4 of the Kyoto Protocol.

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<sup>2</sup> OJ L 167, 9.7.1993, p. 31

The Monitoring Mechanism was amended by Council Decision 99/296/EC of 26 April 1999<sup>3</sup>. The major modifications of the Decision, in accordance with the requirements of the Kyoto Protocol, are: (1) consideration of the quantified emission limitation and reduction commitments by 2008 – 2012 agreed upon in the Protocol; (2) extension to all six greenhouse gases listed in Annex A to the Kyoto Protocol (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, SF<sub>6</sub>); (3) extended reporting and progress assessment requirements for Member States and the European Commission.

**Requirements for the Member States:** Under the Monitoring Mechanism, Member States shall report to the Commission each year, not later than 31 December:

- their anthropogenic CO<sub>2</sub> emissions and removal by sinks for the previous calendar year;
- final national inventory data on emissions by sources and removals by sinks for the other greenhouse gases for the previous year but one and provisional emission data (inventories) for the previous year.

Other greenhouse gases mainly include the five remaining Kyoto gases: methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF<sub>6</sub>). Annual information on emissions of the following gases shall be provided in addition: carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>), non methane volatile organic compounds (NMVOCs) and sulphur oxides (SO<sub>x</sub>), in line with the reporting requirements under the UNFCCC. The methodologies applied should be in accordance with those accepted by the IPCC and agreed upon by the UNFCCC Conferences of the Parties.

**Requirements for the Commission:** Based on the data provided by the Member States, the Commission has to establish a Communitywide greenhouse gas inventory and circulate it to all Member States by 1 March each year. This procedure aims at achieving best available Member States' data on greenhouse gas emissions for the compilation of the final EC inventory to be submitted by the European Community to the UNFCCC Secretariat by 15 April.

Besides providing the annual EC inventory, according to Article 6 of the Monitoring Mechanism, the Commission shall assess annually whether the actual and projected progress of Member States is sufficient to ensure fulfilment of the EC's commitments under the UNFCCC and the Kyoto Protocol and shall report to the European Parliament and the Council. The annual evaluation report of the Commission has to be forwarded to the European Parliament and the Council by October each year. This EEA report serves as an input to the annual evaluation report of the European Commission.

## 2.2. Assessment methodology used in this report

Article 6 of the Monitoring Mechanism states that the Commission shall assess annually whether the actual and projected progress of Member States towards fulfilling the Community's commitments under the UNFCCC and the Kyoto Protocol is sufficient to ensure that the Community and its Member States are on course to fulfil their commitments. Accordingly, the progress evaluation can be seen as a twostep process: (1) The evaluation of *actual progress*, i.e. the measurement of past and actual performance in comparison with emission targets

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<sup>3</sup> OJ L 117, 5.5.1999, p. 35

and objectives; (2) the evaluation of *projected progress*, i.e. the assessment whether the EC and Member States projected emissions (by 2010), taking into account adopted policies and measures, are in line with the UNFCCC and the Kyoto Protocol targets.

This report focuses on *actual progress* by comparing past and actual performance with greenhouse gas emission targets for 2000 and for 2008-2012. By calculating the deviations from the *predetermined* target/objective values in 1998, a measure of the performance of the EC and its Member States compared to national objectives is established. For the Community and each of its Member States, the actual performance is related to two (hypothetical) linear paths: (1) the *target* path for 2000, in order to evaluate the likeliness of meeting the UNFCCC (2000) target; (2) the *target* path for 2008-2012, in order to give first indications on progress towards the Kyoto/burden sharing targets.

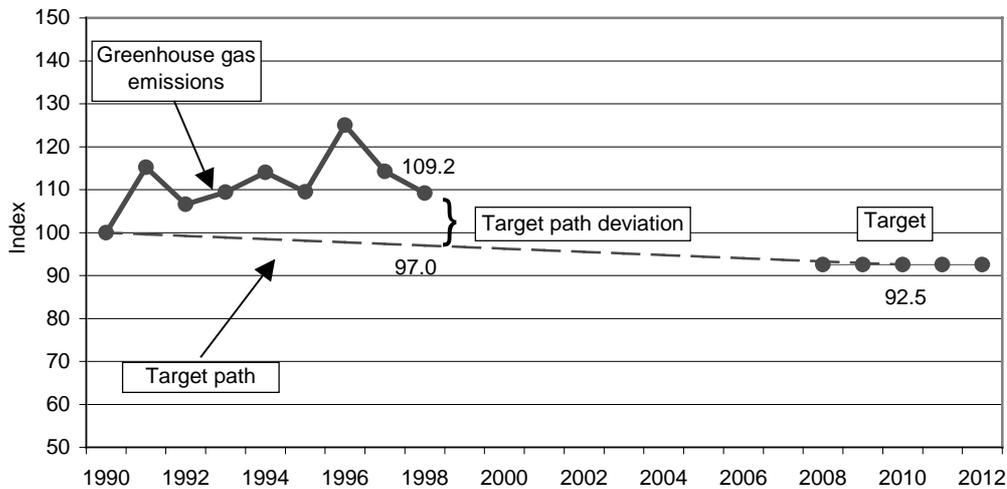
**Note:** This report does not aim at evaluating compliance of Member States with targets. Instead, it aims at evaluating their contribution to the EC greenhouse gas emissions in 1998. This is done by comparing actual values in 1998 with hypothetical values on the linear target paths. These linear paths are not set as such in any official document, but used in this report in order to perform a consistent and comparable assessment of the progress towards the targets within the period 1990 to 1998.

The progress assessment procedure consists of four steps (see Figure 1 for a theoretical example of a country's situation):

1. Plotting the index of actual performance (1990-1998 index of greenhouse gas emission trend data) against the index of the target path (in the example of Figure 1: the Kyoto/burden sharing target).
2. Calculating the hypothetical, interpolated, value on the target path index in 1998 (in Figure 1: 97.0).
3. Calculating the deviation of the emission index value in 1998 (in Figure 1: 109.2) from the value on the target path (in Figure 1 the deviation is 12.2 index points).
4. Awarding smileys according to the achievements with the following ratings:
  - ☺ more than 2 index points *below* linear target path (positive contribution to EC trend)
  - ☹ more than 2 index points *above* linear target path (negative contribution to EC trend)
  - ☺ in a range of plus/minus 2 index points of linear target path (some positive contribution to EC trend)

The performance of the example country in Figure 1 would be evaluated with ☹, not being in line with the Kyoto/burden sharing target.

**Figure 1: Index of greenhouse gas emissions (base 1990) and Kyoto/burden sharing target 2008-2012 (theoretical example for an EU Member State)**



### 2.3. European Community and Member States' greenhouse gas emission targets

#### *European Community*

**The Kyoto greenhouse gas emission target:** In the Kyoto Protocol, the European Community agreed to reduce its greenhouse gas emissions by 8 % below 1990 levels by 2008-2012. In the light of the intention of the EC and all Member States to notify the EC burden sharing agreement however, the reduction targets of the Kyoto Protocol may be achieved jointly, and not all Member States will have to reduce their greenhouse gas emissions by 8 % as long as the EC as a whole meets the target.

**The CO<sub>2</sub> stabilisation target:** In 1990, the Council of Ministers (joint Energy/Environment) of 29 October agreed on the objective to stabilise EU CO<sub>2</sub> emissions by 2000 at 1990 levels. Additionally, Article 4 of the UNFCCC, establishes that Annex I parties to this Convention (including all EC Member States and the European Community as parties) have to adopt policies and measures with the aim of returning their anthropogenic CO<sub>2</sub> and other greenhouse gas emissions, individually or jointly, by the year 2000 to 1990 levels. The Member States of the European Community aim at achieving the stabilisation target throughout the EU as a whole, which has been confirmed in the Council Decision on the Monitoring Mechanism.

#### *Member States*

**Greenhouse gas emission targets for 2008-2012:** According to the Kyoto Protocol, the average greenhouse gas emissions of the EC and its Member States have to be 8 % below 1990 levels during the five year commitment period 2008-2012. In June 1998, the Council of Ministers agreed on different emission limitation and/or reduction targets for each Member State basically according to economic circumstances, called the 'Burden Sharing' agreement. Table 1 summarises all Member States targets. It shows that eight Member States agreed to reduction

targets by 2008-2012 (*Austria, Belgium, Denmark, Germany, Italy, Luxembourg, the Netherlands, the United Kingdom*). Two Member States (*Finland, France*) agreed to stabilise greenhouse gas emissions by 2008-2012, whereas five Member States (*Greece, Ireland, Portugal, Spain, Sweden*) agreed to limit their increases by 2008-2012.

**CO<sub>2</sub> emission targets for 2000:** The objective of stabilising CO<sub>2</sub> emissions at 1990 levels by 2000 was agreed for the European Union as a whole, but Member States contribute in different ways to achieve this target. Most, but not all, Member States have set national CO<sub>2</sub> limitation targets. Three Member States (*Belgium, Denmark and the Netherlands*) have set reduction targets (corrected for temperature variations). Five Member States aim at stabilising their CO<sub>2</sub> emissions by 2000 at 1990 levels (*Austria, Italy, Luxembourg, Sweden the United Kingdom*), whereas France has set a stabilisation target on the basis of per capita fossil fuel use. *Greece, Ireland and Spain* aim at limiting the increase in CO<sub>2</sub> emissions by 2000 (see Table 1).

**Table 1: National greenhouse gas emission targets of EC Member States**

Member State	National CO <sub>2</sub> emission targets by 2000	National greenhouse gas emission targets (including removals) by 2008-2012 under the EU burden sharing agreement
Austria	Stabilisation at 1990 level	-13 %
Belgium	5 % reduction compared to 1990 levels (corrected for temperature variations).	-7.5 %
Denmark	5 % reduction compared to 1990 (corrected for temperature variations and calculated as if all electricity used in Denmark was produced in Denmark)	-21 % <sup>(1)</sup>
Finland	Limitation of the increase in CO <sub>2</sub> emissions from energy production and consumption by the end of the 1990s	0 %
France	Stabilisation of fossilfuel related CO <sub>2</sub> emissions at less than 2tC per capita per year by 2000	0 %
Germany	No 2000 target	-21 %
Greece	Limitation of the increase in CO <sub>2</sub> emissions to 15 %, during the period 1990 to 2000	+25 %
Ireland	Limitation of the increase in CO <sub>2</sub> emissions to 20 % during the period 1990-2000 (or to 11 % if carbon sinks are also included in calculation)	+13 %
Italy	Stabilisation at 1990 level	-6.5 %
Luxembourg	Stabilisation at 1990 level	-28 %
Netherlands	3 % reduction compared to 1990 levels (corrected for temperature variations)	-6 %
Portugal	No 2000 target	+27 %
Spain	Limitation of the increase in CO <sub>2</sub> emissions to 11 to 13 % during the period 1990-2000	+15 %
Sweden	Stabilisation at 1990 level	+4 %
United Kingdom	Stabilisation at 1990 level	-12.5 %

(1) In connection with the agreement Denmark made the following statement: 'Denmark is able to reduce its emissions by 17 % in the first commitment period compared to its 1990 level of about 80 million tonnes corrected CO<sub>2</sub>-equivalents through domestic policies and measures and present measures adopted by the Community. In making its legal commitment to a 21 % reduction as set out in the agreement, Denmark has assumed the further elaboration and adoption of common and coordinated policies and measures (CCPMs) prior to the ratification of the Kyoto Protocol.'

## 2.4. Data sources

**Data on greenhouse gas emissions:** For the preparation of this report, EC greenhouse gas inventories as compiled under the EC Monitoring Mechanism (by EEA and its ETC/AE) and submitted by the European Commission to the UNFCCC have been used. The data is presented in the EEA technical report 'Annual European Community Greenhouse Gas Inventory 1990-1998, submission to UNFCCC' (May, 2000). They are also available on the EEA web site (<http://www.eea.eu.int/>) and are annexed in a highly aggregated form at the end of this report. The EC inventory contains data submitted by the Member States to the European Commission until 1 April 2000. Some Member States have revised their inventories slightly between 1 April 2000 and 15 April, therefore minor differences between data used in this report and Member States submissions to the UNFCCC secretariat might occur.

**Data on energy:** Energy related data is from Eurostat, including annual energy data (Eurostat, 1999b). In a few cases, monthly energy data was used to derive trends for 1997-1998 (Eurostat, 1999a). The term 'energy consumption' used in this report refers to 'gross inland consumption' as defined by Eurostat.

**Other data:** Data on GDP, population and heating degree days are from Eurostat. If other data sources were used, these are referred to in the text. Energy and carbon intensity of GDP refer to real GDP in terms of 1990 ECU.

The geographical coverage of emission statistics and other statistics is not fully consistent (i.e. inclusion of overseas territories). However, this is not expected to distort overall trends.

### *Data restrictions*

Greenhouse gas emission data, as presented in this report, includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from land use change and forestry (LUCF). In addition, no adjustments for temperature variations or electricity trade are made for the EU as a whole.

However, for some Member States: (1) additional information is given on greenhouse gas emissions including F-gases (when complete time series 1990-1998 for these gases were submitted); (2) emission data corrected for temperature variations or electricity trade are used (when targets refer to corrected data and data was submitted).

**Industrial F-gases:** Industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) have not been considered for the EC as a whole, because uncertainties in industrial greenhouse gas emission estimates remain high for two reasons. (1) data gaps on industrial greenhouse gases as reported by Member States still are considerable; (2) several Member States did not report chemical specification of HFCs and PFCs; in this case, average global warming potentials based on information from various EC Member States had to be used in the EC inventory (EEA, 2000a), in order to calculate CO<sub>2</sub> equivalent emissions of industrial gases.

For these reasons, data on industrial gases as reported by Member States differ considerably from data estimates by independent consultants. For example, in 1995 total HFC emissions as reported by Member States were 54 % and 61 % below total EC emission estimates as prepared by Ecofys (2000) and March Consulting (1998) respectively. For PFCs and SF<sub>6</sub>, data as reported by Member

States were 47 % and 28 % respectively below EC emission estimates of Ecofys (2000).

**Land use change and forestry (LUCF):** Data on CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O emissions used in this report do not include emissions and removals from Land use change and forestry (CRF category 5) for two reasons: (1) inconsistent calculation methods of Member States; (2) outstanding methodological decisions which CO<sub>2</sub> sinks are accepted under the Kyoto Protocol (possibly to be decided at COP6 of UNFCCC to be held November 2000).

### 3. Progress of the European Community

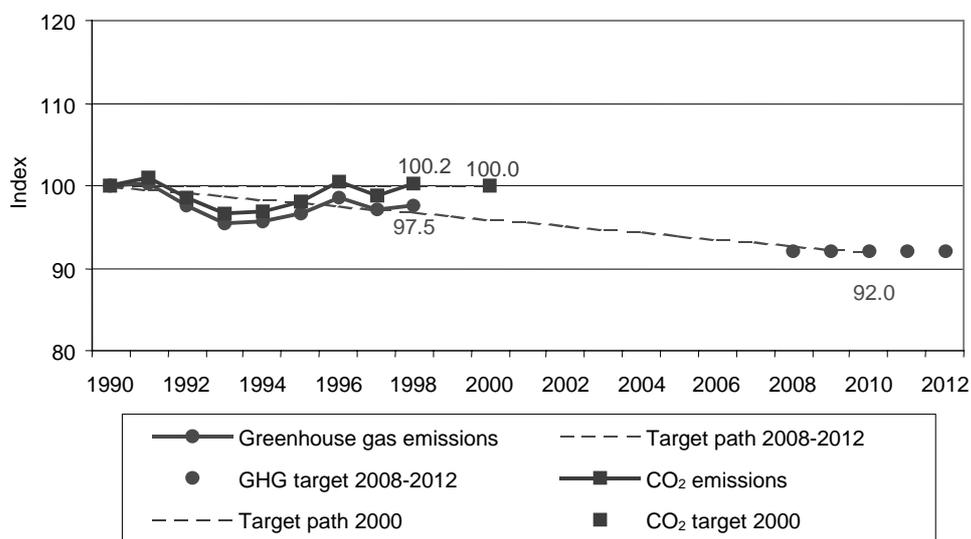
This chapter aims at evaluating progress of the European Community as a whole towards fulfilling its greenhouse gas emission targets. The first section evaluates actual progress of the EC by comparing 1998 greenhouse gas emission data with the (hypothetical) linear target paths in 1998. Section 2 presents overall greenhouse gas emission trends. Section 3 analyses sectoral CO<sub>2</sub> emissions in more detail, since CO<sub>2</sub> emissions account for more than 80 % of EC greenhouse gas emissions. In particular, CO<sub>2</sub> emissions from the main fuel combustion related sectors are considered, e.g. energy industries, manufacturing industries and construction, transport, and small combustion (commerce, services, households, agriculture, public institutions). Sections 4 and 5 focus on energy consumption and electricity production patterns in the EU as the major driving forces of CO<sub>2</sub> and overall greenhouse gas emissions.

#### 3.1. Actual progress of the EC in 1998

In the Kyoto Protocol, the EC agreed to reduce its greenhouse gas emissions by 8 % by 2008-2012, from 1990 levels. In 1998, EU15 greenhouse gas emissions were 4,046 Tg (CO<sub>2</sub> equivalents). This was 104 Tg or 2.5 % below 1990 levels but 0.7 index points above the target path for 2008-2012 (Figure 2).

In the UNFCCC, the EC agreed to stabilise its CO<sub>2</sub> emissions at 1990 levels by 2000. In 1998, EU15 CO<sub>2</sub> emissions were 3,328 Tg. This was 7 Tg or 0.2 % above 1990 levels and 0.2 index points above the target path for 2000. (Figure 2).

**Figure 2: EU15 Greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the EC with its greenhouse gas targets in 2008-2012, but aims at evaluating overall EC greenhouse gas emissions in 1998.

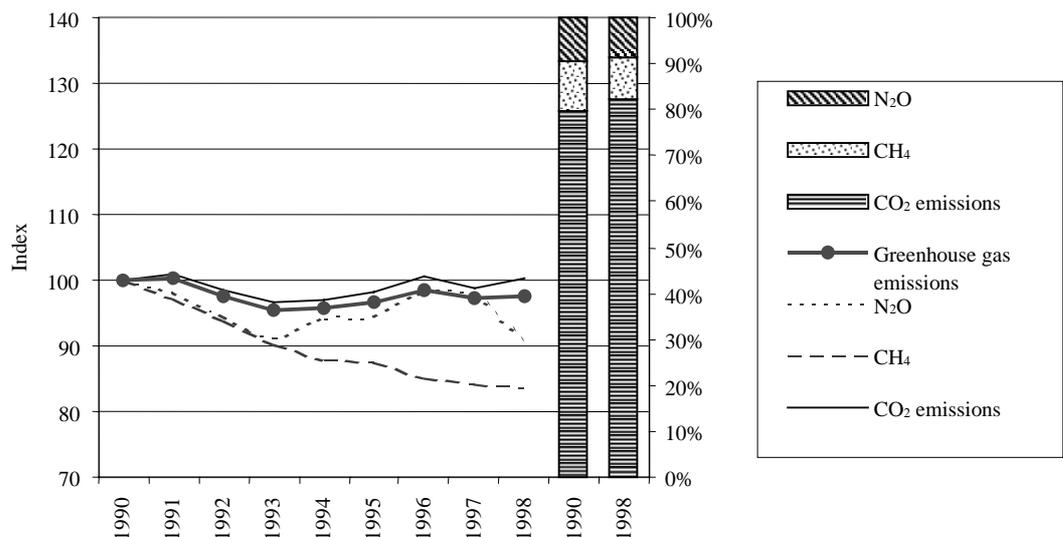
Note (2): Greenhouse gas emission data for the EU as a whole include neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. In addition, no adjustments for temperature variations or electricity trade are considered. See Chapter 2.4 for details.

As indicated in Chapter 2.4 in this assessment report, emissions of industrial F-gases have not been included. However, indicatively, the EU15 total F-gas emissions in 1995 were approximately 70 Tg (CO<sub>2</sub> equivalents) (see EEA report ‘Annual European Community Greenhouse Gas Inventory 1990-1998, submission to UNFCCC’ (May, 2000)). This corresponds to 1.6 % of the total EU15 emissions of the three gases considered in this report (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O). The main conclusions of this report are not expected to change significantly if emissions of F-gases were included.

### 3.2. Overall greenhouse gas emission trends in EU15

As mentioned above, greenhouse gas emissions decreased by 2.5 % between 1990 and 1998. Figure 3 illustrates that the three gases considered in this report (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O) contributed in different ways to this performance. Whereas CO<sub>2</sub> emissions increased slightly by 0.2 %, CH<sub>4</sub> emissions decreased by 16.5 % and N<sub>2</sub>O showed a 9.9 % decline. Since CO<sub>2</sub> emissions account for 82.2 % of EU15 greenhouse gas emissions in 1998, they dominate greenhouse gas emissions clearly. CH<sub>4</sub> and N<sub>2</sub>O emissions account for 9 % and 8.7 % of greenhouse gas emissions respectively (in 1998).

**Figure 3: EU15 greenhouse gas emissions (excl. LUCF)**



Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

#### **CO<sub>2</sub> emissions**

In 1998, CO<sub>2</sub> emissions were 0.2 % above 1990 levels and 1.5 % above 1997 emissions. After the decline in the early 1990s, CO<sub>2</sub> emissions increased from 1994 to 1996 and stabilised since then at about 1990 levels.

More than 90 % of CO<sub>2</sub> emissions are caused by fossil fuel combustion. Therefore energy consumption is the most important driving force of CO<sub>2</sub> emissions. Two factors strongly influence energy consumption: economic growth and outdoor

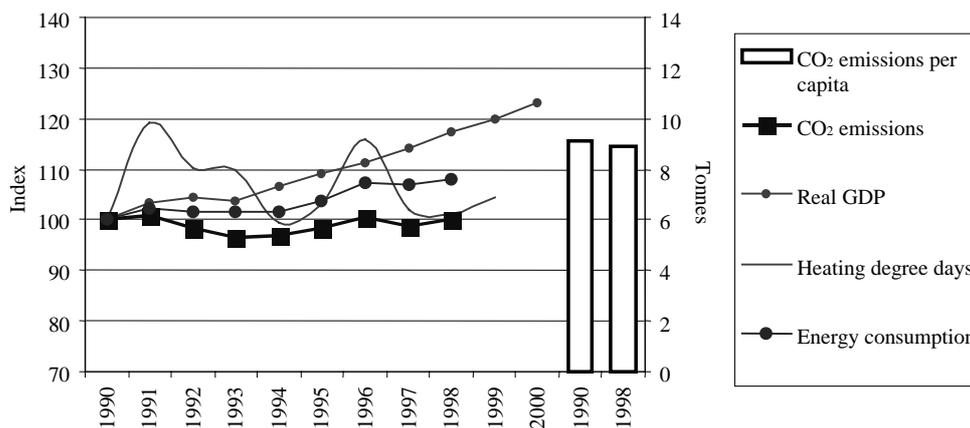
temperature<sup>4</sup> (i.e. cold or mild winters). In addition, weather conditions (i.e. high or low precipitation) can affect CO<sub>2</sub> emissions indirectly by influencing hydro power production: in case of low precipitation, hydro power production decreases and has to be offset by thermal power production.

Figure 4 shows that patterns of energy consumption and CO<sub>2</sub> emissions are similar. However, since energy consumption increased by 8.2 % from 1990 to 1998 compared with a 0.2 % increase in CO<sub>2</sub> emissions, the carbon intensity of energy consumption decreased noticeably. The main reasons for this are efficiency improvements in the German manufacturing and energy industry (in particular in the new Länder due to the economic restructuring process) and the fuel switch from coal to gas in the UK power industry. In addition, a general switch from coal to gas, renewable energies and nuclear power can be observed.

CO<sub>2</sub> emissions were highest in 1991 and 1996 – the two coldest years in the 1990s – thus illustrating the influence of temperature variations on CO<sub>2</sub> emissions<sup>5</sup>. CO<sub>2</sub> emissions were third highest in 1998 – a rather warm year indicating that temperature corrected CO<sub>2</sub> trends are rising in recent years.

The comparison of CO<sub>2</sub> emission trends with economic growth reveals that slow economic growth in the early 1990s was one reason for stable energy consumption and decreasing CO<sub>2</sub> emissions. CO<sub>2</sub> emissions were lowest in 1993, when economic activity declined. As real GDP grew by 17.4 % between 1990 and 1998, carbon intensity of the economy in terms of CO<sub>2</sub> emissions per GDP decreased considerably from 639 kg in 1990 to 545 kg per 1000 ECU. Since CO<sub>2</sub> emissions almost stabilised and population grew by 3 %, CO<sub>2</sub> emissions per capita decreased from 9.1 tonnes in 1990 to 8.9 tonnes in 1998.

**Figure 4: EU15 CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days and energy consumption)**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption (also referred to as 'energy consumption' in this report) as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were taken from EC (2000).

<sup>4</sup> Note that some Member States prepare CO<sub>2</sub> emission estimates, that are corrected for temperature-related effects in order to provide a better analysis of structural developments in CO<sub>2</sub> emissions.

<sup>5</sup> Temperature variations can be measured using so-called heating degree days. Heating degree days are the sum of temperature differences between a certain constant indoor temperature and the daily average of outdoor temperature. Therefore, lower average temperatures lead to higher heating degree days.

Table 2 shows that there are large variations in CO<sub>2</sub> emission trends between Member States. Only three Member States reduced their emissions: Luxembourg (61.1 %), Germany (12.6 %) and UK (6.5 %). Together, they accounted for a reduction of 174 Tg, while in all other Member States emissions increased during the same period by 181 Tg. The largest absolute decrease in CO<sub>2</sub> emissions occurred in Germany (128 Tg) and the United Kingdom (38 Tg). The largest relative increases occurred in the cohesion States Ireland (+26.8 %), Portugal (+24.9 %) and Spain (+20.8 %). The largest increases in absolute terms were in Spain and Italy with 47 Tg and 29 Tg respectively.

Despite large reductions, Germany and UK stayed the two largest emitters contributing 26.6 % and 16.4 % to EU15 CO<sub>2</sub> emissions respectively in 1998. Third and fourth largest emitters were Italy and France with shares of 13.8 % and 12.4 % of EU15 CO<sub>2</sub> emissions respectively. Spain is the fifth largest emitting country in the EU with a share of 8.2 %.

**Table 2: Greenhouse gas emissions and CO<sub>2</sub> emissions in the EU in Gg of CO<sub>2</sub> equivalents (excl. industrial F-gases and LUCF)**

MEMBER STATE	Total greenhouse gas emissions			CO <sub>2</sub> emissions		
	1990	1998	Trend 90/98	1990	1998	Trend 90/98
Austria	75,452	78,548	4.1%	62,130	66,604	7.2%
Belgium	136,014	144,622	6.3%	113,997	121,975	7.0%
Denmark (1)	69,567	75,603	8.7%	52,894	60,125	13.7%
Finland	72,586	76,020	4.7%	59,300	63,950	7.8%
France	538,539	543,691	1.0%	387,590	412,860	6.5%
Germany	1,201,117	1,011,653	-15.8%	1,014,500	886,499	-12.6%
Greece	103,912	119,503	15.0%	85,249	100,324	17.7%
Ireland	53,496	63,728	19.1%	31,575	40,028	26.8%
Italy	514,665	538,171	4.6%	429,694	458,327	6.7%
Luxembourg	14,114	5,872	-58.4%	13,300	5,179	-61.1%
Netherlands (1)	208,936	225,969	8.2%	161,400	181,400	12.4%
Portugal	62,614	73,753	17.8%	43,132	53,891	24.9%
Spain	301,919	360,481	19.4%	226,057	273,017	20.8%
Sweden	69,467	70,291	1.2%	55,443	56,953	2.7%
United Kingdom	727,110	657,727	-9.5%	584,220	546,390	-6.5%
<b>EU-15</b>	<b>4,149,509</b>	<b>4,045,632</b>	<b>-2.5%</b>	<b>3,320,481</b>	<b>3,327,520</b>	<b>0.2%</b>

(1) Non-adjusted data; for adjusted data see corresponding Member States section.

The German emission reduction was mainly caused by the economic restructuring of the five new Länder. These emission reductions may not be sustained at similarly high levels in the future. Other factors positively influencing the reduction of emissions in Germany were increasing efficiency in power and heating plants, the substitution of lignite by natural gas and gas oil, and reduced energy consumption in final consumption sectors. The reduction of CO<sub>2</sub> emissions in UK was primarily the result of liberalising the energy market and the subsequent fuel switches from oil and coal to gas in electricity production (see below).

#### **CH<sub>4</sub> emissions**

CH<sub>4</sub> emissions decreased almost steadily and in 1998 were 16.5 % (72 Tg of CO<sub>2</sub> equivalents) below 1990 levels. The share of CH<sub>4</sub> emissions of total greenhouse gas emissions declined steadily from 10.5 % in 1990 to 9.0 % in 1998. The main sources of CH<sub>4</sub> emissions are agriculture (mainly enteric fermentation and manure management), waste disposal in landfills and fugitive emissions (e.g. in

gas distribution networks). CH<sub>4</sub> emissions from agriculture were reduced by 6 % but their share in CH<sub>4</sub> emissions increased from 43.7 % in 1990 to 49.2 % in 1998. Emissions from waste were reduced by 23.5 %. Their share in CH<sub>4</sub> emissions was reduced from 33 % in 1990 to 30.3 % in 1998. Fugitive emissions from fuels accounted for 16.5 % of CH<sub>4</sub> emissions in 1998, down 2.9 percentage points from 1990. The most important reasons for declining CH<sub>4</sub> emissions are emission control from landfills (collection for flaring or power generation), leak reductions in gas distribution systems and reductions in coal mining.

Table 3 illustrates that there is large variation in CH<sub>4</sub> emission trends in the Member States: whereas Finland and Germany could reduce their CH<sub>4</sub> emissions by 42.1 % and 36.2 % respectively, Spanish CH<sub>4</sub> emissions grew by 26 %. In 1998, Germany was the largest emitter of CH<sub>4</sub> with a share of 20.5 % of EU15 emissions followed by the United Kingdom and France with shares of 15.2 % and 14.3 % respectively.

### *N<sub>2</sub>O emissions*

The share of N<sub>2</sub>O emissions in greenhouse gas emissions declined slightly from 9.5 % in 1990 to 8.7 % in 1998. Figure 3 illustrates that N<sub>2</sub>O emissions were already 9 % below 1990 levels in 1993, but increased until 1996 before reducing again. In 1998, N<sub>2</sub>O emissions were 9.9 % (39 Tg of CO<sub>2</sub> equivalents) below 1990 levels. The main sources are agriculture (soils and fertiliser use) and industrial processes (mainly adipic and nitric acid production). Agricultural uses are difficult to quantify and control, whereas industrial emissions are well understood and can be more easily controlled. Agricultural N<sub>2</sub>O emissions reduced only slightly (-1.7 %), but emissions from industrial processes declined by 35.5 % between 1990 and 1998. Accordingly, the share of agriculture in N<sub>2</sub>O emissions increased 5.1 percentage points to 61.4 % in 1998, whereas the share of industrial processes declined 8 percentage points to 20.1 %. A small but rapidly increasing source of N<sub>2</sub>O emissions almost doubling between 1990 and 1998 is the transport sector after the introduction of the catalytic converter.

In 1998, the largest N<sub>2</sub>O emitter was France with a share of 22.2 % of EU15 emissions followed by the United Kingdom and Germany with shares of 15.8 % and 14.3 % respectively. Large reductions were achieved by Luxembourg (31 %) and Germany (-27.5 %), whereas N<sub>2</sub>O emissions in Finland increased by 33.9 % between 1990 and 1998.

**Table 3: CH<sub>4</sub> and N<sub>2</sub>O emissions in the EU in Gg of CO<sub>2</sub> equivalents (excl. LUCF)**

MEMBER STATE	CH <sub>4</sub> emissions			N <sub>2</sub> O emissions		
	1990	1998	Trend 90/98	1990	1998	Trend 90/98
Austria	11,289	9,648	-14.5%	2,033	2,297	13.0%
Belgium	12,658	12,205	-3.6%	9,360	10,442	11.6%
Denmark	5,848	6,024	3.0%	10,825	9,454	-12.7%
Finland	7,520	4,352	-42.1%	5,766	7,719	33.9%
France	61,390	52,155	-15.0%	89,559	78,675	-12.2%
Germany	116,990	74,655	-36.2%	69,626	50,499	-27.5%
Greece	9,209	9,755	5.9%	9,455	9,424	-0.3%
Ireland	12,836	13,631	6.2%	9,085	10,069	10.8%
Italy	39,727	41,317	4.0%	45,245	38,528	-14.8%
Luxembourg	504	480	-4.8%	310	214	-31.0%
Netherlands	27,138	22,373	-17.6%	20,398	22,196	8.8%
Portugal	13,364	13,332	-0.2%	6,118	6,531	6.8%
Spain	34,626	43,615	26.0%	41,236	43,849	6.3%
Sweden	5,964	5,376	-9.9%	8,060	7,962	-1.2%
United Kingdom	77,212	55,354	-28.3%	65,677	55,983	-14.8%
<b>EU15</b>	<b>436,276</b>	<b>364,271</b>	<b>-16.5%</b>	<b>392,753</b>	<b>353,841</b>	<b>-9.9%</b>

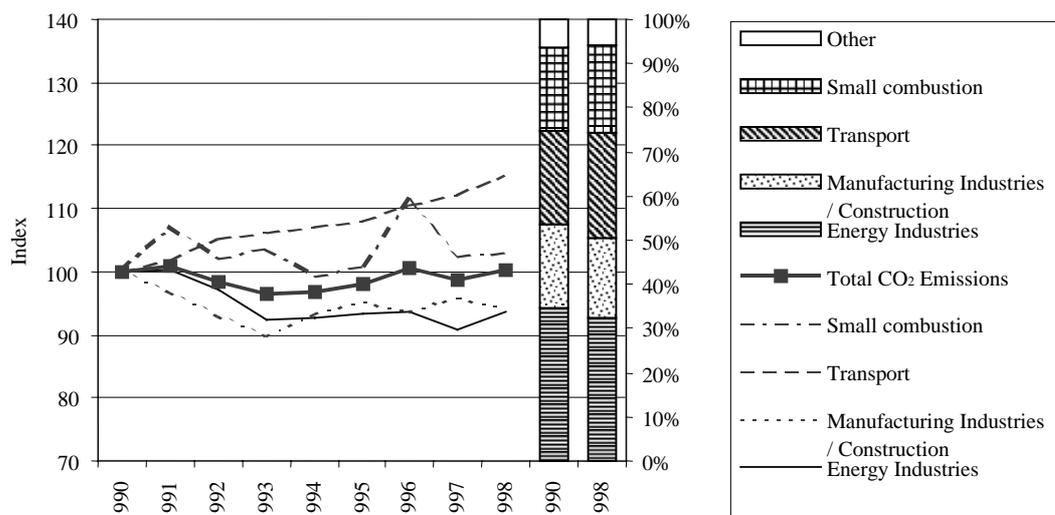
### 3.3. Sectoral breakdown of CO<sub>2</sub> emissions

In the following, CO<sub>2</sub> emission characteristics are analysed in more detail for several reasons: (1) CO<sub>2</sub> emissions account for more than 80 % of all EC greenhouse gas emissions in terms of global warming potential values; (2) therefore, overall greenhouse gas emission trends can be illustrated more clearly by examining CO<sub>2</sub> emissions and their driving forces; (3) high quality of CO<sub>2</sub> emission data in terms of completeness and comparability; and (4) the only binding target so far – the stabilisation target by 2000 – refers to CO<sub>2</sub> emissions. A sectoral breakdown of CO<sub>2</sub> emissions reveals that in 1998 about 94 % of CO<sub>2</sub> emissions came from fossil fuel combustion. Therefore, the focus of this and the following two sections is on CO<sub>2</sub> emissions from fossil fuel combustion and their driving forces.

Figure 5 illustrates the following overall trends of CO<sub>2</sub> emissions from fossil fuel combustion: emissions from transport and small combustion increased in the 1990s, whereas emissions from the energy and the manufacturing industries declined.

**Energy industries:** In 1998, energy industries still have been the largest emitter accounting for 32.3 % of total CO<sub>2</sub> emissions, but reducing its share from 34.6 %. In absolute terms, CO<sub>2</sub> emissions from energy industries decreased by 72 Tg or 6.2 % between 1990 and 1998. Figure 5 illustrates that most of the reductions were achieved by 1993, since then emissions stabilised. The main reasons for this decline were energy efficiency improvements in the German energy industry and the fuel switch in the UK power industry from coal to gas. In absolute terms, Germany and UK reduced CO<sub>2</sub> emissions from energy industries by 74 Tg and 39 Tg respectively.

**Figure 5: Sectoral breakdown of EU15 CO<sub>2</sub> emissions (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

**Transport:** The second largest emitter was transport with a share of 24 % in 1998, up 3.1 percentage points from 1990. In absolute terms, CO<sub>2</sub> emissions from transport increased by 106 Tg (15.3 %) from 1990-1998 as a consequence of growing road traffic in all Member States. Spain (+20 Tg), Germany (+19 Tg) and France (+17 Tg) had the largest increases in absolute terms. Only Finland and the United Kingdom had singledigit growth rates of CO<sub>2</sub> emissions between 1990 and 1998; emissions in all other Member States grew at 10 % or more, with especially high rates in the cohesion countries ranging from 77 % (Ireland) to 29 % (Greece).

From 1990 to 1997, fuel consumption by road transport increased by 12.2 %. Passenger car traffic grew by 14.7 % in terms of person-kilometers travelled. Car ownership increased by 13.2 % from 401 cars per inhabitant in 1990 to 454 cars in 1997. Road haulage increased by 29.4 % in terms of tonne-kilometers. Apart from Finland, where the ratios mentioned stabilised or even slightly reduced, all Member States showed increasing trends, especially the cohesion countries (EC, 1999).

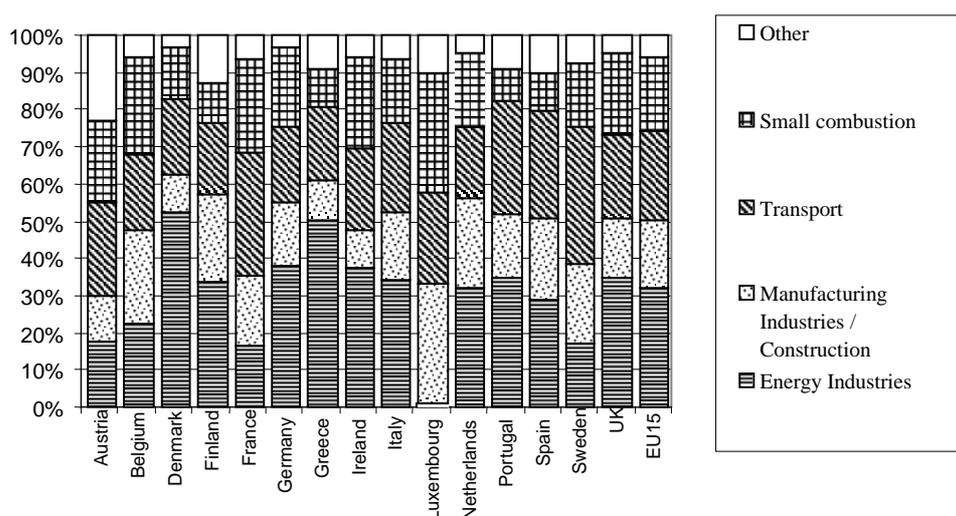
**Small combustion:** The third emitter was small combustion comprising the commercial and service sector, households, agriculture and public institutions. This sector increased its share in total CO<sub>2</sub> emissions slightly from 19.1 % in 1990 to 19.6 % in 1998. In absolute terms, CO<sub>2</sub> emissions from small combustion grew by 19 Tg (3 %) between 1990 and 1998.

The emission variations in this sector are comparatively high because of considerable influence of weather conditions on energy consumption. Accordingly, 1991, 1993 and 1996 CO<sub>2</sub> emissions from small combustion peaked because of cold winters. The largest absolute decrease was in Germany (12 Tg), but also the Nordic countries (Denmark, Finland, Sweden) reduced CO<sub>2</sub> emissions from small combustion. In all other Member States these emissions increased.

**Manufacturing industry:** Industry reduced its emissions by 36 Tg (5.7 %) from 1990 to 1998 with an absolute low in 1993. The most important reasons for decline in the early 1990s were large industrial restructuring after the German unification and low economic activity in almost all Member States. Since 1993, CO<sub>2</sub> emissions from industry increased slightly. German CO<sub>2</sub> emissions decreased by 49 Tg between 1990 and 1993 and were in 1998 at 1993 level. UK reduced CO<sub>2</sub> emissions from manufacturing industry by 6 Tg mainly due to fuel switching from coal to natural gas.

**Sectoral breakdown of CO<sub>2</sub> emissions by Member States:** There are large variations in the sectoral breakdown of CO<sub>2</sub> emissions by Member States mainly according to their energy supply structure. The energy industry is the largest emitter in most Member States (Figure 6): In Denmark and Greece, more than 50 % of CO<sub>2</sub> emissions came from the energy industries in 1998. This corresponds to the high reliance on coal in these countries. In contrast to this, countries where nuclear power or renewable energies have high shares, CO<sub>2</sub> emissions from the energy industries account for less than 20 % (Austria, France, Sweden).

**Figure 6: Sectoral breakdown of CO<sub>2</sub> emissions by Member States in 1998**



Note: Sector names follow CRF categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### 3.4. Energy supply, by fuel

More than 90 % of CO<sub>2</sub> emissions are caused by fossil fuel combustion. From 1990 to 1997, gross inland energy consumption increased by 7.1 % and fossil fuel consumption increased by 4 %. Therefore, the share of fossil fuels in energy consumption declined slightly from 81.3 % in 1990 to 79 % in 1997 (Figure 7). Nuclear power and renewable energies grew at a faster pace than total gross inland consumption, thus contributing to the decarbonisation of energy consumption. In general, coal declined in favour of gas, renewable energies and nuclear power.

**Oil:** The most important energy source in the EU is oil accounting for 41.8 % of gross inland energy consumption in 1997. Primary oil production within the EU is only about 27 % of oil consumption which illustrates the large import dependency of the EU. The largest oil producer within the EU is the United Kingdom

accounting for more than 80 % of EU production. Almost 50 % of oil is used in the transport sector. Second is small combustion with a share of 18 % of inland market consumption.

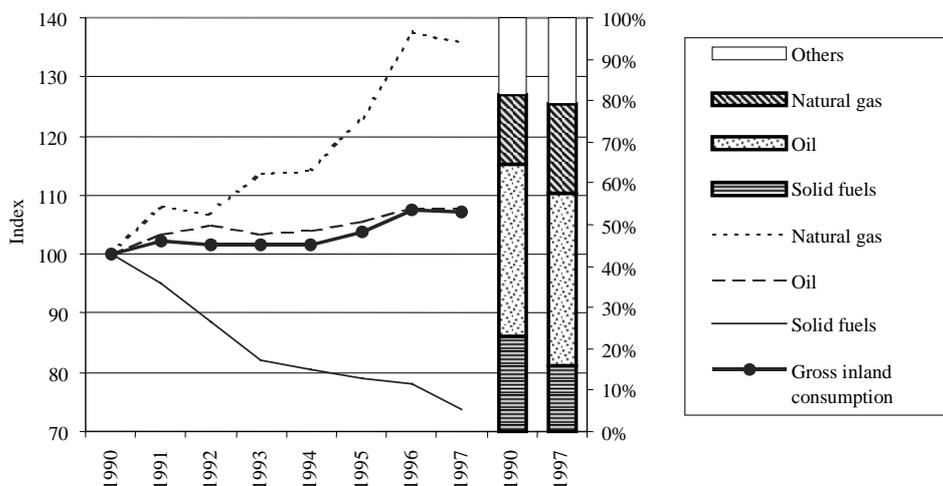
**Natural gas:** In recent years, natural gas has become the second energy source due to large increases in Germany and UK. The share of gas grew by 4.5 percentage points to 21.4 % of gross inland energy consumption in 1997. Gas production expanded substantially especially in UK and in Denmark: in 1997, about 60 % of gas gross inland consumption was produced within the EU, the largest producers being UK and the Netherlands. Small combustion accounts for about 45 % of inland market consumption followed by the industry with a share of about 27 %. The use in power stations more than doubled from 1990 to 1997 and was about 22 % of inland market consumption in 1997.

**Solid fuels:** Despite of a sharp decline, solid fuels (mainly hard coal and lignite) are the third energy source. Their share in gross inland energy consumption decreased from 22.9 % in 1990 to 15.8 % 1997.

Primary production of **hard coal** in the EU declined by almost 40 % between 1990 and 1997 and amounted to about 45 % of gross inland consumption in 1997. The largest producers of hard coal are Germany and UK accounting together for about 80 % of EU15 hard coal production. About two thirds of hard coal were used in power stations in 1997. The use of hard coal for power generation dropped by about 18 %. In absolute terms, hard coal reduction for power use was 40 mio tonnes from 1990 to 1997, of which 37 were reduced in UK.

**Lignite**<sup>6</sup> production decreased by more than 40 % between 1990 and 1997. Consumption in power plants declined by only about 17 %. Therefore, an increasing share of lignite production is used for power generation (90 % in 1997). Germany is the largest producer of lignite in the EU accounting for about two thirds of lignite production in the EU. Greece is second with a share of about 23 %.

**Figure 7: EU15 gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include nuclear power, renewable energy sources and net electricity imports.

<sup>6</sup> Figures include peat

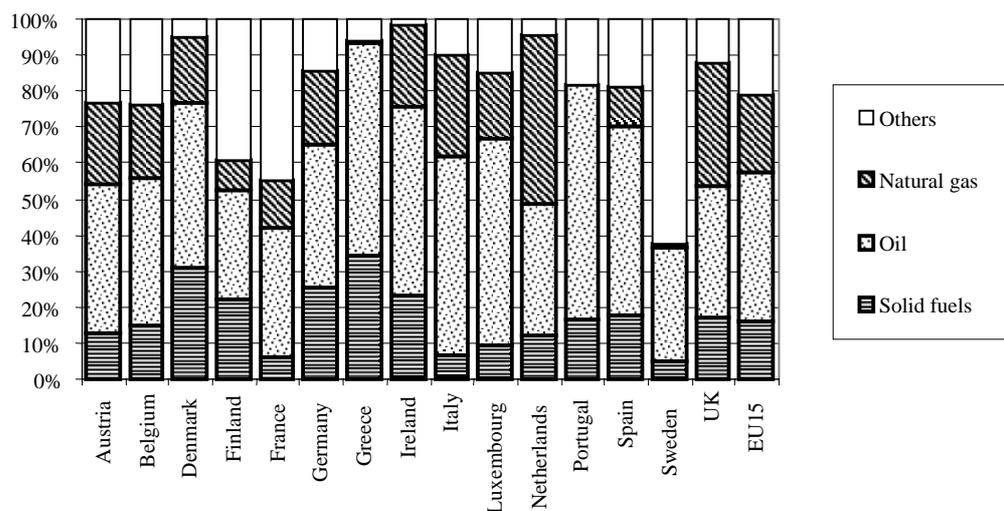
**Nuclear power** is the fourth energy source increasing its share in gross inland energy consumption from 13.8 % in 1990 to 15.1 % of gross inland consumption in 1997.

**Renewable energies:** Renewable energy sources increased their share in gross inland consumption from 4.9 % in 1990 to 5.8 % in 1997. However, the EU target of 12% of energy supply by renewables in 2010 will require significant efforts. Biomass (including waste) and hydro power are the largest renewable energy sources accounting for 3.7 % and 1.8 % of gross inland energy consumption respectively in 1997. Most of the biomass use is firewood consumption in households but also wood waste burned in industry and municipal waste incineration contribute significantly. Geothermal energy, wind power and solar energy accounted for 0.2 %, 0.04 % and 0.02 % of gross inland energy consumption in 1997 respectively but wind and solar energy grew at a fast pace.

**Fossil fuel shares by Member States:** The dependency on fossil fuels varies considerably in the Member States (Figure 8). In 1997, the highest shares of fossil fuels in gross inland consumption showed Ireland (98.2 %), the Netherlands (95.8 %), Denmark (94.9 %), and Greece (93.9 %). The lowest shares have countries relying heavily on nuclear power (France: 40.7 %, Sweden: 35.9 %, Belgium: 21.7 %, Finland: 16.3 %) or on renewables (Sweden: 26.7 %, Austria: 23.3 %, Finland: 20.2 %).

In most countries oil is the largest energy source except for France and Sweden (nuclear power) and the Netherlands (natural gas). In 1997, the largest reliance on oil had Portugal (65.1 %), Greece (58.8 %), Luxembourg (57.3 %) and Italy (55.1 %). The highest shares of gas had the Netherlands (47.2 %) and UK (34.5 %), whereas Sweden, Portugal and Greece hardly used any gas. Greece and Denmark rely considerably on solid fuels with shares of 34.4 % and 30.8 % respectively.

**Figure 8: Fossil fuel shares in gross inland energy consumption by Member States in 1997**



Note: 'Others' include nuclear power and renewable energy sources.

### 3.5. Electricity generation

Gross electricity generation increased by 17.5 % between 1990 and 1997. Per capita electricity generation increased from 5,668 kWh in 1990 to 6,483 kWh in 1997. A shift in power generation from solid fuels and oil to mainly natural gas and, to a much lesser extent, nuclear power can be observed.

Thermal power production increased by 16.5 % between 1990 and 1997 accounting for 51 % of gross electricity generation in 1997, down 0.5 percentage points from 1990. Within thermal power generation, production shifted from hard coal and oil to natural gas and, to a lesser extent, lignite and, to a very small extent, to biomass.

**Solid fuels:** Solid fuels accounted for 27.1 % of gross electricity generation in 1997. Hard coal's share in gross electricity generation declined from 26.8 % in 1990 to 19.5 %. Although hard coal fired power production was reduced in several Member States, UK accounts for the bulk of the reductions: between 1990 and 1997, EU15 hard coal fired power generation dropped by 80 TWh, in UK by 85 TWh.

In contrast to hard coal fired power production, electricity generated by lignite firing increased by 48.3 % (60 TWh) between 1990 and 1997. Germany increased its power production from lignite by 74.5 % (60 TWh). As lignite consumption in German power stations decreased by about 24 %, thermal efficiency of lignite fired power production increased substantially.

**Natural gas:** Gas fired power production increased by 134.1 % between 1990 and 1997; its share in gross electricity generation grew from 6.9 % in 1990 to 13.7 % in 1997. Again, UK is the main responsible for this trend. In the EU, power produced from natural gas increased by 190 TWh, UK accounted for an increase of 104 TWh. Next were Italy with 22 TWh and Germany and the Netherlands with 14 TWh each.

**Oil:** Oil fired power production declined by 4.2 % or 8 TWh. Accordingly, its share in gross electricity generation decreased from 9.4 % in 1990 to 7.7 % in 1997. UK reduced oil fired power production by 26 TWh between 1990 and 1997, whereas Italy increased by 10 TWh.

With an increase of 19.4 %, **nuclear power** production grew slightly faster than total power production. Therefore, the share of nuclear power in gross electricity generation increased slightly from 34.9 % in 1990 to 35.5 % in 1997.

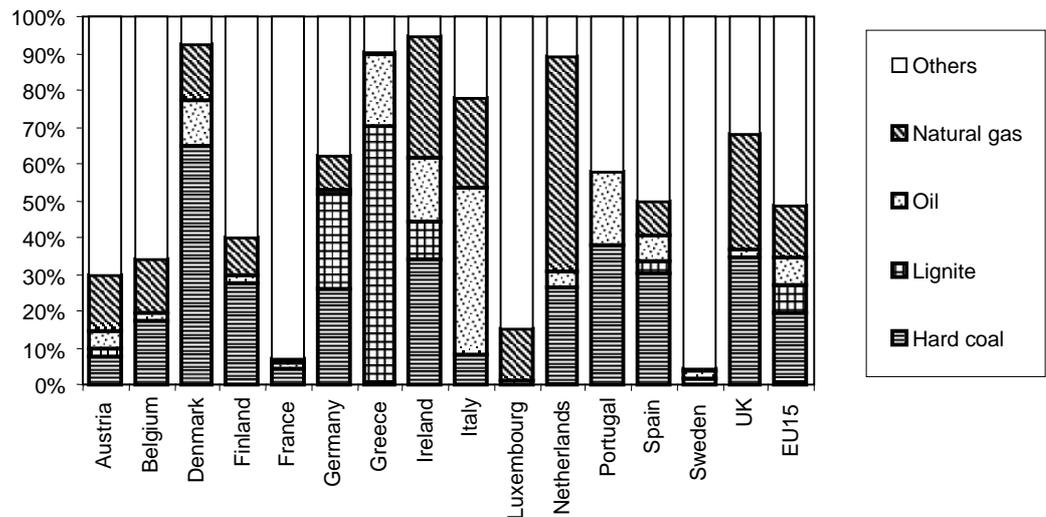
**Renewable electricity production:** In total, electricity generation from renewable energy sources increased its share in electricity generation slightly from 14.4 % in 1990 to 14.6 % in 1997. Hydro power production grew by 14.3 % and accounted for 13 % of gross electricity generation in 1997. Wind and biomass fired power production increased by 6 TWh (increase by a factor 8) and 12 TWh (+76.8 %) respectively between 1990 and 1997. Germany and Denmark account for the bulk of new wind power production, whereas biomass increased considerably in Finland and the Netherlands.

**Fossil fuels in power production by Member States:** The pattern of fossil fuel consumption in power production is very similar to the pattern of fossil fuel shares in gross inland energy consumption mentioned above. The reliance on fossil fuels

in electricity generation in the Member States varies even more (Figure 9). In 1997, the highest shares of fossil fuels in gross electricity generation showed Ireland (94.6 %), Denmark (92.5 %), Greece (90.2 %) and the Netherlands (89 %). The lowest shares had countries relying heavily on nuclear power (France: 78.4 %, Belgium: 60.1 %, Sweden: 46.8 %, Finland: 30.2 %,) or on power production from renewables (Austria: 68.4 %, Sweden: 48.3 %, Finland: 27.8 %). In addition the following features are relevant:

- Denmark: large share of hard coal fired power production (64.9 %), but also large share of wind power (4.4 %)
- Germany: large reliance on solid fuels (51.6 %), which has grown slightly since 1990 due to increases in lignite fired power production
- Greece: high share of lignite fired power production (69.8 %)
- Netherlands: high share of gas fired power production (58.3 %)
- United Kingdom: almost equal share in power production from hard coal (34.7 %) and natural gas (31.1 %); in 1990 the shares have been 64.2 % and 1 % respectively.

**Figure 9: Fossil fuel shares in gross electricity generation by Member States in 1997**



Note: 'Others' include nuclear power and electricity production from renewable energy sources

## Summary on actual progress of the European Community

	Progress of EU15	
	CO <sub>2</sub> emission targets for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☺	☺

## Variations of greenhouse gas emissions 1990-1998 of EU15 and the Member States in Tg of CO<sub>2</sub> equivalents (excl. industrial F-gases and LUCF)

	EU15	AT	BE	DK	FI	FR	DE	GR
Greenhouse gases <sup>(1)</sup>	-103.9	+3.1	+8.6	+6.0 (-5.3)	+3.4	+5.2	-189.5	+15.6
CH <sub>4</sub>	-72.0	-1.6	-0.5	+0.2	-3.2	-9.2	-42.3	+0.5
N <sub>2</sub> O	-38.9	+0.3	+1.1	-1.4	+2.0	-10.9	-19.1	-0.03
CO <sub>2</sub> <sup>(1)</sup>	+7.0	+4.5	+8.0	+7.2 (-4.1)	+4.7	+25.3	-128.0	+15.1
Energy industries	-71.7	-0.7	-4.6	+5.3	+3.0	+2.4	-74.0	+7.0
Manufacturing industries	-36.0	+0.7	+5.0	+0.2	+1.2	+0.5	-49.1	+0.7
Transport	+105.8	+3.2	+4.1	+1.7	+0.4	+16.7	+18.5	+4.5
Small combustion	+19.2	+1.5	+5.8	-0.6	-0.6	+9.0	-12.3	+2.4
	IE	IT	LU	NL	PT	ES	SE	UK
Greenhouse gases	+10.2	+23.5	-8.2	+17.0	+11.1	+58.6	+0.8	-69.4
CH <sub>4</sub>	+0.8	+1.6	-0.02	-4.8	-0.03	+9.0	-0.6	-21.9
N <sub>2</sub> O	+1.0	-6.7	-0.1	+1.8	+0.4	+2.6	-0.1	-9.7
CO <sub>2</sub> <sup>(1)</sup>	+8.5	+28.6	-8.1	+20.0 (+17.5)	+10.8	+47.0	+1.5	-37.8
Energy industries	+4.0	+13.1	-1.8	+6.0	+2.8	+4.4	+0.9	-39.3
Manufacturing industries	+0.1	+1.6	-4.9	+2.4	+1.2	+11.2	-0.9	-5.9
Transport	+3.8	+14.6	-1.6	+6.2	+4.8	+20.4	+2.5	+6.2
Small combustion	+0.2	+1.8	+0.5	+0.8	+1.2	+4.0	-1.1	+6.3

(1) For Denmark and the Netherlands adjusted data (for 1990 and 1998) is given in brackets.

## Variations of greenhouse gas emissions 1990-1998 of EU15 and the Member States in percent (excl. industrial F-gases and LUCF)

	EU15	AT	BE	DK	FI	FR	DE	GR
Greenhouse gases <sup>(1)</sup>	-2.5%	+4.1%	+6.3%	+8.7% (-6.8%)	+4.7%	+1.0%	-15.8%	+15.0%
CH <sub>4</sub>	-16.5%	-14.5%	-3.6%	+3.0%	-42.1%	-15.0%	-36.2%	+5.9%
N <sub>2</sub> O	-9.9%	+13.0%	+11.6%	-12.7%	+33.9%	-12.2%	-27.5%	-0.3%
CO <sub>2</sub> <sup>(1)</sup>	+0.2%	+7.2%	+7.0%	+13.7% (-6.7%)	+7.8%	+6.5%	-12.6%	+17.7%
Energy industries	-6.2%	-5.9%	-14.4%	+20.2%	+16.3%	+3.6%	-17.9%	+15.9%
Manufacturing industries	-5.7%	+9.6%	+19.4%	+4.2%	+8.4%	+0.7%	-25.0%	+7.0%
Transport	+15.3%	+23.5%	+20.1%	+15.6%	+3.4%	+13.8%	+11.4%	+29.4%
Small combustion	+3.0%	+11.6%	+22.3%	-6.7%	-8.8%	+9.6%	-6.0%	+30.0%
	IE	IT	LU	NL	PT	ES	SE	UK
Greenhouse gases	+19.1%	+4.6%	-58.4%	+8.2%	+17.8%	+19.4%	+1.2%	-9.5%
CH <sub>4</sub>	+6.2%	+4.0%	-4.8%	-17.6%	-0.2%	+26.0%	-9.9%	-28.3%
N <sub>2</sub> O	+10.8%	-14.8%	-31.0%	+8.8%	+6.8%	+6.3%	-1.2%	-14.8%
CO <sub>2</sub> <sup>(1)</sup>	+26.8%	+6.7%	-61.1%	+12.4% (+10.4%)	+24.9%	+20.8%	+2.7%	-6.5%
Energy industries	+36.1%	+9.2%	-96.5%	+11.3%	+17.8%	+5.9%	+9.9%	-17.1%
Manufacturing industries	+2.2%	+2.0%	-74.8%	+5.7%	+15.1%	+23.0%	-6.5%	-6.3%
Transport	+76.8%	+15.2%	-56.2%	+21.6%	+41.9%	+35.1%	+13.3%	+5.3%
Small combustion	+2.5%	+2.4%	+49.3%	+2.1%	+34.0%	+16.7%	-9.9%	+5.6%

(1) For Denmark and the Netherlands adjusted data (for 1990 and 1998) is given in brackets. If for Denmark the electricity trade correction is only taken into account for the year 1990 the adjusted Danish greenhouse gas emissions decreased by 0.3% from 1990 to 1998 and the adjusted CO<sub>2</sub> emissions increased by 1.6%.

## 4. Progress in the individual EC Member States

This chapter aims at evaluating progress of each Member State towards fulfilling the Community greenhouse gas commitments. In the first section, latest emission data of the Member States is analysed in detail. First, for each Member State actual emission data is plotted against the target paths for 2000, and the target path for 2008-2012. Then, overall emission trends of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O are presented. CO<sub>2</sub> emissions and their driving forces are examined in more detail as they represent more than 80 % of greenhouse gas emissions. Sectoral CO<sub>2</sub> emissions in energy industries, manufacturing industries and construction, transport, and small combustion (commerce, services, households, agriculture, public institutions) are dealt with because fuel combustion accounts for more than 90 % of CO<sub>2</sub> emissions. Finally, energy consumption and electricity production patterns of the Member States are examined briefly because they are the most important driving forces of CO<sub>2</sub> and greenhouse gas emissions.

### 4.1. Greenhouse gas trends and progress in the EC Member States

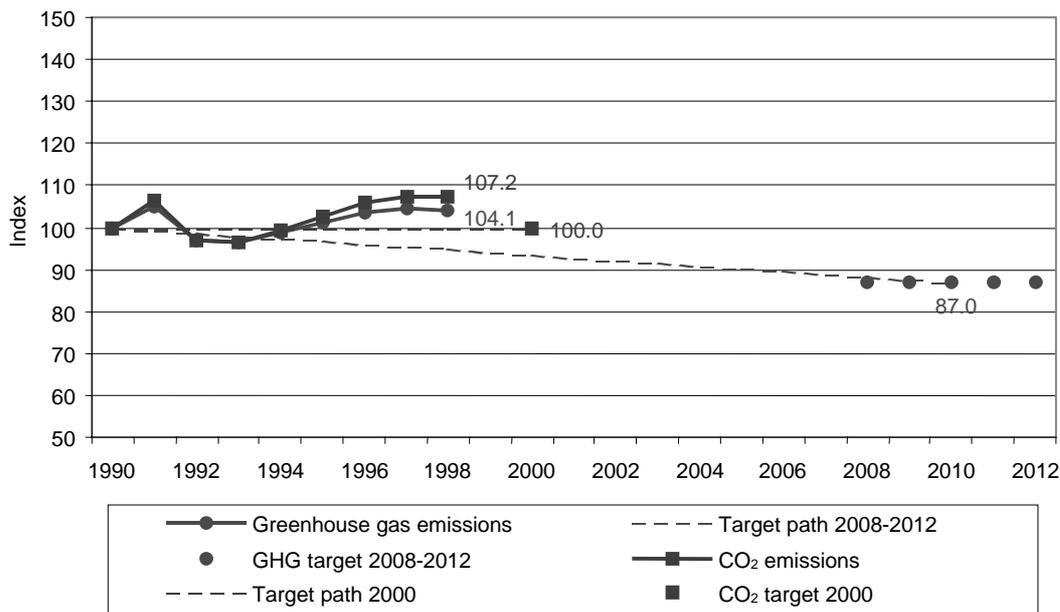
#### 4.1.1. Austria

##### *Actual progress in Austria*

In the burden sharing agreement related to the Kyoto Protocol, Austria agreed to reduce its greenhouse gas emissions by 2008-2012 by 13 % compared to 1990 levels. In 1998, Austrian greenhouse gas emissions were 78.5 Tg. This was 4.1 % (3.1 Tg) above 1990 levels and 9.3 index points above the linear target path for 2008-2012 (Figure 10). Austria accounted for 1.9 % of EU15 greenhouse gas emissions in 1998.

For CO<sub>2</sub> emissions, Austria has set a stabilisation target by 2000. Figure 10 shows that Austria's emissions are not in line with the stabilisation target. In 1998, Austrian CO<sub>2</sub> emissions were 66.6 Tg, which was 7.2 % (4.5 Tg) above 1990 levels. Therefore, CO<sub>2</sub> emissions were 7.2 index points above the target path.

**Figure 10: Austrian greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

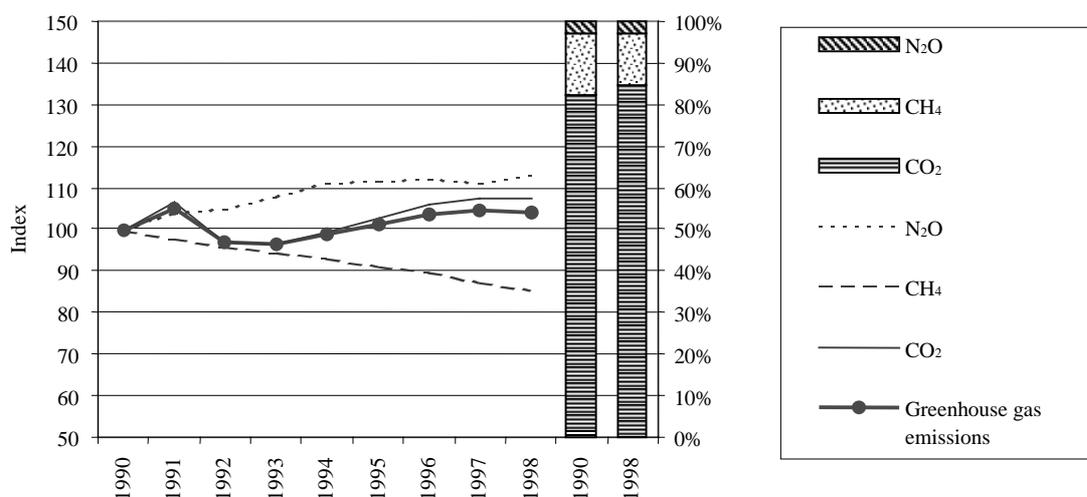
### Greenhouse gas emission trends

Figure 11 illustrates that CO<sub>2</sub> emissions accounted for 84.8 % of Austrian greenhouse gas emissions in 1998, up 2.5 percentage points from 1990. CH<sub>4</sub> emissions made up for 12.3 % of Austrian greenhouse gas emissions in 1998, down 2.7 percentage points. N<sub>2</sub>O emissions amounted for 2.9 % of greenhouse gas emissions in 1998, which was the smallest share amongst EU15 Member States (EU15 average 8.7 %).

**CH<sub>4</sub> emissions:** From 1990 to 1998, Austrian CH<sub>4</sub> emissions declined steadily and were 14.5 % (1.6 Tg of CO<sub>2</sub> equivalents) below 1990 levels in 1998. The most important sources are waste and agriculture accounting for 53.9 % and 41.8 % respectively of CH<sub>4</sub> emissions. CH<sub>4</sub> emissions from both sources showed decreasing trends between 1990 and 1998. In contrast to that, fugitive CH<sub>4</sub> emissions from oil and natural gas showed a 29.5 % increase but accounted for only 1.2 % of Austrian CH<sub>4</sub> emissions in 1998.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions grew considerably in the first half of the 1990s, stabilised until 1995 but increased again in 1998. In absolute terms, N<sub>2</sub>O emissions increased by 13 % (0.3 Tg of CO<sub>2</sub> equivalents). The largest emitter of N<sub>2</sub>O emissions is agriculture accounting for 44.1 %, down 6.3 percentage points. In absolute terms, N<sub>2</sub>O emissions from agriculture stabilised. Second is transport increasing its share from 16 % in 1990 to 25.6 %. Between 1990 and 1994, N<sub>2</sub>O emissions went up by 72.2 % after introducing the catalytic converter; between 1994 and 1997 emissions stabilised but in 1998 they increased again.

**Figure 11: Austrian greenhouse gas emissions (excl. LUCF)**



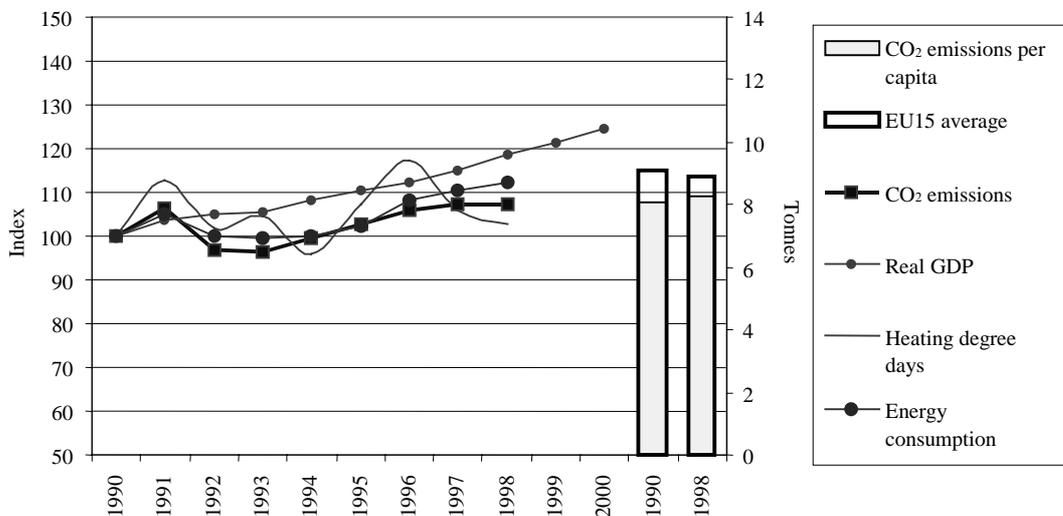
Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

### Austrian CO<sub>2</sub> emission trends and driving forces

In 1998, CO<sub>2</sub> emissions were 7.2 % above 1990 and 0.3 % below 1997 levels. CO<sub>2</sub> emissions per capita increased slightly from 8.1 in 1990 to 8.2 tonnes in 1998, which is still below EU15 average but gradually approaching it (Figure 12). After a peak in 1991, due to marked economic activity and low temperatures, and lows in 1992 and 1993, CO<sub>2</sub> emissions have been rising until 1997. CO<sub>2</sub> emissions have levelled in 1998, but with rather warm temperatures. Indeed, temperature adjusted data indicate rising trends since 1996 (Schleicher et al, 2000). The marked fall of CO<sub>2</sub> emissions in 1992 is partly due to increased hydro power production and corresponding lower power production in thermal power plants (see below).

Economic growth and gross inland energy consumption were 18.6 % and 12.3 % respectively above 1990 levels indicating a slight decoupling of CO<sub>2</sub> emissions from economic growth and energy consumption. Accordingly, CO<sub>2</sub> intensity of GDP has decreased by almost 10 % from 495 kg to 447 kg per 1000 ECU. This is the third lowest figure in EU15 and well below the EU15 average of 545 kg. Growth of gross inland energy consumption has been below real GDP growth indicating slight reductions of energy intensity since 1991.

**Figure 12: Austrian CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were taken from OESTAT (1999 and 1998).

### **Sectoral breakdown of CO<sub>2</sub> emissions**

In 1998, about 77 % of Austrian CO<sub>2</sub> emissions came from fossil fuel combustion. Three sectors of fossil fuel combustion increased in absolute terms (transport, industry, small combustion), whereas CO<sub>2</sub> emissions from energy industries decreased between 1990 and 1998 (Figure 13). In general, a shift from energy industries and other sectors to transport and small combustion can be observed.

**Transport:** The transport sector is the largest emitter in Austria accounting for 25.2 % of all CO<sub>2</sub> emissions in 1998. The importance of transport is a consequence of the low share of energy industries and rapidly growing transport emissions: between 1990 and 1998, CO<sub>2</sub> emissions from transport grew by 23.5 % (3.2 Tg) which is well above the EU15 average growth rate of 15.3 %. Reasons for this are rapidly growing car ownership and usage. For example, car ownership grew by 20.9 % from 1990 to 1997 and was 469 cars per inhabitant in 1997 (EU15 average: 454) (EC, 1999). As one measure against rising CO<sub>2</sub> emissions from road transport, the implementation of road pricing was planned, but delayed for technical reasons. As an intermediate step a motorway toll for both freight and passenger transport has been introduced, which is independent of kilometers driven (lump sum).

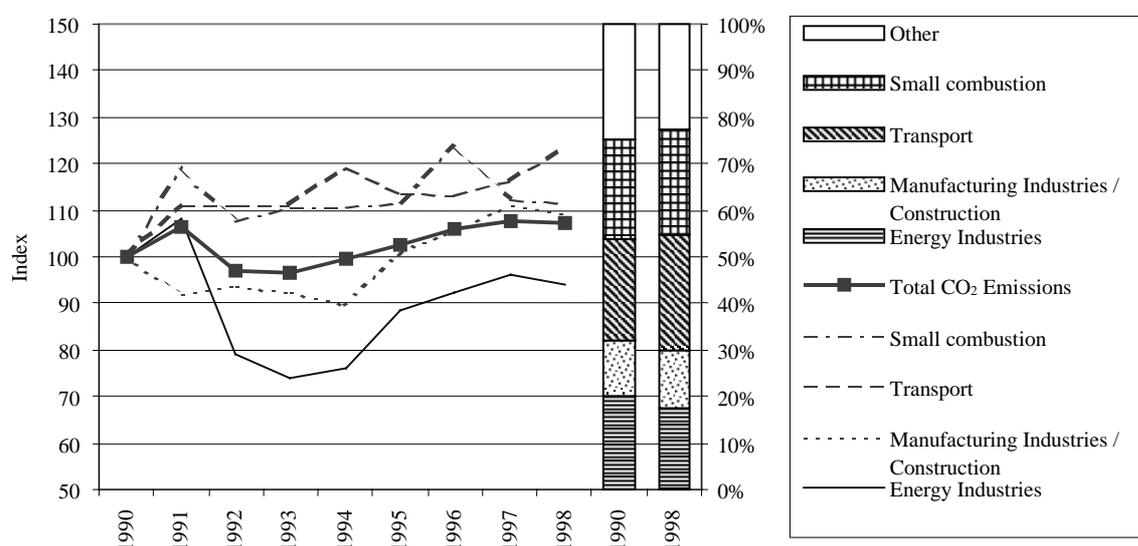
**Small combustion:** The second largest emitter is the small combustion sector with a share of 22.3 % in 1998. In absolute terms, CO<sub>2</sub> emissions from small combustion grew by 1.5 Tg (11.6 %). The increase is due to growing household numbers outweighing to some extent higher insulation standards and more efficient heating/warm water supply in new buildings. The pattern of CO<sub>2</sub> emissions is very close to temperature variations showing peaks in 1991 and 1996.

**Energy industries:** The energy industry is third with 17.5 % of total CO<sub>2</sub> emissions in 1998. This is the only sector having reduced its emissions (by 5.9 % or 0.7 Tg between 1990 and 1998). The minor importance of CO<sub>2</sub> emissions from the energy industry is due to the high share of renewables in the electricity production (about two thirds of electricity is generated in hydro power plants).

**Manufacturing industries:** CO<sub>2</sub> emissions from manufacturing industries increased by 0.7 Tg (9.6 %) between 1990 and 1998. Their share in total CO<sub>2</sub> emissions was with 12.2 % in 1998 almost the same as in 1990.

Compared with other Member States, in Austria CO<sub>2</sub> emissions of 'other' sectors are important. This is due to comparatively large CO<sub>2</sub> emissions from industrial processes (17.9 % of all CO<sub>2</sub> emissions), especially metal production and mineral products.

**Figure 13: Sectoral CO<sub>2</sub> emissions for Austria (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### *Energy supply, by fuel*

Gross inland energy consumption has increased between 1990 and 1997 by 10.6 %. The energy consumption per capita was 3.5 toe, which is slightly lower than the EU15 average (3.8 toe).

Figure 14 illustrates that in 1997 fossil fuels accounted for 76.9 % of total energy consumption, which was almost the same share as in 1990. As Austria has only few fossil fuel resources, import dependency of fossil fuels is high. Domestic lignite production although on a sharp decline is given a small guaranteed market for electricity production. 23.3 % of gross inland energy consumption are based on renewable energies, mainly biomass and hydro power.

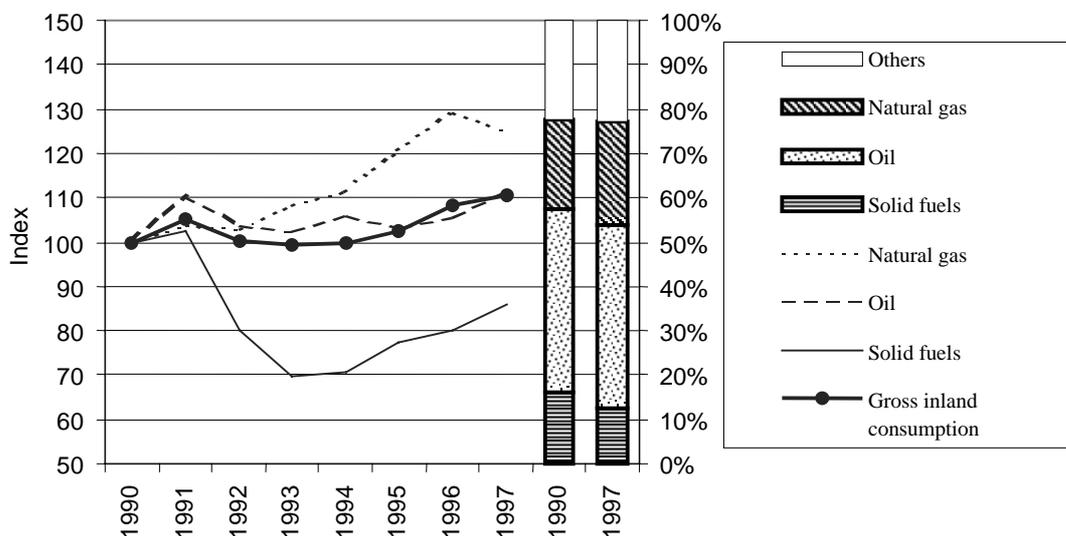
**Oil:** Oil is the most important energy source accounting for 41.3 % of energy consumption in 1997 (compared to 41 % in 1990). In absolute terms, oil consumption has increased by 11.3 % from 1990 to 1997, one reason for this being increasing road transport trends.

**Natural gas:** The use of natural gas has increased by 24.9 %, which is mainly due to enhanced use in the small combustion and in power stations (+72.5 % and +21.6 % respectively between 1990 and 1996). Therefore, the share of natural gas in total energy consumption has increased from 20.4 % in 1990 to 23.1 % in 1997.

**Solid fuels:** In contrast to that, the use of solid fuels declined sharply from 1990 to 1993, but recovered since then. The consumption curve of solid fuels is very similar to the curve of CO<sub>2</sub> emissions in the energy industries illustrating the high importance of solid fuels for electricity production. Indeed, about one third of hard coal and almost all domestic lignite production is used for power generation.

**Renewable energies:** The use of renewable energies increased by 14.7 % between 1990 and 1997. This was partly due to various renewable energy promotion measures (subsidies, buyback tariffs for electricity, tax incentives) for biomass use, combined heat and power, wind power and solar energy. As one result of these measures, Austria accounted for 18.3 % of total EU surface area of installed solar collectors (Eurostat, *Renewable energy sources statistics in the European Union 1989-1997*). Biomass and hydropower are the dominant renewable energy sources accounting for 12.4 % and 10.9 % of gross inland energy consumption in 1997. Both energy sources increased more than overall energy consumption thus enhancing their shares.

**Figure 14: Austrian gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include renewable energy sources and net electricity imports.

### Electricity generation

Gross electricity generation has increased in Austria by 10.6 % from 1990 to 1997. Per capita electricity generation was 7,047 kWh per inhabitant in 1997 being 8.7 % above EU15 average. The power supply sector is characterised by a high share of

renewable production: 65.6 % of electricity is generated in hydro power plants, the rest is produced in conventional thermal power plants. Austria has no nuclear power.

Thermal electricity production has increased by 3.4 % between 1990 and 1997. The most important fuel for thermal power production is natural gas: 43.8 % of thermal electricity generation is fuelled by natural gas. Second are solid fuels with 28.3 % but decreasing trends between 1990 and 1997. Petroleum products are used in 14.2 % of thermal power plants and the share of biomass is 8 %. The use of biomass for thermal electricity production has increased by almost 50 % from 1990 to 1997.

***Summary on actual progress in Austria***

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☹	☹
	Variations 1990/1998 in Tg of CO <sub>2</sub> equivalents and percent	
Greenhouse gases	+3.1 Tg	+4.1 %
CH <sub>4</sub>	-1.6 Tg	-14.5 %
N <sub>2</sub> O	+0.3 Tg	+13.0 %
CO <sub>2</sub>	+4.5 Tg	+7.2 %
Energy industries	-0.7 Tg	-5.9 %
Manufacturing industries	+0.7 Tg	+9.6 %
Transport	+3.2 Tg	+23.5 %
Small combustion	+1.5 Tg	+11.6 %

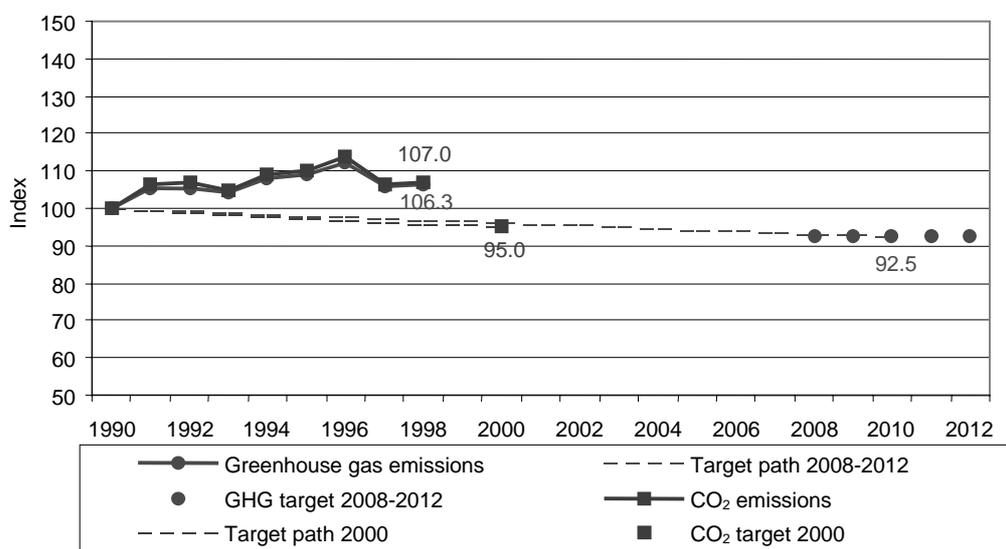
#### 4.1.2. Belgium

##### *Actual progress in Belgium*

In the burden sharing agreement, Belgium agreed to reduce its greenhouse gas emissions to 7.5 % of 1990 levels by 2008-2012. In 1998, Belgian greenhouse gas emissions were 144.6 Tg. This was 6.3 % (8.6 Tg) above 1990 levels and 9.3 index points above the linear target path for 2008-2012 (Figure 15). Belgium accounted for 3.6 % of EU15 greenhouse gas emissions in 1998.

For CO<sub>2</sub> emissions, Belgium set a 5 % reduction target by 2000 (corrected for temperature variations). In 1998, CO<sub>2</sub> emissions were 122 Tg, which was 7 % (8 Tg) above 1990 levels. Therefore, Belgian CO<sub>2</sub> emissions were 11 index points above the target path for 2000 respectively in 1998 (however not corrected for temperature variations).

**Figure 15: Belgian greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

##### *Greenhouse gas emission trends*

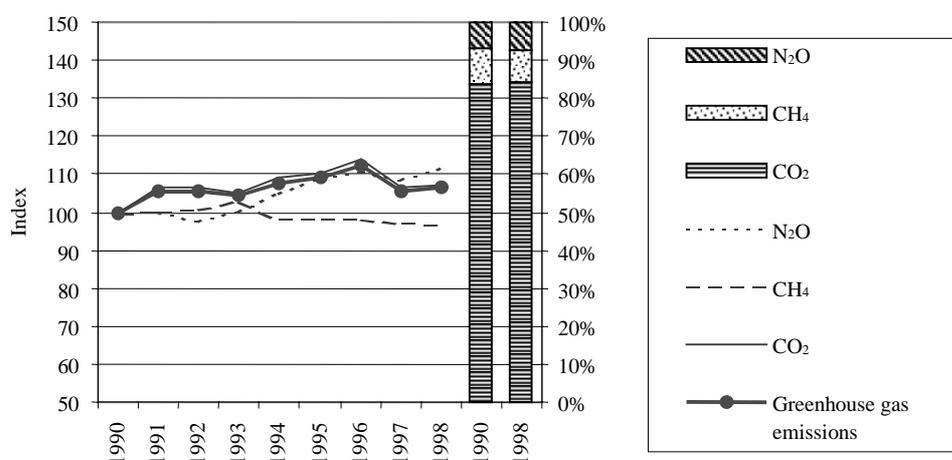
Figure 16 illustrates that the share of CO<sub>2</sub> emissions in greenhouse gas emissions increased slightly from 83.8 % in 1990 to 84.3 % in 1998. CH<sub>4</sub> emissions were second accounting for 8.4 % in 1998, down 0.9 percentage points from 1990. The share of N<sub>2</sub>O emissions increased from 6.9 % in 1990 to 7.2 % in 1998.

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions decreased slightly by 3.6 % (0.5 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. Agriculture and waste account for more than 90 % of CH<sub>4</sub> emissions. The share of agricultural CH<sub>4</sub> emissions decreased from 63.2 % in 1990 to 60.3 % in 1998. In contrast to that, waste increased its share by 2.8 percentage points to 31.6 % in 1998. Fugitive emissions of oil and gas

accounting for about 6 % of CH<sub>4</sub> emissions increased considerably in the first half of the 1990s, but showed a slump in 1995; over the whole period 1990-1998 they stabilised.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions increased by 11.6 % (1.1 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. The most important sources are industrial processes, agriculture and fuel combustion. In 1998, industrial processes accounted for 44.9 % of N<sub>2</sub>O emissions, up 6.8 percentage points from 1990. Agriculture was responsible for 32 % of N<sub>2</sub>O emissions, down 4.1 percentage points. As in many other Member States, N<sub>2</sub>O emissions from transport increased much by 159.9 % between 1990 and 1998.

**Figure 16: Belgian greenhouse gas emissions (excl. LUCF)**



Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

### *CO<sub>2</sub> emission trends and driving forces*

Belgian CO<sub>2</sub> emissions increased almost alongside with energy consumption and economic activity (Figure 17). The recession in 1993 pulled down CO<sub>2</sub> emissions, but recovered economic growth rates afterwards led to steady increases of CO<sub>2</sub> emissions. Only in 1997 and 1998, CO<sub>2</sub> emissions decoupled from energy consumption and economic activity.

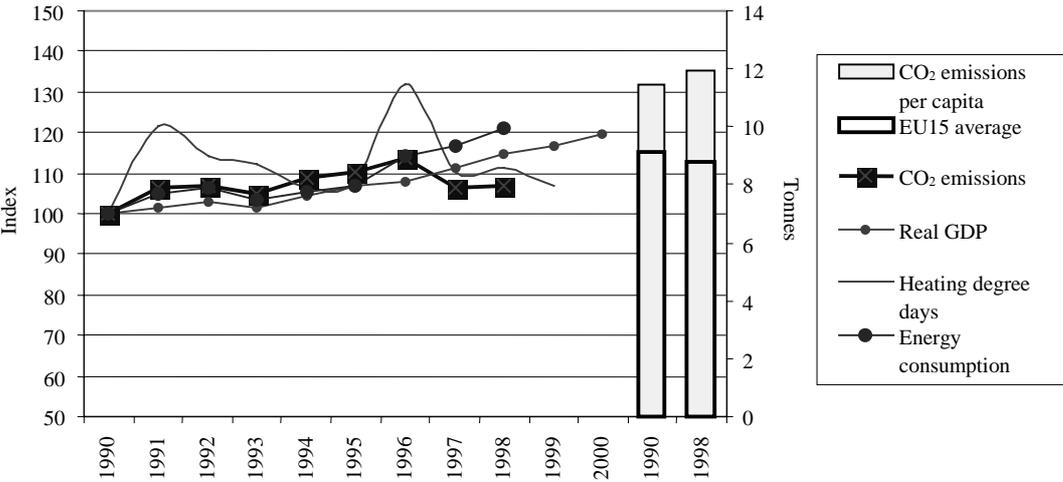
The 1997 decrease of CO<sub>2</sub> emissions is the reason for declining carbon intensity of GDP in the period 1990-1998. CO<sub>2</sub> emissions per GDP and per inhabitant are amongst the highest in the EU: CO<sub>2</sub> emissions per 1000 ECU reduced from 738 kg in 1990 to 690 kg in 1998 (EU15 average in 1998: 545 kg). Per capita emissions grew from 11.5 tonnes in 1990 to 12 tonnes in 1998 compared with the EU15 average of 8.9 tonnes in 1998.

### *Sectoral breakdown of CO<sub>2</sub> emissions*

About 94 % of Belgian CO<sub>2</sub> emissions come from fossil fuel combustion. Within fossil fuel combustion, CO<sub>2</sub> emissions grew in all sectors but energy industries between 1990 and 1998 (Figure 18). In general, a shift from energy industries and other sectors to small combustion industry and transport can be observed.

**Small combustion:** Figure 18 illustrates that the increase in CO<sub>2</sub> emissions was driven by small combustion which has become the largest emitter in the 1990s, increasing its share from 22.8 % in 1990 to 26 % in 1998. In absolute terms, CO<sub>2</sub> emissions from small combustion increased by 22.3 % (5.8 Tg) between 1990 and 1998 with a peak in 1996 due to cold weather. Final energy consumption in small combustion increased by 26.6 % between 1990 and 1997 and gas oil use in this sector by 25.4 %.

**Figure 17: Belgian CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



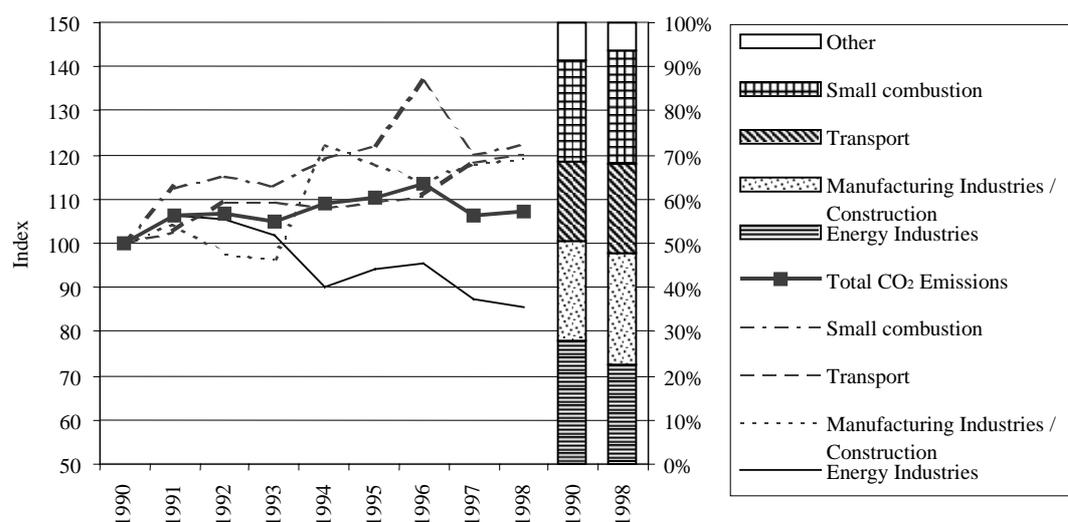
Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were obtained from Eurostat.

**Energy industries:** Second largest CO<sub>2</sub> emitters are energy industries having reduced their share from 28 % in 1990 to 22.4 % in 1998. In absolute terms, CO<sub>2</sub> emissions from energy industries declined by 4.6 Tg. The major reason for this has been a significant decline of coal-fired electricity production.

**Manufacturing industries:** CO<sub>2</sub> emissions in the manufacturing industry declined gradually until 1993 but shot up in 1994 (Figure 18). In 1998, CO<sub>2</sub> emissions from industry were 5 Tg above 1990 levels. Industry's share in CO<sub>2</sub> emissions increased from 22.6 % in 1990 to 25.2 % in 1998.

**Transport:** CO<sub>2</sub> emissions from transport increased by 4.1 Tg (20.1 %) between 1990 and 1998. Their share grew from 18 % in 1990 to 20.2 % in 1998. From 1990 to 1997, passenger road transport increased by 16.5 % and road haulage grew by 44 %, which was well above EU15 average growth of 29.4 % (EC, 1999).

**Figure 18: Sectoral CO<sub>2</sub> emissions of Belgium (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### *Energy supply, by fuel*

Gross inland energy consumption grew by 16.5 % between 1990 and 1997. The fossil fuel share has been stable at around 77 % in the 1990s and is very near to the EU15 average (Figure 19). The energy mix has switched from coal and – to a small extent – nuclear power to oil and natural gas after phasing out the exploitation of coal. Except for nuclear power, which accounted for 21.7 % of gross inland consumption in 1997, Belgium has few domestic energy resources; energy import dependency was 78.2 % in 1997.

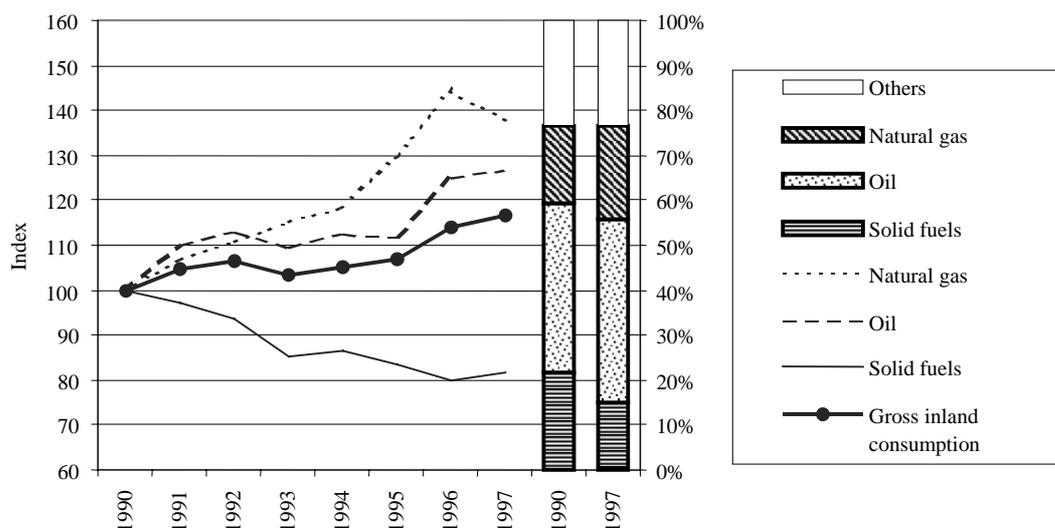
**Oil:** Oil is the largest primary energy source in Belgium accounting for 40.8 % in 1997, up 3.3 percentage points from 1990. Transport accounted for 41.1 % of oil inland market consumption in 1997 followed by small combustion with a share of 30.7 %.

**Natural gas:** As in many other EC Member States, the use of natural gas increased significantly in Belgium. Its share in gross inland consumption grew from 17.3 in 1990 to 20.4 % in 1997. Especially gas use in power stations (+76.5 %) and in small combustion (+32.4 %) grew rapidly in the 1990s.

**Solid fuels:** In contrast to increasing gas consumption, hard coal's share in gross inland energy consumption declined from 21.7 % in 1990 to 15.2 % in 1997. Whereas coal consumption in power stations, coking plants and small combustion decreased, only coal use in industry increased.

**Renewable energies:** Renewable energies accounted for 1.2 % of gross inland energy consumption. The bulk of renewables is biomass (1.1 %), consumption of which was stable between 1990 and 1997. Hydro power consumption increased by 14.4 %, but accounted for less than 0.1 % of gross inland consumption.

**Figure 19: Belgian gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include nuclear power, renewable energy sources and net electricity imports.

### *Electricity generation*

Gross electricity generation increased by 11.4 % between 1990 and 1997. Per capita electricity production was 7,757 kWh in 1997 which was above EU15 average (6,483 kWh).

Power production is dominated by nuclear power (1997: 60.1 %) and thermal power production from fossil fuels (1997: 38.3 %). Coal decreased its share from 24.1 % in 1990 to 17.4 % in 1997, whereas gas expanded from 7.6 % to 14.6 %.

### *Summary on actual progress for Belgium*

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☹	☹
	<b>Variations 1990/1998 in Tg of CO<sub>2</sub> equivalents and percent</b>	
Greenhouse gases	+8.6 Tg	+6.3 %
CH <sub>4</sub>	-0.5 Tg	-3.6 %
N <sub>2</sub> O	+1.1 Tg	+11.6 %
CO <sub>2</sub>	+8.0 Tg	+7.0 %
Energy industries	-4.6 Tg	-14.4 %
Manufacturing industries	+5.0 Tg	+19.4 %
Transport	+4.1 Tg	+20.1 %
Small combustion	+5.8 Tg	+22.3 %

### *4.1.3. Denmark*

#### *Actual progress in Denmark*

The evaluation of the Danish contribution to progress of the EC as a whole can be performed in different ways. In absolute terms, Danish greenhouse gas and CO<sub>2</sub> emissions fluctuated considerably in the 1990s (Figure 20). In 1998, Danish greenhouse gas emissions were 75.6 Tg, which was 6 Tg or 8.7 % above 1990 levels. If industrial F-gases are included, Danish greenhouse gas emissions increased by 9.5 % between 1990 and 1998. CO<sub>2</sub> emissions in 1998 were 60.1 Tg after falling sharply from 1996, which means that emissions were 13.7 % (7.2 Tg) above 1990 levels.

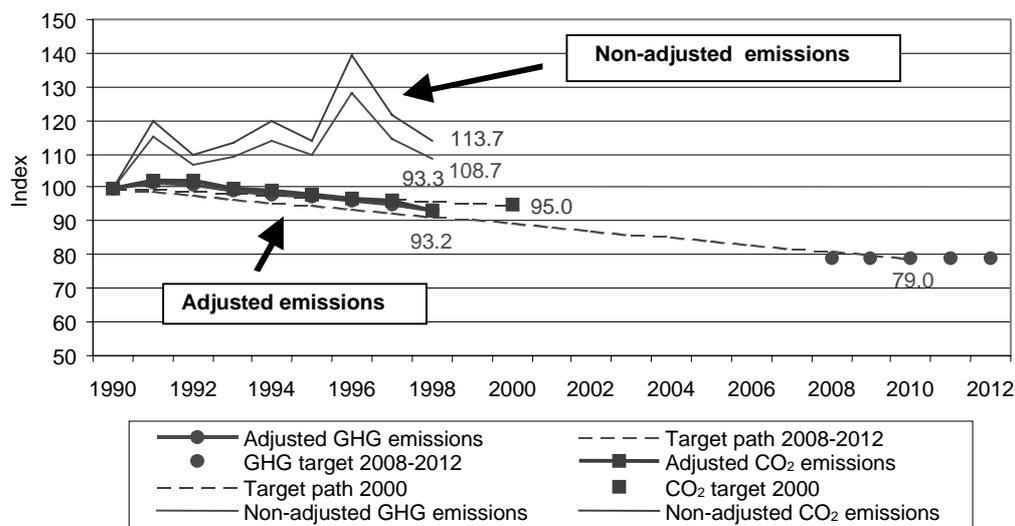
However, in the EC burden sharing arrangement, Denmark agreed to a 21 % reduction target of greenhouse gas emissions by 2008-2012 corrected for temperature and electricity trade variations. Similarly, the 5 % reduction target for CO<sub>2</sub> emissions by 2000 applies to corrected emissions. The main reason for corrected emission targets, is the specific situation of Denmark as swing producer of electricity in the Nordic electricity pool (see section on electricity generation).

For the evaluation of progress in this report, the targets under the burden sharing agreement are relevant. Therefore, temperature and electricity trade corrections are taken into account for Denmark for all years 1990-1998. Adjusted Danish greenhouse gas emissions (excluding F-gases and LUCF) decreased by 6.8 % from 1990 to 1998. This was 1.6 index points above the hypothetical linear target path for 2008-2012 (Figure 20). Corrected CO<sub>2</sub> emissions decreased by 6.7 % between 1990 and 1998, which was 2.7 index points below the linear target path for 2000.

If however the electricity trade correction (adjustment) is only taken into account for the year 1990 and the temperature correction is not taken into account the adjusted Danish greenhouse gas emissions (excluding F-gases and LUCF) decreased by 0.3% from 1990 to 1998. This was 8.1 index points above the hypothetical linear target path for 2008-2012. Corrected CO<sub>2</sub> emissions increased by 1.6% between 1990 and 1998, which was 5.6 index points above the linear target path for 2000.

<p>For evaluation of progress under the burden sharing agreement, adjusted data has been considered for Denmark in this report (Figure 20). However, the detailed analysis of the greenhouse gas emissions from Denmark refers to non-adjusted data.</p>
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**Figure 20: Danish greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. As the Danish targets refer to temperature and electricity trade adjusted emissions, adjusted data has been taken into account for Denmark, for all years 1990-1998.

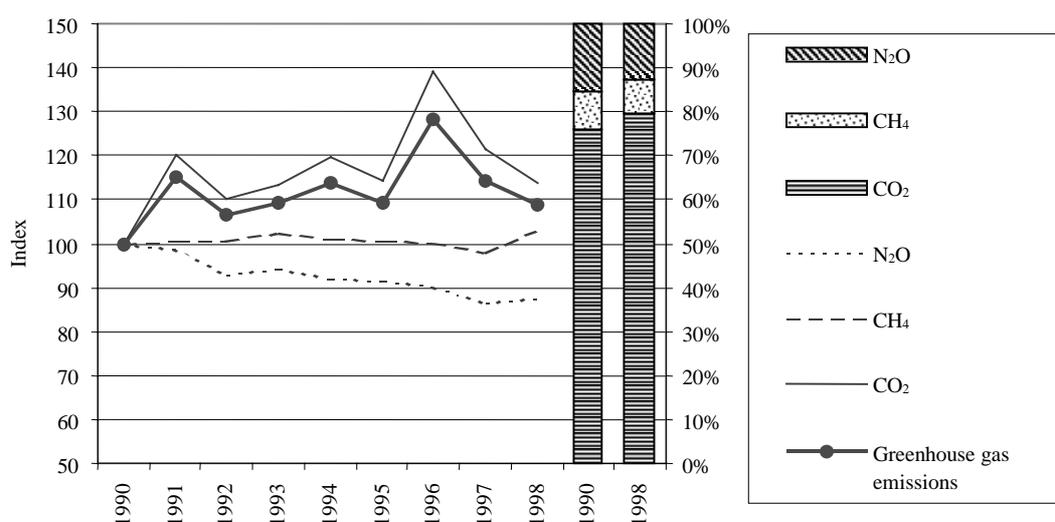
### Greenhouse gas emission trends

Figure 21 illustrates that the share of (non-adjusted) CO<sub>2</sub> emissions in greenhouse gas emissions grew from 76 % in 1990 to 79.5 % in 1998. N<sub>2</sub>O emissions accounted for 12.5 % of greenhouse gas emissions in 1998, down 3.1 percentage points from 1990. CH<sub>4</sub> emissions reduced its share from 8.4 % in 1990 to 8 % in 1998.

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions were almost stable (+0.2 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. Only in 1998, a sharp increase was experienced mainly due to increased CH<sub>4</sub> emissions from energy industries in that year. The largest sources of CH<sub>4</sub> emissions are agriculture and waste. Agricultural CH<sub>4</sub> emissions declined by 4.8 % between 1990 and 1998. Their share in CH<sub>4</sub> emissions declined from 69.3 % in 1990 to 64 % in 1998. CH<sub>4</sub> emissions from waste declined by 11.2 % from 1990 to 1998. Their share in CH<sub>4</sub> emissions was 19.3 % in 1998, down 3.1 percentage points from 1990.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions decreased by 12.7 % (1.4 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. Agriculture accounted for 90.6 % of N<sub>2</sub>O emissions in 1998, down 4.2 percentage points. N<sub>2</sub>O emissions from transport grew at a rapid pace (+195.1 %) to a share of 4.5 % in total N<sub>2</sub>O emissions in 1998.

**Figure 21: Danish greenhouse gas emissions, non-adjusted (excl. LUCF)**



Note: The figure shows the trend in non-adjusted greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

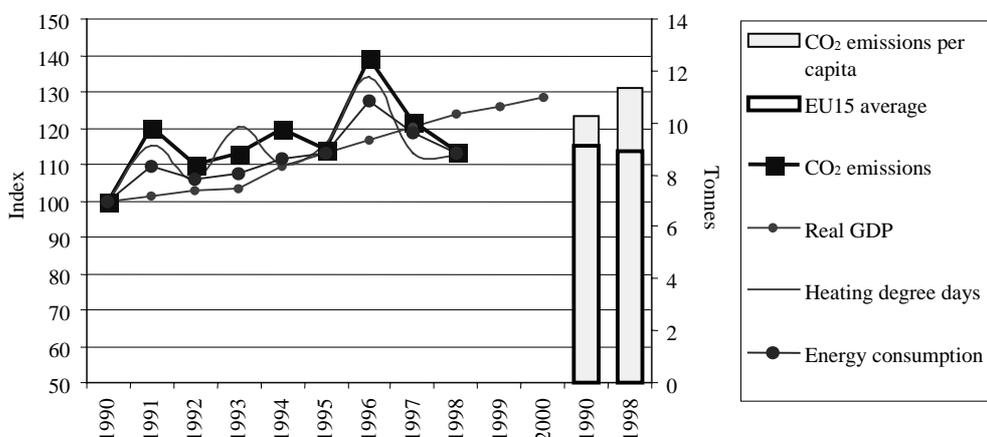
### *CO<sub>2</sub> emission trends and driving forces*

As mentioned above, the Danish CO<sub>2</sub> emissions showed large variations between 1990 and 1998. They peaked in 1996, when CO<sub>2</sub> emissions were almost 40 % above 1990 levels. Gross inland energy consumption increased by 12.9 % from 1990 to 1998. As real GDP grew by 23.7 % in the same period, energy and carbon intensity of GDP improved. However, as Figure 22 illustrates, the curves of gross inland energy consumption and CO<sub>2</sub> emissions fluctuate considerably (due to changing net electricity exports).

CO<sub>2</sub> emissions per GDP were 478 kg per 1000 ECU in 1998 (EU15 average 545 kg), which was an 8 % decrease from 1990 levels. As Denmark has neither nuclear nor large scale hydro power, CO<sub>2</sub> emissions per capita are above EU15 average. Between 1990 and 1998 they increased from 10.3 to 11.4 tonnes per inhabitant moving away from the declining EU15 average (8.9 tonnes). With the influence of electricity exchange taken into account for all years, the CO<sub>2</sub> emission per capita decreased from 11.9 in 1990 to 10.7 in 1998.

Although the degree day curve is very similar to the CO<sub>2</sub> emission curve (except for 1993 and 1994), temperature variations are not the main driving force of CO<sub>2</sub> emissions. Instead, electricity trade can explain a large part of the erratic movement of CO<sub>2</sub> emissions. In 1996, net electricity exports were about 30 % of total net electricity production. In 1990, Denmark was a large net importer of electricity (net imports were also about 30 % of net power production in that year). The scope of electricity exports depends heavily on weather conditions (temperature and precipitation) in the neighbouring Nordic countries.

**Figure 22: Danish non-adjusted CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of non-adjusted CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were taken from the Danish submission under the Monitoring Mechanism.

### *Sectoral breakdown of CO<sub>2</sub> emissions*

More than 96 % of Danish CO<sub>2</sub> emissions come from fossil fuel combustion. Within fossil fuel combustion, CO<sub>2</sub> emissions grew in all sectors but small combustion between 1990 and 1998 (Figure 23). In general, a shift from small combustion and manufacturing industries to energy industries and transport can be observed.

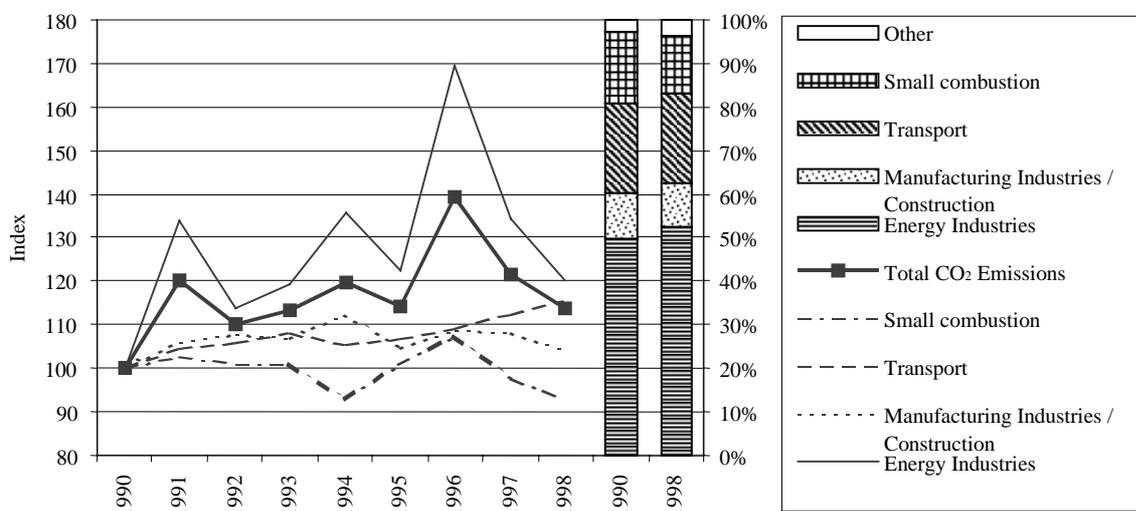
**Energy industries:** The sectoral breakdown of CO<sub>2</sub> emissions illustrates the dominance of the electricity sector for Danish greenhouse gas emissions. Figure 23 shows that, in 1998, 52.4 % of CO<sub>2</sub> emissions were emitted in the energy industry sector. Of all EC Member States, only Greece has a comparable high share of CO<sub>2</sub> emissions from the energy industry. Over the whole period from 1990 to 1998, CO<sub>2</sub> emission from the energy industries grew by 20.2 % (5.3 Tg), i.e. slightly faster than overall CO<sub>2</sub> emissions.

**Transport:** The second most important sector is the transport sector with almost steady increases (+1.7 Tg) from 1990 to 1998. As the emission growth rate of 15.6 % in the transport sector was very close to overall CO<sub>2</sub> emissions growth in the 1990s, the share of CO<sub>2</sub> emissions in the transport sector stabilised.

Apparently, the low car ownership ratio of 340 cars per 1000 inhabitants in 1997 (EU15 average was 454) due to the highest vehicle purchase taxes of EU15, is offset by higher car use: in 1997, the Danes travelled on average 12,445 passenger-km per person which was the highest figure of EU15 (EU15 average 10,128 passenger-km). However, cycling is at a record high level as well: in 1993, 18 % of trips were made by bicycle and in 1995, each Dane travelled 893 km by bicycle compared to an EU15 average of 186 km (EC, 1999).

CO<sub>2</sub> emissions from **manufacturing industries** and **small combustion** developed below average between 1990 and 1998. Former showed a small increase of 0.2 Tg, whereas latter declined by 0.6 Tg.

**Figure 23: Sectoral CO<sub>2</sub> emissions of Denmark, non-adjusted (excl. LUCF)**



Note: The figure shows the trend in non-adjusted sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### *Energy supply, by fuel*

As Denmark has no nuclear or large hydro power plants, the Danish energy supply is highly dependent on fossil fuels. The share of fossil fuels in gross inland consumption increased from 90.4 % in 1990 to almost 95 % in 1997<sup>7</sup> (Figure 24).

**Oil:** Oil is the largest single energy source accounting for 46.2 % of gross inland consumption. Denmark is a substantial producer of oil and gas and, therefore, is in total close to self-sufficiency in energy supply. Almost 50 % of oil inland market consumption is used for transport. Small combustion and power production account for about 20 % and 18 % of inland market consumption respectively.

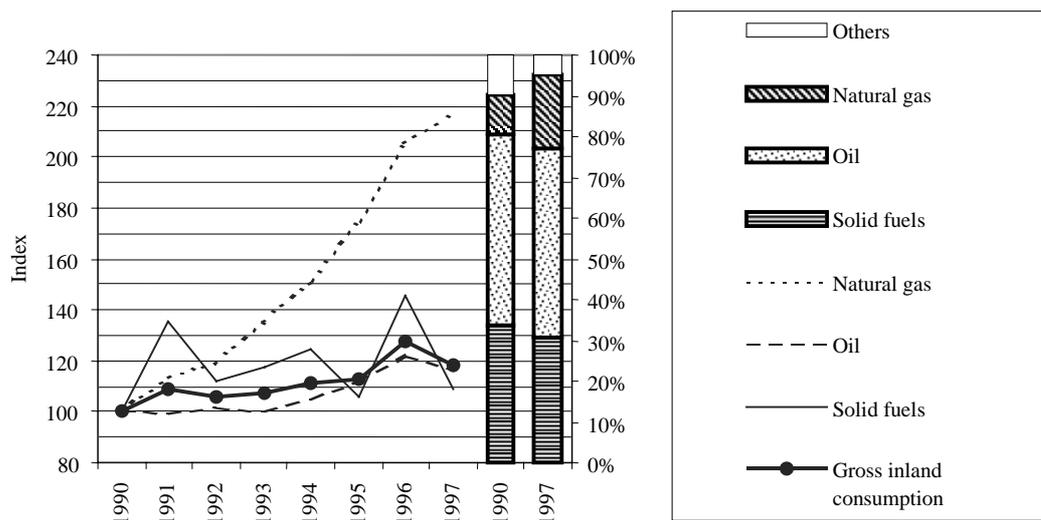
**Solid fuels:** Denmark's share of solid fuels is amongst the highest in the EU, although there is no domestic coal production. In 1997, 30.8 % of gross inland consumption was supplied by hard coal. Again, electricity production is the main responsible for high hard coal consumption in Denmark. In 1997, almost two thirds of electricity was generated in thermal power plants fuelled by hard coal.

**Natural gas:** Apart from the high share of coal, Danish energy consumption is characterised by a sharp increase in natural gas consumption in the 1990s. Figure 24 illustrates that gas consumption more than doubled between 1990 and 1997 and the share of gas in gross inland consumption grew from 9.8 % in 1990 to 17.9 % in 1997.

<sup>7</sup> In case of Denmark, this ratio is slightly misleading as Denmark was a considerable net exporter of electricity in 1997. Net exports of electricity decrease gross inland energy consumption, so the fossil fuel contribution is higher than if Denmark did not export electricity. For the same reason, shares of fossil fuels and renewables do not add up to 100 %.

**Renewable energies:** Renewable energy consumption increased by almost 50 % between 1990 and 1997. Thus the share of renewable energies in gross inland consumption increased to 8 % in 1997 (see footnote 7). The largest renewable energy source is biomass accounting for 7.1 % of gross inland energy consumption in 1997. Wind power more than trebled to a share of 0.8 % in gross inland energy consumption in 1997. Solar energy increased by a factor 4 but was below 0.1 % of gross inland energy consumption in 1997.

**Figure 24: Danish gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include renewable energy sources and net electricity imports.

### **Electricity generation**

The Danish electricity production is characterised by:

1. **high per capita electricity generation:** gross electricity generation increased by 71.5 % between 1990 and 1997. This increase is due to increased export of electricity. Gross electricity generated for domestic consumption increased by 11.0 %. In 1997, per capita electricity generation was at 8,396 kWh per person (EU15 average 6,483 kWh) and grew by 67 % compared to 1990. This increase is due to increased export of electricity. In 1997, per capita electricity generated for domestic consumption was at 6,545 kWh per person (close to the EU average) and grew by 8 % compared to 1990.
2. **high share of coal fuelled power generation:** Although this share fell significantly from 90.3 % in 1990 to 64.9 % in 1997, it is still among the highest in the European Union. In the same period, gas fuelled power generation rose from 2.6 % to 15.4 % of power generation.
3. **high variations of net electricity exports due to fluctuating needs in neighbouring Nordic countries:** Up to 30 % of the Danish electricity production is exported to other Nordic countries and to Germany. In the Nordic electricity market, Danish power producers act as swing producers: if unfavourable weather conditions limit electricity production in Norway and Sweden, coal fired power plants in Denmark back up the Nordic electricity pool. Thermal power plants are well suited for compensating low hydro power production for their flexible operation. Norway relies almost entirely on hydro power; Sweden produced almost 50 % of electricity in hydro power plants in

1997. For electricity exports mainly coal fired power stations are in use, thus increasing CO<sub>2</sub> emissions in years with high net electricity exports significantly.

4. **high share of mainly gas fuelled combined heat and power (CHP):** District heating currently accounts for about 50 % of energy demand for space heating; 70 % of district heating is based on CHP (IEA, 1998b).
5. **sharp increase in biomass and wind power in the 1990s:** The share of wind power in electricity production has almost doubled from 2.4 % in 1990 to 4.4 % in 1997. Biomass increased from 0.5 % to 3 % in the same period.

### Summary on actual progress for Denmark

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☹ (1)	☹ (1)
	Variations 1990/1998 in Tg of CO <sub>2</sub> equivalents and percent	
	ADJUSTED DATA for 1990 and 1998 <sup>(2)</sup>	
Greenhouse gases	-5.3 Tg	-6.8 %
CO <sub>2</sub>	-4.1 Tg	-6.7 %
	NON-ADJUSTED DATA	
Greenhouse gases	+6.0 Tg	+8.7 %
CH <sub>4</sub>	+0.2 Tg	+3.0 %
N <sub>2</sub> O	-1.4 Tg	-12.7 %
CO <sub>2</sub>	+7.2 Tg	+13.7 %
Energy industries	+5.3 Tg	+20.2 %
Manufacturing industries	+0.2 Tg	+4.2 %
Transport	+1.7 Tg	+15.6 %
Small combustion	-0.6 Tg	-6.7 %

1) Refers to non-adjusted data.

2) Includes adjustments for temperature variations and electricity trade for 1990 and 1998. If only adjustments for electricity trade in 1990 were taken into account the trend from 1990 to 1998 would be – 0.3% for greenhouse gas emissions (or 8.1 points above the linear target path for 2008-2012) and +1.6% for CO<sub>2</sub> (or 5.6 points above the linear target path for 2000).

#### 4.1.4. Finland

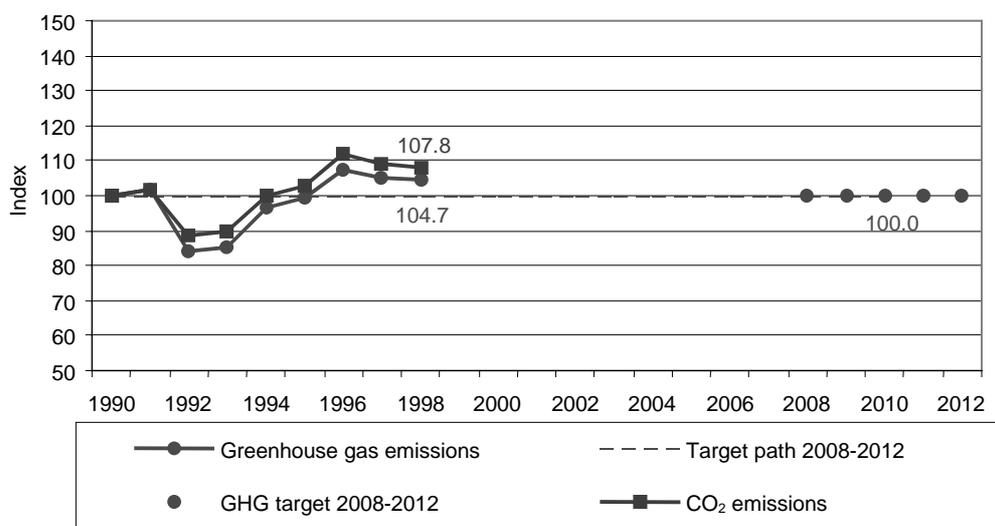
##### Actual progress in Finland

In the EC burden sharing arrangement, Finland agreed to stabilise its greenhouse gas emissions by 2008-2012. In 1998, greenhouse gas emissions were 76 Tg. This was 4.7 % (3.4 Tg) above 1990 levels and 4.7 index points above the target path for 2008-2012 (Figure 25). Finland accounted for 1.9 % of EU15 greenhouse gas emissions in 1998.

For CO<sub>2</sub> emissions, Finland's target is to stop increases of CO<sub>2</sub> emissions from energy production and use by the end of the 1990s. As this target is not quantified, actual CO<sub>2</sub> emissions can not be compared with a CO<sub>2</sub> target path for 2000. In 1998, CO<sub>2</sub> emissions were 64 Tg, which was 7.8 % (4.7 Tg) above 1990 levels.

The data used in this report is consistent with the data collected under the EC Monitoring Mechanism and submitted by the Member States to the European Commission by 1 April 2000. As Finland has revised its inventory slightly between 1 April 2000 and 15 April, minor differences between the data used in this report and the Finnish submission to the UNFCCC secretariat might occur.

**Figure 25: Finnish greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

##### Greenhouse gas emission trends

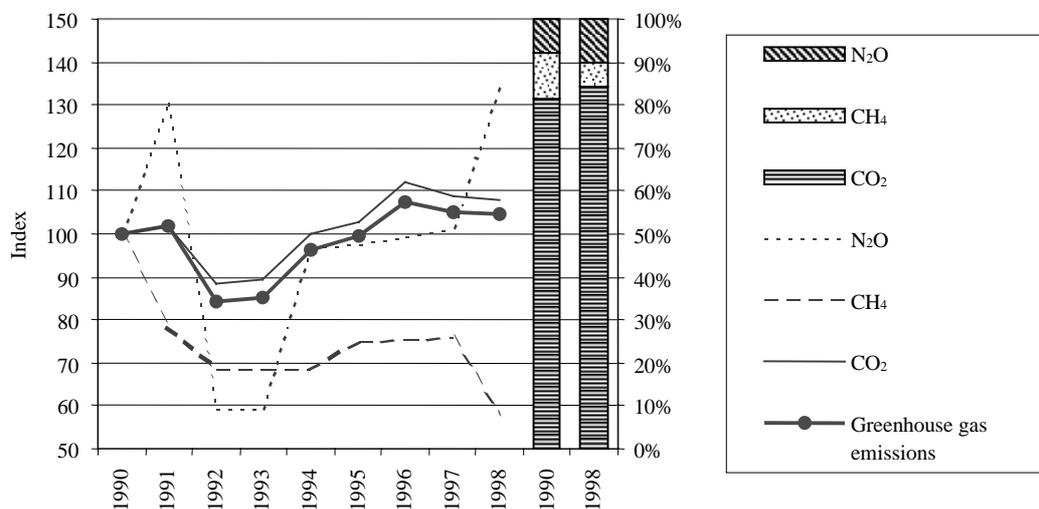
The share of CO<sub>2</sub> emissions in greenhouse gas emissions grew from 81.7 % in 1990 to 84.1 % in 1998. N<sub>2</sub>O emissions were second with a share of 10.2 % in 1998, up 2.3 percentage points from 1990. CH<sub>4</sub> emissions accounted for 5.7 % of total Finnish greenhouse gas emissions in 1998, down 4.7 percentage points from 1990.

However, data on greenhouse gas time series has to be regarded with care as for Finland no consistent time series exists. This might be one reason for high fluctuations of N<sub>2</sub>O emissions illustrated in Figure 26.

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions decreased by 42.1 % (3.2 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. Main sources are waste and agriculture. Waste reduced its share in CH<sub>4</sub> emissions from 67 % in 1990 to 47.4 % in 1998. In contrast to this, CH<sub>4</sub> emissions from agriculture – although declining in absolute terms – increased their share from 26.2 % in 1990 to 39.2 %.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions grew by 33.9 % (2 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. Agriculture is the main N<sub>2</sub>O emitter accounting for 51.5 % of total N<sub>2</sub>O emissions in 1998, down 2.8 percentage points from 1990. Fuel combustion was second with a share of 32.2 % in 1998, up 2.7 percentage points from 1990.

**Figure 26: Finnish greenhouse gas emissions (excl. LUCF)**



Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

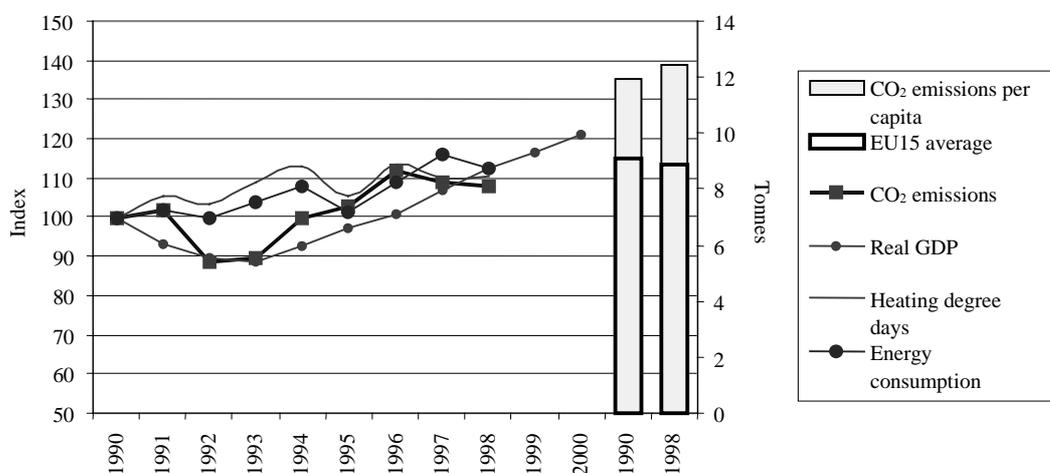
### *CO<sub>2</sub> emission trends and driving forces*

Finland is the coldest EU Member State. This is one reason for the highest CO<sub>2</sub> emissions per capita (together with Belgium). Having increased by 4.2 % since 1990, CO<sub>2</sub> emissions were 12.4 tonnes per inhabitant in 1998 (Figure 27).

The CO<sub>2</sub> emission curve of Finland reflects economic growth patterns: in the early 1990s, a severe recession hit the country leading to reductions of economic activity and CO<sub>2</sub> emissions of more than 10 % compared to 1990 levels. In 1994, the economy recovered and the second half of the 1990s viewed sustained economic growth. Accordingly, CO<sub>2</sub> emissions increased whereas in recent years variations seem to be closer to temperature variations.

Gross inland energy consumption did not decline in the early 1990s but showed a pattern very close to the temperature variation. By 1998, energy consumption and real GDP were 12.5 % and CO<sub>2</sub> emissions were 7.8 % above 1990 levels. Therefore, CO<sub>2</sub> emissions per GDP declined to 536 kg per 1000 ECU, which was slightly below EU15 average (545 kg).

**Figure 27: Finnish CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were obtained from the Finnish Environment Institute.

### *Sectoral breakdown of CO<sub>2</sub> emissions*

About 87 % of Finnish CO<sub>2</sub> emissions come from fossil fuel combustion. Within fossil fuel combustion, CO<sub>2</sub> emissions grew in all sectors but small combustion between 1990 and 1998 (Figure 28). In general, a shift from small combustion and transport to energy industries can be observed.

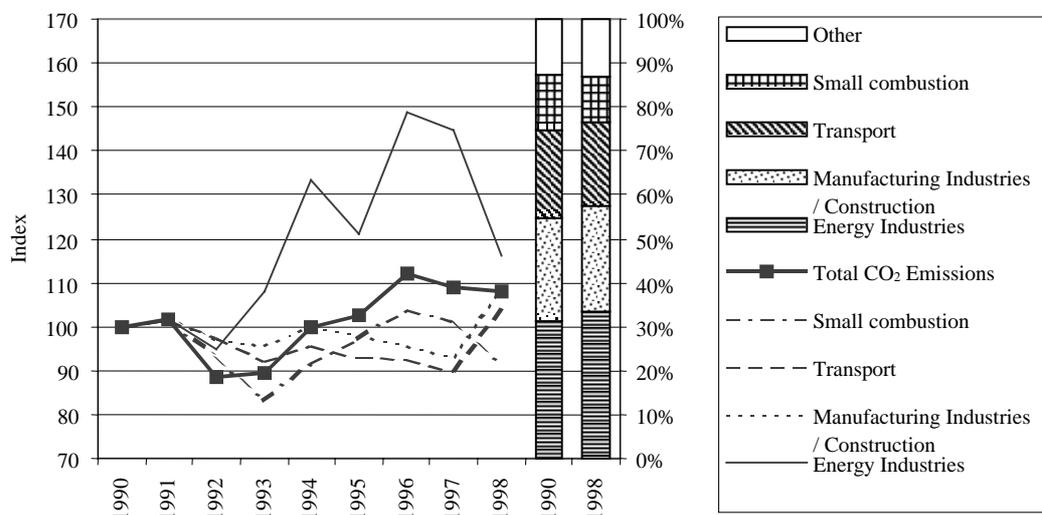
**Energy industries:** The energy industry is the largest emitter of CO<sub>2</sub> emissions increasing its share from 31 % in 1990 to 33.4 % in 1998. In absolute terms, CO<sub>2</sub> emissions from energy industries increased by 3 Tg (16.3 %) from 1990 to 1998. The peak was in 1996, when CO<sub>2</sub> emissions from public electricity and heat production were almost 50 % higher than in 1990. As 1996 was an unusually cold and dry year in the Nordic region, electricity production from hydro power plants decreased and coal fired power production reached record high levels.

**Manufacturing industries:** The second largest emitting sector is the industry with a share in total CO<sub>2</sub> emissions of 23.9 %. In absolute terms, CO<sub>2</sub> emissions from manufacturing industries grew by 1.2 Tg between 1990 and 1998. The relatively high share of manufacturing industries in total CO<sub>2</sub> emissions reflects the importance of highly energyintensive primary industries in Finland, such as wood products, pulp and paper, and metals.

**Transport:** CO<sub>2</sub> emissions from transport grew by 0.4 Tg or 3.4 % between 1990 and 1998. Apart from Luxembourg, this was the slowest growth among EC Member States. Fuel consumption by road transport decreased slightly (-0.8 %) between 1990 and 1997. Road passenger transport increased by 0.6 % (EC, 1999). One reason for exceptional low growth rates of road transport might be that in Finland prices of private car use rose almost parallel with real disposable income. In other EC Member States, disposable income grew at a faster pace than prices of car use thus reducing road transport prices in real terms (EEA, 2000b).

**Small combustion:** The share of CO<sub>2</sub> emissions from small combustion declined from 12.3 % in 1990 to 10.4 % in 1998. In absolute terms, CO<sub>2</sub> emissions decreased by 0.6 Tg between 1990 and 1998.

**Figure 28: Sectoral CO<sub>2</sub> emissions of Finland (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### *Energy supply, by fuel*

Gross inland energy consumption increased by 16.2 % from 1990 to 1997. Per capita energy consumption is the highest among EC Member States (apart from Luxembourg): it has increased from 5.7 toe in 1990 to 6.4 toe in 1997 (EU average in 1997: 3.8 toe). Energy intensity of GDP increased from 268 toe per MECU in 1990 to 292 toe in 1997 (EU15 average: 237 toe).

In 1997, the share of fossil fuels in gross inland consumption was 61 %. Renewable energies (biomass and hydro power) accounted for 20.2 % of gross inland energy consumption, nuclear power for 16.3 % (Figure 29)<sup>8</sup>.

**Oil:** Oil is the largest energy source with a share of 30.2 % in gross inland consumption in 1998, down 4.7 percentage points. About 45 % of oil inland consumption is used by transport. Small combustion and non-energy use account for about 25 % and 15 % respectively.

**Solid fuels:** The breakdown of gross inland consumption by fuel type reveals that in Finland, in contrast to most other EC Member States, the consumption of solid fuels increased substantially in recent years. Between 1990 and 1997, the use of solid fuels increased by 43.5 % and their share in energy consumption rose from 17.8 % in 1990 to 22 % in 1997<sup>9</sup>. This was mainly due to increases in coal-fired electricity production.

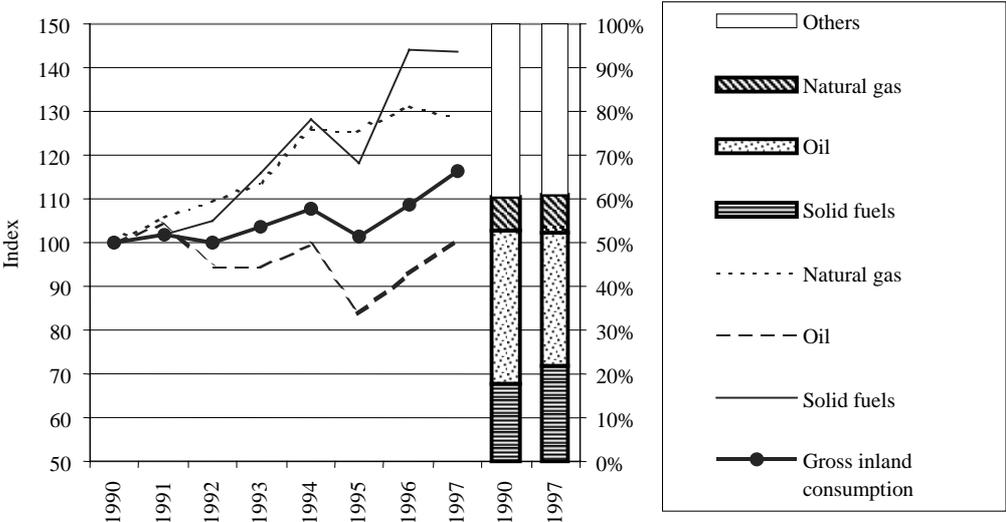
<sup>8</sup> Finland is a considerable net electricity importer. Net imports of electricity increase gross inland energy consumption, so the shares of fossil fuels, renewables and nuclear power do not add up to 100 %.

<sup>9</sup> Note, that Finland is a substantial peat producer and peat is included in solid fuels. According to IEA (1999a), peat contributed 6.2 % to total primary energy supply in 1997.

**Natural gas:** Natural gas consumption accounted for 8.8 % of gross inland consumption in 1997, but increased substantially. About 56 % of natural gas consumption was used in power stations, industry use accounted for 36 % of inland market consumption.

**Renewable energies:** Renewable energy consumption increased by 26.7 % between 1990 and 1997. Biomass increased its share in gross inland energy consumption from 15.2 % in 1990 to 17 % in 1997, which is the highest share of all EC Member States. Hydro power stabilised its share in gross inland energy consumption at around 3.2 %.

**Figure 29: Finnish gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include nuclear power, renewable energy sources and net electricity imports.

High energy use due to cold climate and energy intensive industries led Finland to implement energy efficiency measures very early. Building codes requiring effective insulation came into force in the 1960s, and a requirement for triple glazing for all new buildings was adopted in the 1970s. Finland also has one of the largest shares of combined heat and power production (CHP) and district heating in the EC: one third of electricity is produced in CHP plants, and 50 % of the building stock is connected to the district heating network. In addition, Finland was the first country to introduce a CO<sub>2</sub> tax in 1990 (IEA, 1999a).

**Electricity generation**

Gross electricity generation per capita increased by 23.3 % from 10,934 kWh in 1990 to 13,478 kWh in 1997. Per capita power production was more than double of the EU15 average of 6,483 kWh; only Sweden's per capita electricity generation was higher. In addition, growth was almost 10 percentage points above EU15 average growth.

In 1997, coal, gas and oil accounted for about 40 % of Finnish electricity production (27.8 % coal, 10 % gas, 2 % oil). In 1996, more than 30 % of power production came from coal, whereas in 1990 (an unusual wet and mild year) the share of coal was only 18.5 %. Gas has increased slightly from 8.6 % in 1990 to

10 % in 1997, whereas power generation from petroleum products decreased from 3.1 % to 2 %.

In 1997, 30.2 % of gross electricity was produced in the two Finnish nuclear power plants and 17.7 % came from hydro power plants. A striking feature of the Finnish electricity production is the high share of biomass combustion which accounted for 10.1 % of total electricity generation in 1997. In addition, Finland is a significant electricity importer.

***Summary on actual progress for Finland***

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	No target	☹
	Variations 1990/1998 in Tg of CO <sub>2</sub> equivalents and percent	
Greenhouse gases	+3.4 Tg	+4.7 %
CH <sub>4</sub>	-3.2 Tg	-42.1 %
N <sub>2</sub> O	+2.0 Tg	+33.9 %
CO <sub>2</sub>	+4.7 Tg	+7.8 %
Energy industries	+3.0 Tg	+16.3 %
Manufacturing industries	+1.2 Tg	+8.4 %
Transport	+0.4 Tg	+3.4 %
Small combustion	-0.6 Tg	-8.8 %

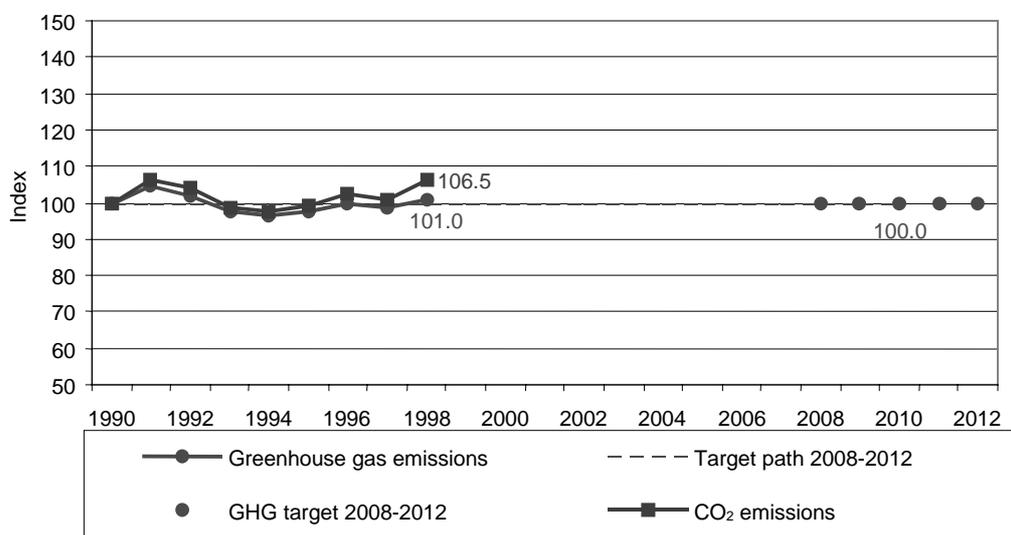
#### 4.1.5. France

##### *Actual progress in France*

In the burden sharing agreement, France agreed to stabilise greenhouse gas emissions at 1990 levels by 2008-2012. In 1998, French greenhouse gas emissions were 543.7 Tg, which was 1 % (5.2 Tg) above 1990 levels and the target path for 2008-2012 (Figure 30). If industrial F-gases are included, French greenhouse gas emissions increased by 0.9 % between 1990 and 1998. France accounted for 13.4 % of EU15 greenhouse gas emissions in 1998.

In 1998, CO<sub>2</sub> emissions were 412.9 Tg, which was 6.5 % (25.3 Tg) above 1990 levels. Per capita emissions of carbon dioxide increased slightly from 1990 to 1998.

**Figure 30: French greenhouse gas emissions compared with targets for 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

##### *Greenhouse gas emission trends*

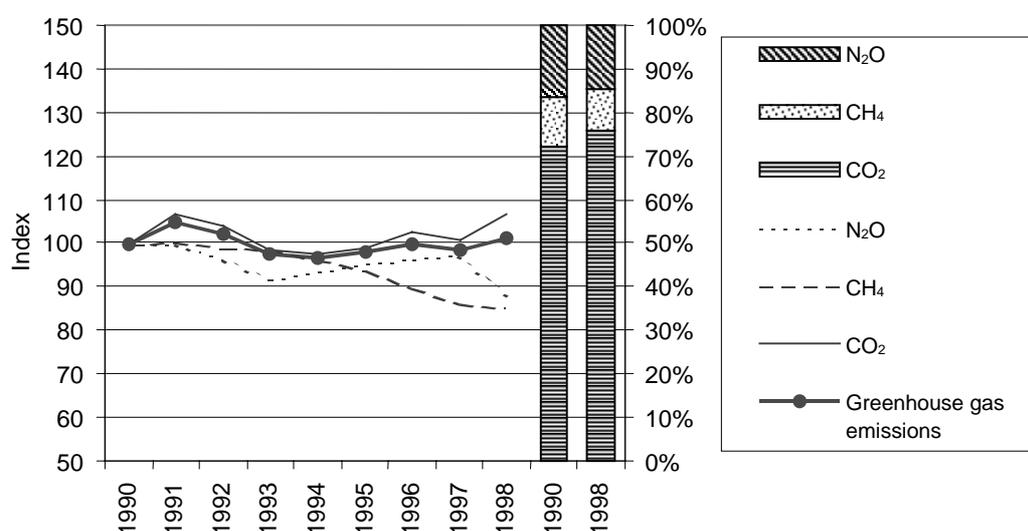
The breakdown of greenhouse gases illustrates a comparatively high share of N<sub>2</sub>O emissions and relative low share of CO<sub>2</sub> emissions (Figure 31). This is mainly due to high reliance on nuclear power and the relative importance of agriculture. CO<sub>2</sub> emissions increased their share in greenhouse gas emissions from 72 % in 1990 to 75.9 % in 1998. N<sub>2</sub>O emissions were second but their share decreased from 16.6 % in 1990 to 14.5 % in 1998. CH<sub>4</sub> emissions accounted for 9.6 % in 1998, down 1.8 percentage points from 1990.

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions declined almost steadily and were 15 % (9.2 Tg of CO<sub>2</sub> equivalents) below 1990 levels in 1998. The main source is agriculture which – although declining in absolute terms – increased its share in CH<sub>4</sub> emissions from 55.8 % in 1990 to 61.8 % in 1998. The second source is waste with a share of 22.1 % in 1998, down 5.9 percentage points from 1990.

**N<sub>2</sub>O emissions:** After declining between 1990 and 1993 and increasing between 1994 and 1997, N<sub>2</sub>O emissions declined sharply in 1998 and were 12.2 % (10.9 Tg of CO<sub>2</sub> equivalents) below 1990 levels in that year. Emissions from agriculture accounting for the bulk of N<sub>2</sub>O emissions almost stabilised in absolute terms.

Therefore, the share of agriculture in N<sub>2</sub>O emissions increased from 62.9 % in 1990 to 69.8 % in 1998. The second source was industrial processes with a share of 20.5 % in N<sub>2</sub>O emissions in 1998, down 10.5 percentage points from 1990. This was due to reduction measures in the adipic acid production. As in many Member States, N<sub>2</sub>O emissions from transport show a large increase between 1990 and 1998 (+136.8 %), but accounted for a small share (3.7 %) in 1998.

**Figure 31: French greenhouse gas emissions (excl. LUCF)**



Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

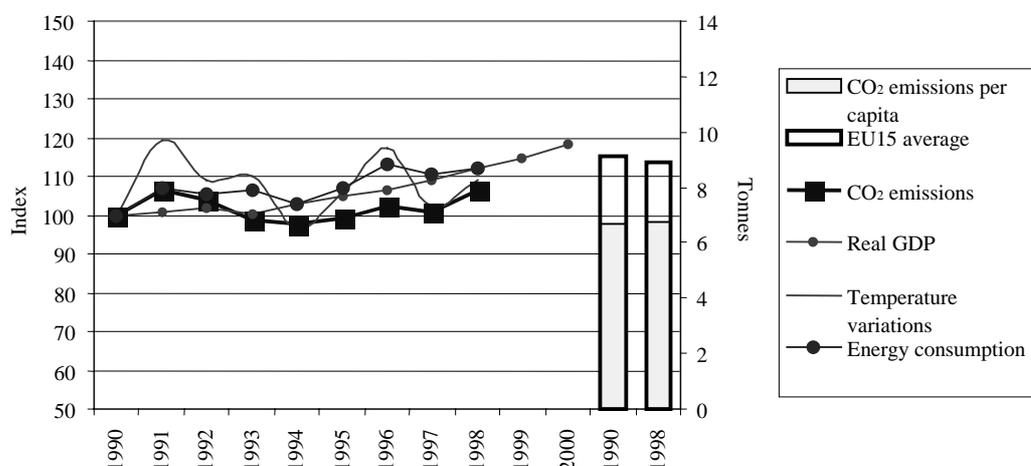
### ***CO<sub>2</sub> emission trends and driving forces***

With the marked increase of 5.6 % compared to 1997, In 1998 CO<sub>2</sub> emissions reached their highest level in the 1990s being slightly higher than 1991 (Figure 32). Economic growth and climatic circumstances (implying increased use of thermal power) seem to be considerable driving forces. Apart from 1998, CO<sub>2</sub> emissions peaked in 1991 and 1996 (the two coldest years) and showed their lowest values in 1994 (a very warm year).

As real GDP and gross inland energy consumption rose by 12.3 % and 12.2 % respectively between 1990 and 1998, energy intensity of GDP has not improved. However, as CO<sub>2</sub> emission growth fell below both, carbon intensities of GDP and of energy consumption has improved to some extent.

The French population increased by 4.8 % from 1990 to 1998, thus CO<sub>2</sub> emissions per capita (excluding emissions from LUCF) rose slightly from 6.6 to 6.8 tonnes per inhabitant staying well below EU15 average of 8.9 tonnes.

**Figure 32: French CO<sub>2</sub> emissions and driving forces (real GDP growth, temperature variation, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note (1): The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; data on temperature variation were taken from the French submission under the Monitoring Mechanism.

Note (2): French data on greenhouse gas emissions submitted under the Monitoring Mechanism includes data for overseas territories. This may lead to inconsistencies with GDP and energy consumption data from Eurostat. However, a distortion of overall trends is not expected.

### **Sectoral breakdown of CO<sub>2</sub> emissions**

More than 93 % of French CO<sub>2</sub> emissions come from fossil fuel combustion. Within fossil fuel combustion, CO<sub>2</sub> emissions from manufacturing industries stabilised, all other sectors increased between 1990 and 1998 (Figure 33). In general, a shift from manufacturing and energy industries to transport and small combustion can be observed.

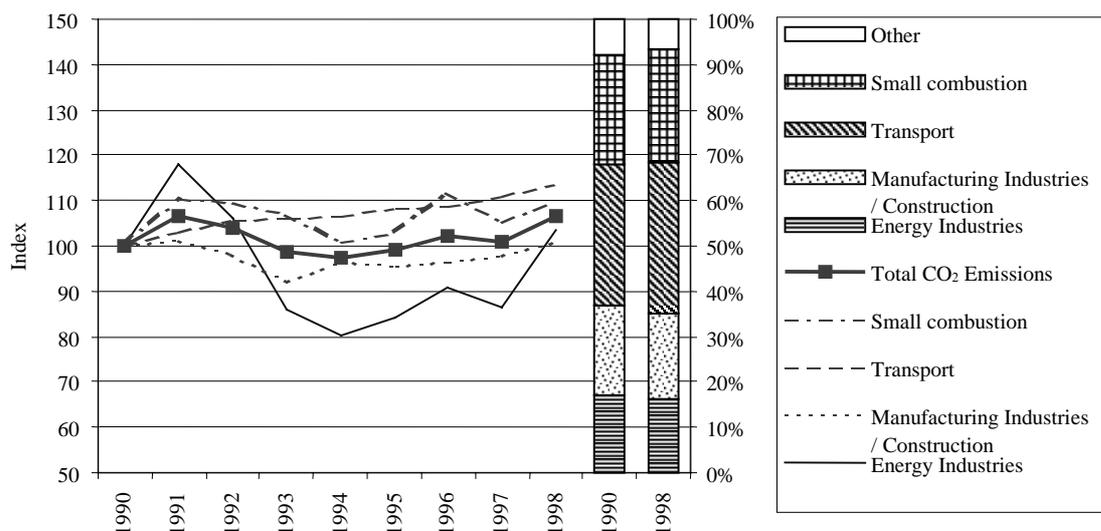
**Energy industries:** The sectoral breakdown of CO<sub>2</sub> emissions reveals that emissions from energy industries show high fluctuations (Figure 33), but its share is rather small (due to large nuclear power production). After a sharp rise in 1991, CO<sub>2</sub> emissions in the energy industries fell by almost one third until 1994. By 1998, they were again 3.6 % (2.4 Tg) above 1990 levels with a sharp increase in 1998. According to monthly Eurostat data, this was mainly due to a substantial rise in hard coal fired power production in 1998. As the share of the energy industry in total CO<sub>2</sub> emissions in France is relatively low (16.4 % in 1998), the influence of these fluctuations is not as dominant as in other Member States.

**Transport:** Transport is the largest CO<sub>2</sub> emitter in France growing considerably between 1990 and 1998 (by 16.7 Tg or 13.8 %). Therefore, transport's share in total CO<sub>2</sub> emissions increased from 31.3 % in 1990 to 33.4 % in 1998. In 1997, the car ownership ratio was 478 passenger cars per 1000 inhabitants which was above the EU15 average of 454. Growth rates of passenger and freight road transport are not far from EU15 average, but car use seems to be high in France: in 1997, the French travelled 11,691 km per person, which is third in EU15 and about 15 % above EU15 average (EC, 1999).

**Small combustion:** Small combustion is the second largest emitter in France accounting for 25 % of CO<sub>2</sub> emissions in 1998, up 0.7 percentage points from 1990. In absolute terms, CO<sub>2</sub> emissions from small combustion increased by 9 Tg between 1990 and 1998. Temperature variations seem to have some influence on CO<sub>2</sub> emissions from this sector.

**Manufacturing industry:** CO<sub>2</sub> emissions from manufacturing industries grew by 0.5 Tg. Due to this very small growth, industry's share in total CO<sub>2</sub> emissions decreased by 1 percentage point to 18.8 % in 1998.

**Figure 33: Sectoral CO<sub>2</sub> emissions of France (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### **Energy supply, by fuel**

Gross inland energy consumption grew by 10.6 % from 1990 to 1997. Per capita energy consumption increased slightly from 3.9 toe in 1990 to 4.1 toe in 1997 (EU15 average 3.8 toe).

The most important energy sources are nuclear power and oil. Energy mix has shifted from oil and coal to nuclear power and gas. The special feature of French energy supply is the high share of nuclear power: between 1990 and 1997, nuclear power grew by 24.8 % and increased its share in gross inland consumption from 36.1 % to 40.7 %.

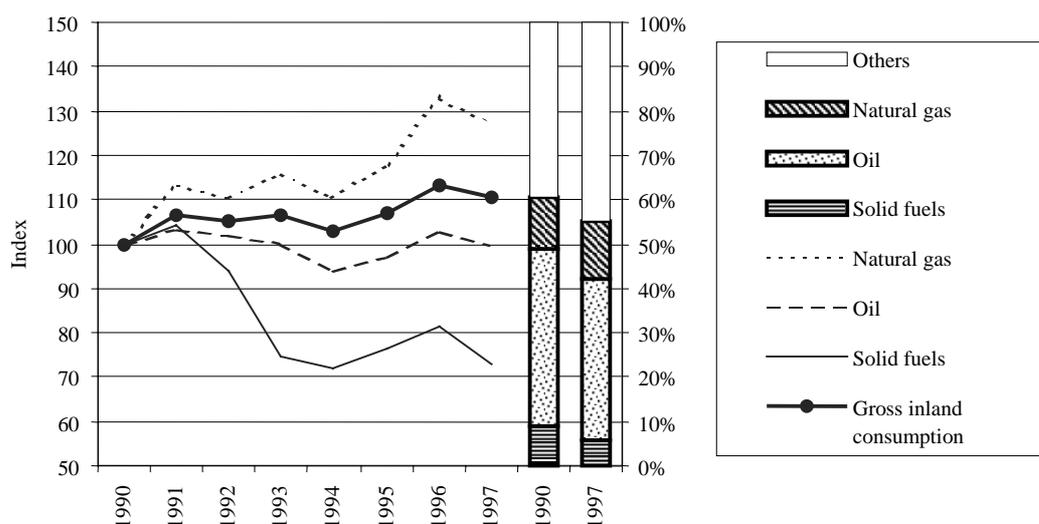
**Oil:** Oil is the second energy source in France. Having stabilised in absolute terms between 1990 and 1997, the share of oil decreased from 40 % in 1990 to 36.1 % in 1997 (Figure 34). More than 50 % of oil inland market consumption is used in transport. Small combustion and non-energy use account for about 20 % and 18 % of oil inland market consumption.

**Natural gas:** Gas consumption increased by 27.3 % enlarging its share from 11.2 % in 1990 to 12.9 % in 1997. Especially the use of natural gas in power stations grew rapidly. In absolute terms, however, power generation in gas fired power stations is small.

**Solid fuels:** The use of solid fuels declined by 26.9 % and their share in total energy consumption decreased from 9.1 % in 1990 to 6 % in 1997. About 40 % of gross inland hard coal consumption is used in power stations, 35 % in coking plants and 22 % in industry.

**Renewable energies:** Renewable energies increased by 13.3 % between 1990 and 1997 and accounted for 6.6 % of gross inland energy consumption in 1997. About two thirds of renewable use is biomass, one third is hydro power.

**Figure 34: French gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include nuclear power, renewable energy sources and net electricity imports.

### **Electricity generation**

Electricity generation in France is at a high level and growth rates are above EU15 average: in 1997, per capita electricity production was at 8,620 kWh, which was one third higher than EU15 average of 6,483 kWh. Gross electricity generation has increased by 20.1 % from 1990 to 1997, which also was above the EU15 average growth of 17.5 %.

The French power market is characterised by a high share of nuclear power: in 1997, 78.4 % of gross electricity generation was produced in nuclear power plants, which was by far the largest share of EC Member States. Second is hydro power with a share of 13.5 %. Therefore, thermal power production plays only a minor role in France. Its share has decreased from 11.4 % in 1990 to 8.1 % in 1997. Coal and lignite fired power production declined to 4.4 % of total electricity generation in 1997, whereas the share of gasfired power production increased to 1 %.

The nuclear power strategy has been implemented in the 1970s and 1980s in order to reduce the import dependency of the French energy system (although relying mostly on imported uranium). France's endowment with fossil fuels is limited; the production of oil and gas has never attained high levels and the output of coal was falling in line with the closure of uneconomic mines.

However, a CO<sub>2</sub> relevant disadvantage of the pronounced electricity strategy was the promotion of electric space heating, because a significant part of electricity in

winter is produced from fossil fuels. The use of fossil fuels in thermal power plants is less efficient than the direct use of fossil fuels for space heating.

A second feature of the French energy system is the importance of France as the largest electricity exporter in the EU. In 1997, net electricity exports were about 65 TWh, which were almost 14 % of total net generation in France. The largest importing countries are Italy, the United Kingdom and the Netherlands. In contrast to Denmark, France mainly exports base load electricity produced in nuclear power plants. Therefore, net exports do not fluctuate so much and the impact of net electricity exports on CO<sub>2</sub> emissions is limited.

***Summary on actual progress for France***

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	No target	☺
	Variations 1990/1998 in Tg of CO <sub>2</sub> equivalents and percent	
Greenhouse gases	+5.2 Tg	+1.0 %
CH <sub>4</sub>	-9.2 Tg	-15.0 %
N <sub>2</sub> O	-10.9 Tg	-12.2 %
CO <sub>2</sub>	+25.3 Tg	+6.5 %
Energy industries	+2.4 Tg	+3.6 %
Manufacturing industries	+0.5 Tg	+0.7 %
Transport	+16.7 Tg	+13.8 %
Small combustion	+9.0 Tg	+9.6 %

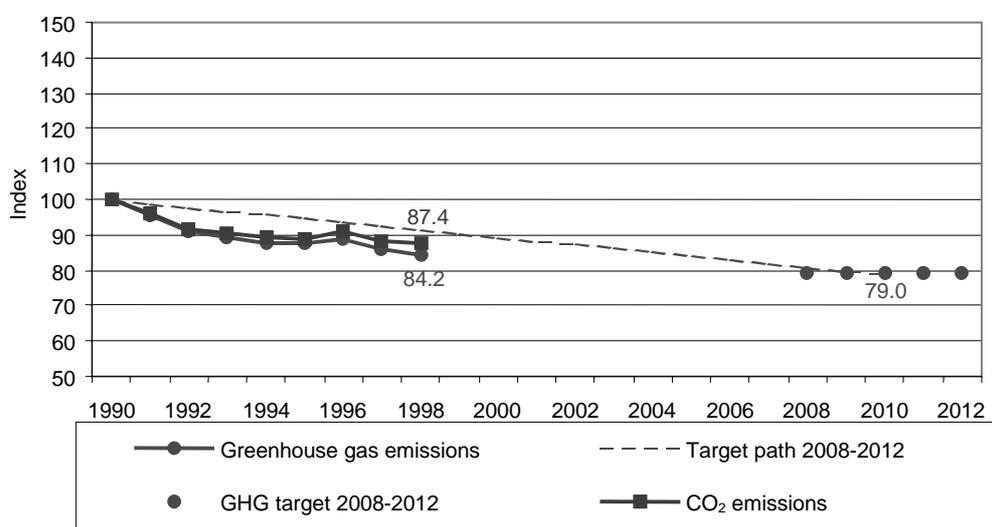
#### 4.1.6. Germany

##### Actual progress in Germany

In the burden sharing agreement, Germany agreed to a 21 % reduction of greenhouse gas emissions by 2008-2012. In 1998, greenhouse gas emissions were 1,011.7 Tg. This was 15.8 % (189.5 Tg) below 1990 levels and 7.4 index points below the linear target path for 2008-2012 (Figure 35). If industrial F-gases are included, German greenhouse gas emissions decreased by 15.5 % between 1990 and 1998. Germany accounted for 25 % of EU15 greenhouse gas emissions in 1998.

In 1998, CO<sub>2</sub> emissions were 886.5 Tg. This was 12.6 % (128 Tg) below 1990 levels. Germany has no CO<sub>2</sub> emission reduction target for 2000.

**Figure 35: German greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

##### Greenhouse gas emission trends

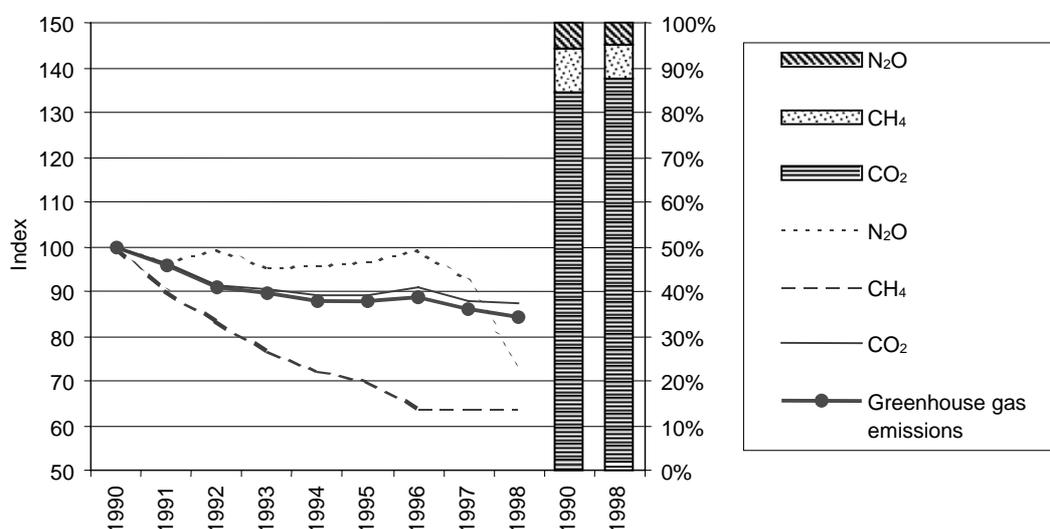
Figure 36 illustrates that all three greenhouse gases considered in this report declined, but CO<sub>2</sub> emissions less than the other two gases. Accordingly, the share of CO<sub>2</sub> in greenhouse gas emissions rose from 84.5 % in 1990 to 87.6 % in 1998. The share of CH<sub>4</sub> in greenhouse gas emissions declined from 9.7 % in 1990 to 7.4 % in 1998. N<sub>2</sub>O emissions accounted for 5 % of German greenhouse gas emissions in 1998, down 0.8 percentage points from 1990.

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions declined substantially by 36.2 % (42.3 Tg of CO<sub>2</sub> equivalents) between 1990 and 1996 and then stabilised. Agriculture is the largest source of CH<sub>4</sub> emissions in Germany accounting for 44.2 % of CH<sub>4</sub> emissions in 1998, up 10.1 percentage points from 1990. Second are fugitive emissions from fuels accounting for 32.5 % of CH<sub>4</sub> emissions in 1998, up 4.5 percentage points

from 1990. CH<sub>4</sub> emissions from waste decreased by more than 60 % in absolute terms. Therefore, waste's share in CH<sub>4</sub> emissions decreased by 13.2 percentage points to 20.8 % in 1998.

**N<sub>2</sub>O emissions:** German N<sub>2</sub>O emissions were almost stable until 1996, but then declined sharply and were 27.5 % (19.1 Tg of CO<sub>2</sub> equivalents) below 1990 levels in 1998. Agriculture is the largest source of N<sub>2</sub>O emissions accounting for 51.6 % of N<sub>2</sub>O emissions in 1998, up 8.9 percentage points from 1990. Fuel combustion accounted for 24.5 % of N<sub>2</sub>O emissions in 1998, up 8.2 percentage points from 1990. Especially emissions from transport increased sharply but levelled in recent years. N<sub>2</sub>O emissions from industrial processes declined sharply in 1998 after new N<sub>2</sub>O emission reduction methods were introduced in two adipic acid plants. Accordingly, the share of industrial processes in N<sub>2</sub>O emissions declined from 36.5 % in 1990 to 17.8 % in 1998.

**Figure 36: German greenhouse gas emissions (excl. LUCF)**



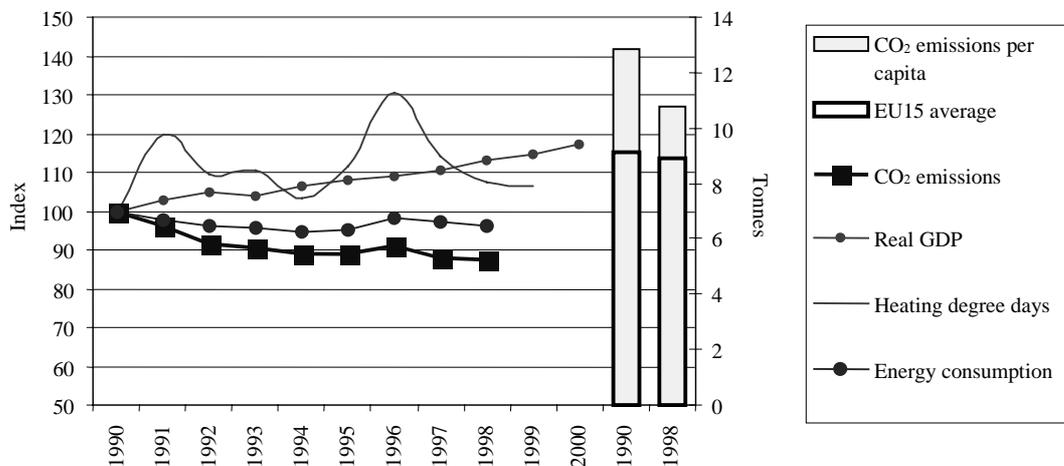
Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

### ***CO<sub>2</sub> emission trends and driving forces***

Germany has experienced a 12.6 % reduction of CO<sub>2</sub> emissions since 1990, despite of a 13 % growth of real GDP. As gross inland energy consumption decreased by 3.9 %, both, energy and carbon intensity of the economy improved substantially. The carbon intensity in terms of CO<sub>2</sub> emissions per GDP has decreased from 858 kg per 1000 ECU to 593 kg, which was still above EU15 average (545 kg). CO<sub>2</sub> emissions per capita went down from 12.8 to 10.8 tonnes also approaching EU average (Figure 37).

The decoupling of energy consumption and CO<sub>2</sub> emissions from economic growth is mainly due to the restructuring of the energy supply system and the industry after German unification. After the German unification, uneconomic lignite production and subsidies on energy prices were strongly reduced. This led to declining use of lignite in power production and industry and substantial improvements in energy efficiency. However, the pace of CO<sub>2</sub> emission reduction has slowed down since 1993.

**Figure 37: German CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were obtained from Eurostat.

The CO<sub>2</sub> emission reductions have been achieved almost entirely in the new Länder, where per capita CO<sub>2</sub> emissions were cut by about 40 % between 1990 and 1995 (the last year for which separate data exists), whereas only slight reductions have been achieved in the old Länder (UBA, 1999). Similarly, energy intensity in terms of primary energy consumption per GDP has been reduced by almost 40 % in the new Länder compared to a decrease of 4 % in the old Länder. Nevertheless, the energy intensity of the new Länder was still almost 80 % above the level of the old Länder in 1995, which suggests scope for further efficiency improvements (Boeckem, 1999).

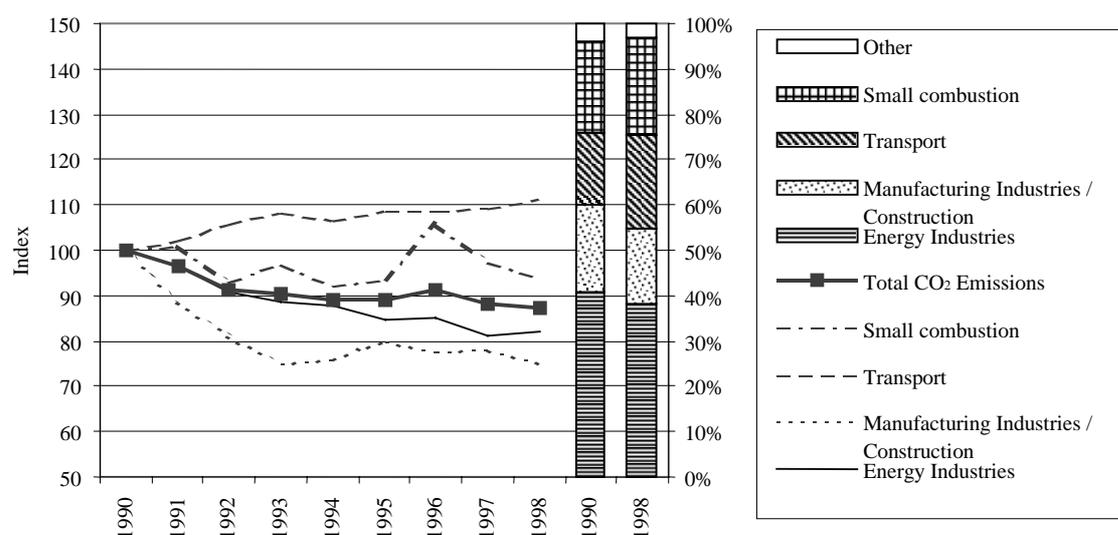
#### *Sectoral breakdown of CO<sub>2</sub> emissions*

About 97 % of German CO<sub>2</sub> emissions come from fossil fuel combustion. Within fossil fuel combustion, CO<sub>2</sub> emissions from all sectors but transport decreased between 1990 and 1998 (Figure 38). In general, a shift from manufacturing and energy industries to transport and small combustion can be observed.

**Energy industries:** In 1998, the energy supply sector has been the largest CO<sub>2</sub> emitter in Germany with a share of 38.2 % having slightly reduced from 40.7 % in 1990. The main reason for this high share is the large reliance of German electricity production on solid fuels. In absolute terms, however, CO<sub>2</sub> emissions from energy industries decreased by 74 Tg (17.9 %). The main reason for this were efficiency improvements in coal fired electricity production. Germany reduced lignite consumption in power stations by about 24 % between 1990 and 1997, but increased power production from lignite by 74.5 %.

**Small combustion:** The second largest emitter was small combustion which accounted for 21.6 % of total CO<sub>2</sub> emissions in 1998, up 1.5 percentage points from 1990. In absolute terms, CO<sub>2</sub> emissions from small combustion decreased by 12.3 Tg (6 %) between 1990 and 1998. Temperature variations influence considerably on this sector's emissions.

**Figure 38: Sectoral CO<sub>2</sub> emissions of Germany (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

**Manufacturing industries:** Emissions from manufacturing industries and construction decreased substantially by 25 % (49.1 Tg) mainly due to the economic restructuring in the new Länder and associated large improvements of energy efficiency. Therefore, the share of industry in total CO<sub>2</sub> emissions declined from 19.4 % in 1990 to 16.6 % in 1998. Figure 38 illustrates that all reductions were achieved by 1993; since then CO<sub>2</sub> emissions stabilised.

**Transport:** The only growing sector in absolute terms has been transport (+18.5 Tg). As a consequence, the transport share increased sharply from 16 % in 1990 to 20.4 % in 1998. However, it has to be noted that three quarters of the increase in the transport sector took place until 1993; since then growth has slowed down. Fuel consumption by road transport increased by 8.6 % between 1990 and 1997. According to EC (1999), passenger road transport grew by 8.4 %, but road haulage showed a large increase of 65.1 % between 1990 and 1997.

#### *Energy supply, by fuel*

Gross inland energy consumption has fallen by 3 % between 1990 and 1997. Energy consumption per capita decreased from 4.5 toe in 1990 to 4.2 in 1997 (EU15 average 3.8 toe). Figure 39 illustrates that in 1997, fossil fuels amounted for 85.8 % of German gross inland energy consumption (compared to 87.7 % in 1990).

**Oil:** Oil is the most important fossil fuel with a share of 39.9 % of energy consumption in 1997 and a growth rate of 10.5 %. About 47 % of oil inland market consumption was used for transport in 1997, second was small combustion with about 28 %.

**Natural gas:** In the 1990s, natural gas use grew at a fast pace (+29.3 %) increasing its share in gross inland consumption from 15.5 % in 1990 to 20.7 % in 1997. Especially growth of gas consumption in small combustion and power stations was high. Small combustion is the largest gas consumer in Germany accounting for

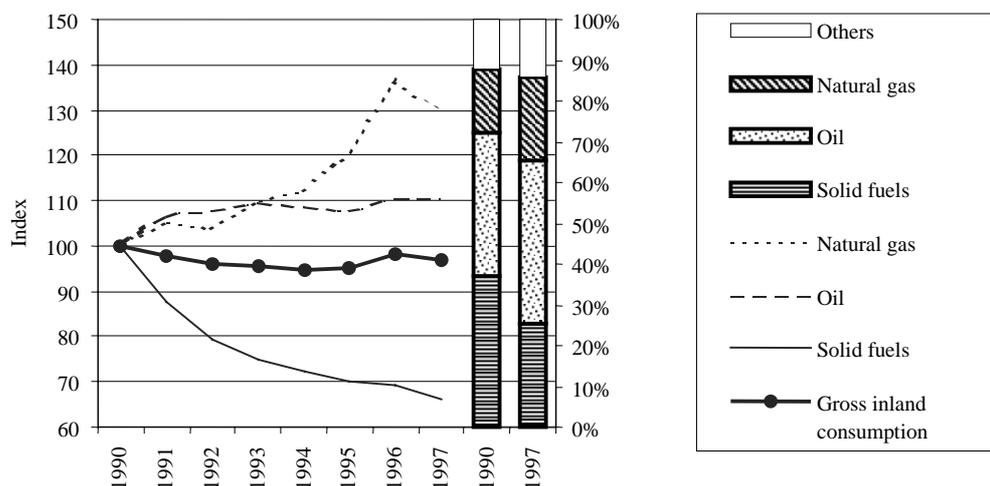
about 47 % of gas inland market consumption. Industry and power stations account for 27 % and 16 % of gas inland consumption respectively.

**Solid fuels:** Coal and lignite consumption declined by 34.1 %, but remain important especially for electricity production. Germany is the largest hard coal consumer and producer in the European Community and the largest lignite consumer and producer in the world: in 1997, 42 % and 67.8 % of EU15 hard coal and lignite primary production respectively were produced in Germany. As hard coal and lignite are substantial domestic fossil energy sources, they are seen as important contribution to reduce import dependency on fossil fuels. Besides, the coal industry is an important regional employer.

Costs of hard coal production are more than three times the price of imported coal, leading to heavy subsidisation of domestic hard coal production. In 1997, a law was issued to put a progressively reduced ceiling on hard coal subsidies for the period 1998-2005. In addition, hard coal subsidies have been made transparent (IEA, 1998c). In 1996, direct subsidies of hard coal amounted to more than 10 billion DM but are supposed to decline to 5.5 billion by 2005. Indirect subsidies, e.g. subsidies for miners' pension schemes, are supposed to be of the same magnitude (Boeckem, 1999).

**Renewable energies:** Renewable energies increased by 35.5 % between 1990 and 1997 and accounted for 2.3 % of gross inland energy consumption in 1997. Biomass (1.7 %) and hydro power (0.4 %) are the largest renewable energy sources, but other sources are increasing at a fast pace: wind power and solar energy increased by factors 42 and 8 respectively.

**Figure 39: German gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include nuclear power, renewable energy sources and net electricity imports.

### **Electricity generation**

Gross electricity generation grew by 21.6 % from 1990 to 1997 (EU15 average 17.5 %). Electricity generation per capita grew by 17.3 % to 6,725 kWh in 1997 and was close to EU15 average (6,483 kWh).

Most of the electricity is produced by thermal combustion: 64.8 % of electricity is generated in thermal power plants, 30.9 % is produced in nuclear power plants. Hydro and wind account for 4.3 %. However, the wind industry experienced rapid growth rates in recent years from 71 GWh in 1990 to 3,000 GWh in 1997.

Therefore, Germany has become the largest wind power producer in the EU accounting for more than 40 % of EU15 wind power production. The rise in wind power was triggered by direct subsidies and the Electricity Feed law, which obliged electricity companies to buy electricity from renewables at a premium.

Thermal electricity production increased by 27 % between 1990 and 1997, whereas overall fuel input decreased by 12 %. The efficiency improvements seem to have been achieved mainly in lignite fired power plants: electricity production from lignite increased by 74.5 % between 1990 and 1997, whereas lignite use in power stations declined by 24 %.

German thermal electricity generation still depends to a large extent on solid fuels. In 1997, almost 80 % of fuel inputs for thermal electricity production were hard coal (40.1 %) and lignite (39.7 %). Power production from hard coal increased slightly between 1990 and 1997, but lignite fired electricity production grew by 74.5 %. Natural gas contributed only 14 % to thermal electricity production but its importance is growing.

***Summary on actual progress for Germany***

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	No target	☺
	Variations 1990/1998 in Tg of CO <sub>2</sub> equivalents and percent	
Greenhouse gases	-189.5 Tg	-15.8 %
CH <sub>4</sub>	-42.3 Tg	-36.2 %
N <sub>2</sub> O	-19.1 Tg	-27.5 %
CO <sub>2</sub>	-128.0 Tg	-12.6 %
Energy industries	-74.0 Tg	-17.9 %
Manufacturing industries	-49.1 Tg	-25.0 %
Transport	+18.5 Tg	+11.4 %
Small combustion	-12.3 Tg	-6.0 %

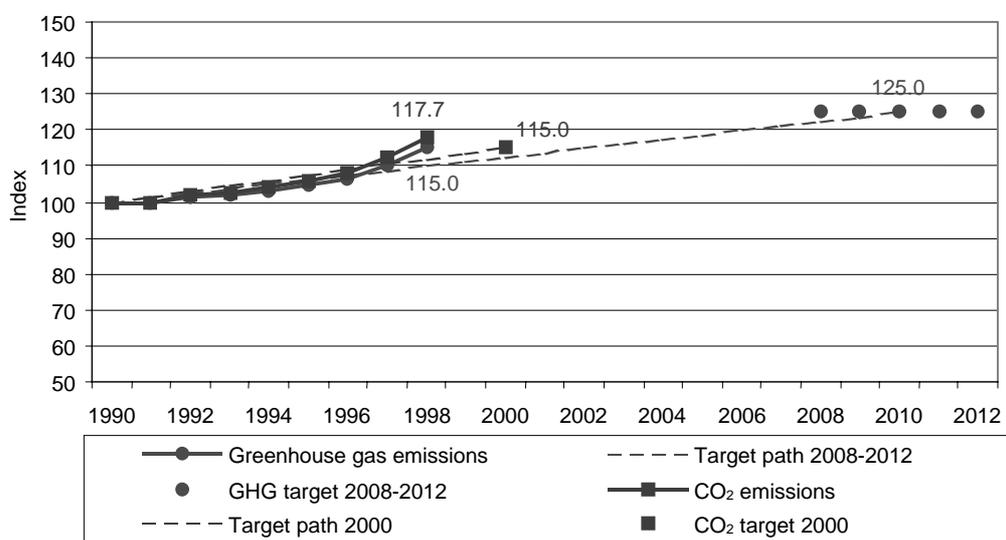
#### 4.1.7. Greece

##### *Actual progress in Greece*

In the burden sharing agreement, Greece agreed to limit its greenhouse gas emissions to a 25 % increase by 2008-2012. In 1998, Greek greenhouse gas emissions were 119.5 Tg. This was 15 % (15.6 Tg) above 1990 levels and 5 index points above the linear target path for 2008-2012 (Figure 40). Greece accounted for 3 % of EU greenhouse gas emissions in 1998.

For CO<sub>2</sub>, Greece aims at limiting emissions to a 15 % increase by 2000. In 1998, CO<sub>2</sub> emissions were 100.3 Tg, which was 17.7 % (15.1 Tg) above 1990 levels. This was equivalent to surpassing the CO<sub>2</sub> target path by 5.7 index points.

**Figure 40: Greek greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

##### *Greenhouse gas emission trends*

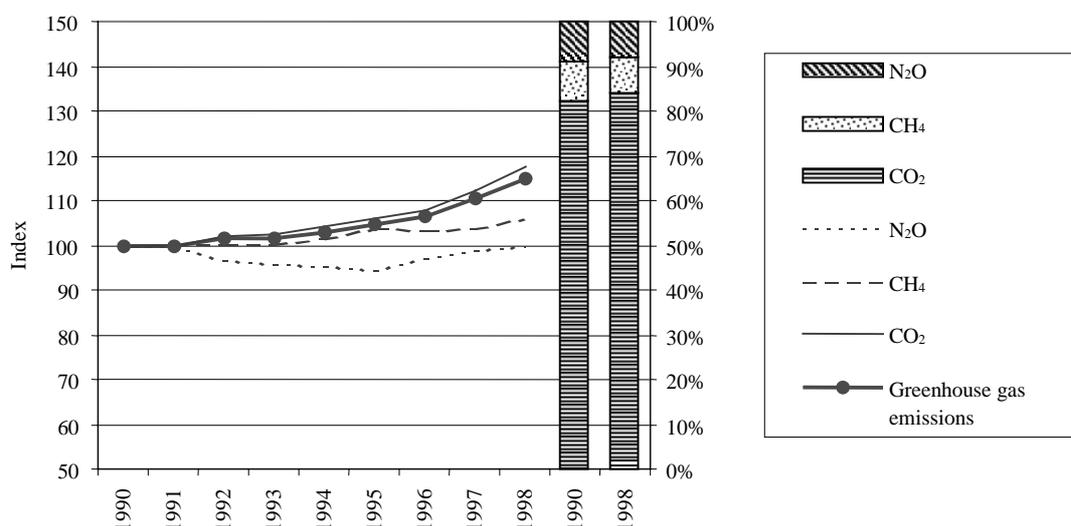
Figure 41 illustrates that 84 % of Greek greenhouse gas emissions were CO<sub>2</sub> emissions in 1998, up 2 percentage points by 1990. CH<sub>4</sub> and N<sub>2</sub>O emissions decreased their shares to 8.2 % and 7.9 % of greenhouse gas emissions respectively.

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions increased slowly but steadily by 5.9 % (0.5 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. The largest source of CH<sub>4</sub> emissions is agriculture accounting for 60 % of CH<sub>4</sub> emissions in 1998, down 1.7 percentage points from 1990. Waste is the second largest emitter with an almost stable share of 24.5 % in 1998. Fugitive emissions of solid fuels increased noticeably and accounted for 11.2 % of CH<sub>4</sub> emissions in 1998.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions stabilised over the period 1990-1998. Again, agriculture is the most important emission source accounting for 64.8 % of N<sub>2</sub>O

emissions in 1998, down 4.7 percentage points. Fuel combustion is the second largest source of N<sub>2</sub>O emissions increasing its share from 22.6 % in 1990 to 27.9 % in 1998. As in many other Member States, N<sub>2</sub>O emissions from transport account for a small share but increased much in the 1990s: in Greece these emissions increased by 114.3 % between 1990 and 1998.

**Figure 41: Greek greenhouse gas emissions (excl. LUCF)**

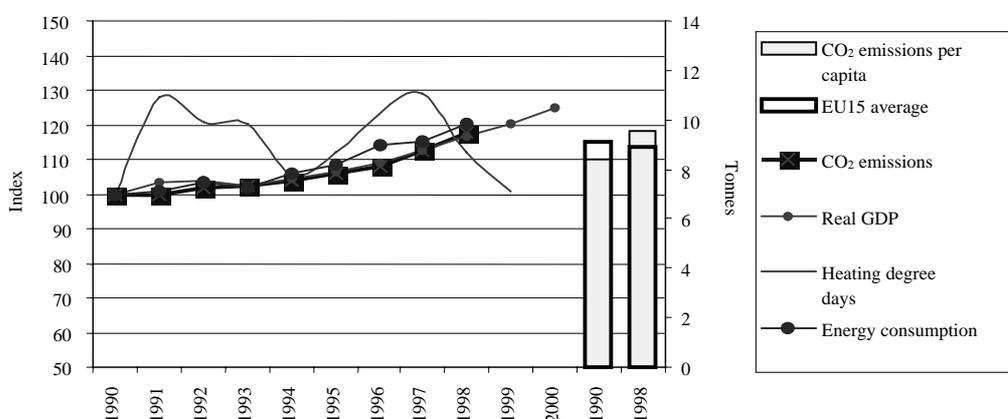


Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

### *CO<sub>2</sub> emission trends and driving forces*

Greek CO<sub>2</sub> emissions increased steadily, but growth rates accelerated since mid 1990s (Figure 42). Except for the early 1990s, the CO<sub>2</sub> emission curve is very similar to the economic growth curve. Therefore, CO<sub>2</sub> emissions per GDP stabilised (at high levels): in 1998, CO<sub>2</sub> emissions per GDP were 1,319 kg per 1000 ECU, which was by far the highest ratio in the EU (EU15 average: 545 kg). Reasons for this are high energy intensity of GDP and high share of lignite fired power production. CO<sub>2</sub> emissions per capita increased from 8.4 tonnes in 1990 to 9.5 tonnes in 1998 (EU15 average in 1998: 8.9 tonnes).

**Figure 42: Greek CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**

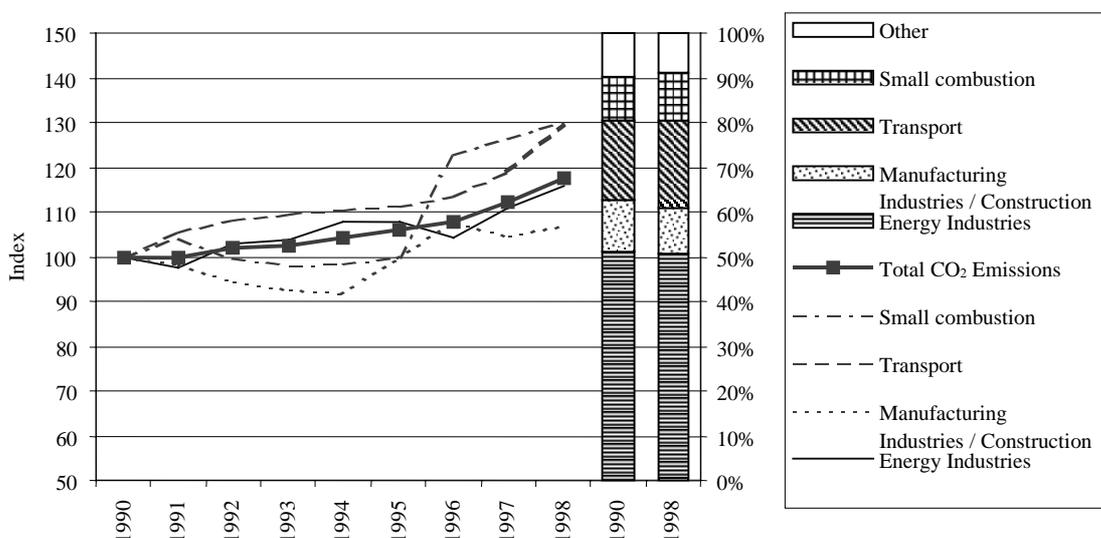


Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were obtained from Eurostat. Energy consumption increased faster than CO<sub>2</sub> emissions and economic activity. Therefore, carbon intensity of energy consumption decreased and energy intensity of the economy increased slightly. In addition, Figure 42 illustrates that temperature variations do not seem to influence on CO<sub>2</sub> emissions noticeably.

**Sectoral breakdown of CO<sub>2</sub> emissions:**

About 91 % of Greek CO<sub>2</sub> emissions come from fossil fuel combustion. Figure 43 illustrates that CO<sub>2</sub> emissions in all fossil fuel combustion sectors increased in the 1990s. CO<sub>2</sub> emissions from small combustion and transport increased most rapidly. Therefore, a slight shift from manufacturing and energy industries to transport and small combustion can be observed.

**Figure 43: Sectoral CO<sub>2</sub> emissions of Greece (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

**Energy industries:** Energy industries are by far the largest CO<sub>2</sub> emitters in Greece, accounting for 50.4 % of CO<sub>2</sub> emissions in 1998 (only Denmark has a higher share). In absolute terms, CO<sub>2</sub> emissions from energy industries increased by 7 Tg (15.9 %) between 1990 and 1998. The main reason for the large share of CO<sub>2</sub> emissions from energy industries is the large reliance on thermal electricity production in general and on lignite firing in particular: about 90 % of Greek electricity is produced in thermal power stations, about 70 % of gross electricity is produced in lignite fired power plants.

Lignite produces the highest CO<sub>2</sub> emissions per unit energy of all common fossil fuels except peat and coke. In addition, the efficiency of electricity production using lignite is lower than for other fuels because a large portion of energy must be spent within the power plant to dry the fuel and handle the large quantities of solid material (IEA, 1998d).

**Transport:** Transport is the second emitter with rapidly growing CO<sub>2</sub> emissions. In 1998, CO<sub>2</sub> emissions from transport were 4.5 Tg (29.4 %) above 1990 levels. The share of transport in total CO<sub>2</sub> emissions grew from 17.8 % in 1990 to 19.6 % in 1998. Fuel consumption by road transport grew by 26 % between 1990 and 1997. According to EC (1999), road transport both passenger and goods increased substantially between 1990 and 1997: passenger road transport (in person kilometers) increased by 32 % and road haulage (in tonne kilometers) grew by 51.4 %. Although car ownership grew substantially to 229 cars per 1000 inhabitants in 1997, it was still far below the EU15 average of 454 (EC, 1999).

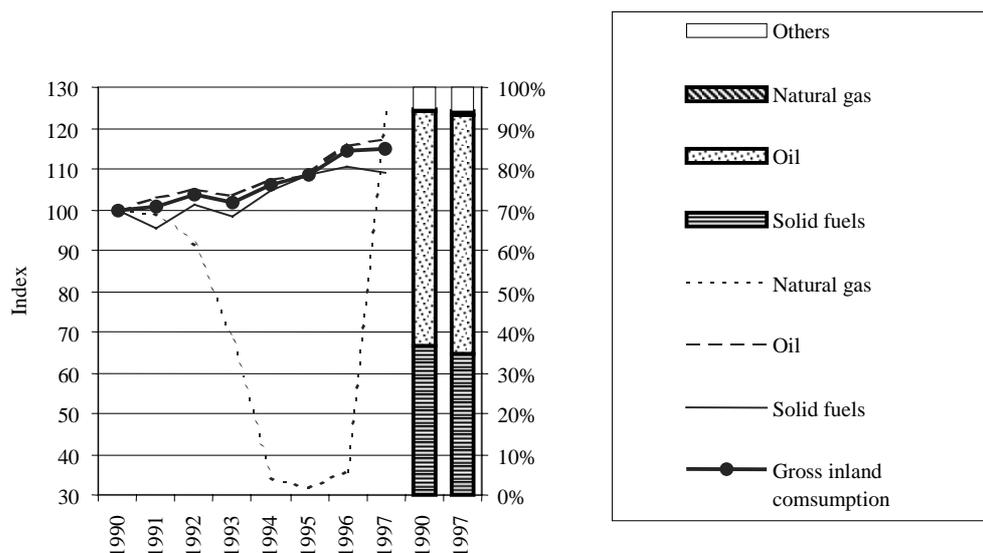
**Small combustion:** Small combustion increased its share in CO<sub>2</sub> emissions by 1 percentage point to 10.6 % in 1998. Figure 43 illustrates that up to 1995, CO<sub>2</sub> emissions from small combustion stabilised but in 1996 they shot up by 23.7 index points and then increased at a slower pace. In absolute terms, CO<sub>2</sub> emissions from small combustion increased by 2.4 Tg (30 %) between 1990 and 1998.

**Industry:** Although CO<sub>2</sub> emissions from industry increased by 0.7 Tg (7 %), their share in total CO<sub>2</sub> emissions decreased from 11.5 % in 1990 to 10.5 % in 1998.

### *Energy supply, by fuel*

Gross inland energy consumption increased by 15.1 % between 1990 and 1997, which was well above EU15 average of 7.1 % growth. Figure 44 illustrates that energy consumption relies heavily on fossil fuels accounting for 93.9 % of gross inland consumption in 1998. Energy intensity of GDP increased to 349 toe per MECU in 1998 and was the highest in the EU (EU15 average: 237 toe). Reasons for this are relatively low prices for transport fuels and electricity for industry (IEA, 1998d). The energy mix is characterised by high shares of solid fuels and oil, but hardly any gas.

**Figure 44: Greek gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include renewable energy sources and net electricity imports.

About two thirds of domestic energy consumption is imported; lignite is the only significant primary energy production in Greece accounting for about 30 % of gross inland consumption.

**Oil:** Oil is the largest energy source accounting for 58.8 % of gross inland consumption in 1997, up 1 percentage point. Almost all oil is imported. About 45 % of inland market consumption is used in the transport sector. Small combustion is second accounting for about 22 % of inland market consumption. Industry and power stations are responsible for 15 % and 14 % respectively.

**Solid fuels:** Solid fuels accounted for 34.4 % of gross inland consumption in 1997, down 2 percentage points from 1990. Greece was one of the few Member States, where solid fossil fuel use increased from 1990 to 1997 (by 9 %). Lignite accounts for the bulk of solid fuel consumption. Lignite is the only substantial domestic energy production and increased by 13.4 % between 1990 and 1997. In 1997, 22.5 % of EU15 lignite production was produced in Greece. Almost all lignite is used in power stations.

**Natural gas:** Natural gas use declined sharply between 1990 and 1994, but recovered in 1997 after opening a new gas supply system to import natural gas from Russia. More than 50 % of gas is used in power stations, non-energy use and industry account for the rest.

**Renewable energies:** Renewable energies increased by 23.5 % between 1990 and 1997 and accounted for 5.3 % of gross inland energy consumption in 1997. Biomass (3.6 %) and hydro power (1.3 %) are the largest renewable energy sources. Solar energy increased by more than 50 % and accounted for a remarkable 0.4 % of gross inland energy consumption. In 1997, more than 40 % of EU15 solar energy was produced in Greece.

### *Electricity production*

Gross electricity generation increased by 24.3 % from 1990 to 1997, which was more than the EU15 average growth of 17.5 %. However, in 1997, power production per capita was with 4,149 kWh well below EU15 average of 6,483 kWh. Greek electricity supply is characterised by a large reliance on thermal power production, but relations shifted at least to a small extent. Between 1990 and 1997, hydro power production more than doubled, thermal power production grew by almost 20 %. Therefore, hydro power increased its share in electricity production from 5.7 % in 1990 to 9.4 % in 1997, whereas thermal power production decreased from 94.3 % in 1990 to 90.5 % in 1997.

Greece has the highest share of lignite fired electricity generation in the EU. Lignite fired power production increased in absolute terms, but its share declined slightly from 71.9 % of gross electricity generation in 1990 to 69.8 % in 1997. Oil fired power production increased in absolute terms but decreased its share by 3 percentage points to 19.1 % in 1997.

### *Summary on actual progress in Greece*

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☹	☹
	Variations 1990/1998 in Tg of CO <sub>2</sub> equivalents and percent	
Greenhouse gases	+15.6 Tg	+15.0 %
CH <sub>4</sub>	+0.5 Tg	+5.9 %
N <sub>2</sub> O	-0.03 Tg	-0.3 %
CO <sub>2</sub>	+15.1 Tg	+17.7 %
Energy industries	+7.0 Tg	+15.9 %
Manufacturing industries	+0.7 Tg	+7.0 %
Transport	+4.5 Tg	+29.4 %
Small combustion	+2.4 Tg	+30.0 %

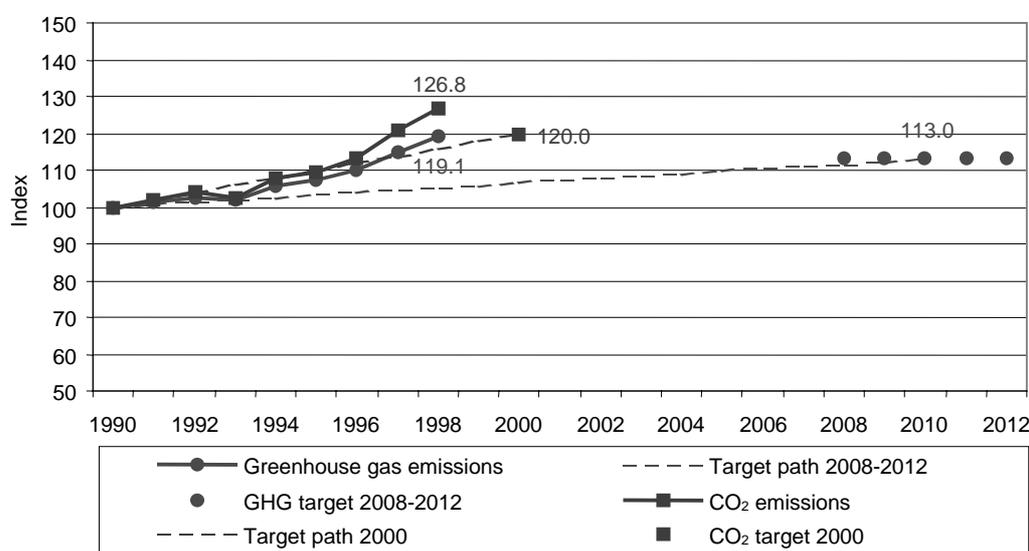
#### 4.1.8. Ireland

##### *Actual progress in Ireland*

In the burden sharing agreement, Ireland agreed to limit its greenhouse gas emissions at 13 % above 1990 levels by 2008-2012. In 1998, Ireland's greenhouse gas emissions were 63.7 Tg. This was 19.1 % (10.2 Tg) above 1990 levels thus deviating from the linear target path by 13.9 index points (Figure 45). Ireland accounted for 1.6 % of EU15 greenhouse gas emissions in 1998.

For CO<sub>2</sub> emissions, Ireland set a 20 % limitation target for 2000. In 1998, CO<sub>2</sub> emissions were 40 Tg, which was 26.8 % (8.5 Tg) above 1990 levels. Therefore, CO<sub>2</sub> emissions were 10.8 index points above the target path for 2000 in 1998.

**Figure 45: Irish greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

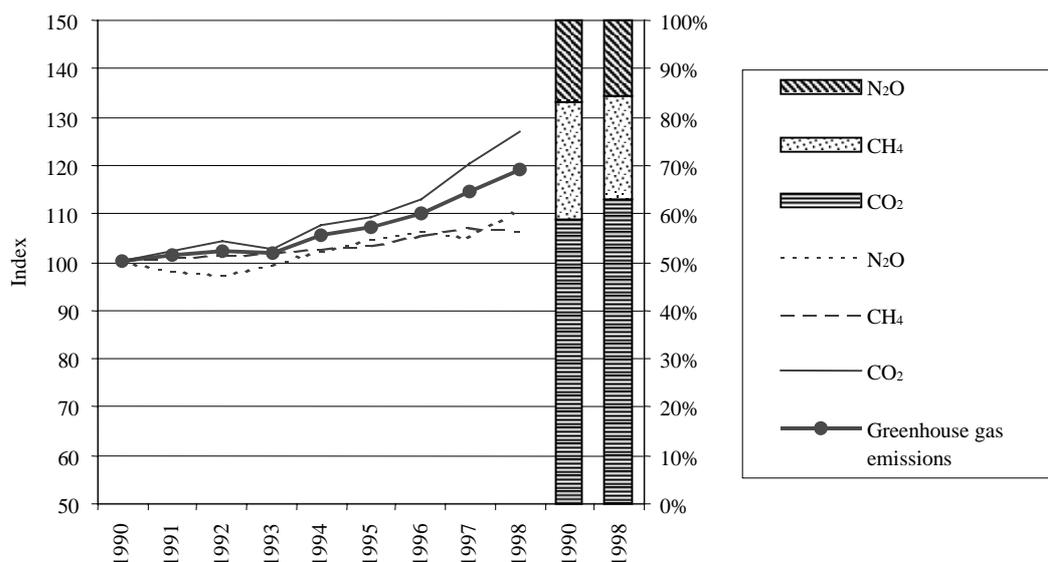
##### *Greenhouse gas emission trends*

Figure 46 illustrates that all Irish greenhouse gas emissions increased between 1990 and 1998. Due to the high importance of agriculture in the Irish economy, the share of CO<sub>2</sub> emissions in greenhouse gas emissions is lower than in all other Member States. In 1998, 62.8 % of greenhouse gas emissions were CO<sub>2</sub> emissions, up 3.8 percentage points. CH<sub>4</sub> emissions accounted for 21.4 % and N<sub>2</sub>O for 15.8 % of greenhouse gas emissions in 1998. As their growth fell behind CO<sub>2</sub> emission growth, their shares decreased between 1990 and 1998.

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions grew almost steadily by 6.2 % (0.8 Tg of CO<sub>2</sub> equivalents) from 1990 to 1998. Agriculture and waste account for almost 100 % of CH<sub>4</sub> emissions. After a 10 % increase between 1990 and 1998, emissions from agriculture accounted for about 87 % of CH<sub>4</sub> emissions in 1998. CH<sub>4</sub> emissions from waste increased until 1996, but then decreased sharply to 10 % below 1990 levels.

**N<sub>2</sub>O emissions:** After a small decline in the early 1990s, N<sub>2</sub>O emissions grew by 10.8 % (1 Tg of CO<sub>2</sub> equivalents) from 1990 to 1998. Again, agriculture is by far the largest emitter accounting for about 78 % of N<sub>2</sub>O emissions. Second is fuel combustion with a share of 14 % in 1998. As in many EC Member States, N<sub>2</sub>O emissions from transport exploded; in Ireland they more than trebled. Industrial processes reduced their share from 11.4 % in 1990 to 8.1 % in 1998.

**Figure 46: Irish greenhouse gas emissions (excl. LUCF)**



Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

### *CO<sub>2</sub> emission trends and driving forces*

Ireland's economy grew rapidly in the 1990s. Driven by foreign investment, real GDP increased by 80.4 % from 1990 to 1998 (EU15 average: 17.4 %). Accordingly, energy consumption and CO<sub>2</sub> emissions grew by 28.1 % and 26.8 % respectively (Figure 47). This means that energy and carbon intensity of GDP decreased considerably, but carbon intensity of energy consumption was stable. CO<sub>2</sub> emissions per GDP decreased from 881 kg per 1000 ECU in 1990 to 619 kg in 1998 (EU15 average in 1998: 545 kg). But, CO<sub>2</sub> emissions per capita increased from 9 tonnes in 1990 to 10.8 tonnes in 1998 (EU15 average in 1998: 8.9 tonnes). In Ireland, temperature variations seem to have only minor influence on CO<sub>2</sub> emissions. In cold years like 1991, 1993 and 1996 no deviation of CO<sub>2</sub> emissions can be observed, even not in the small combustion sector.

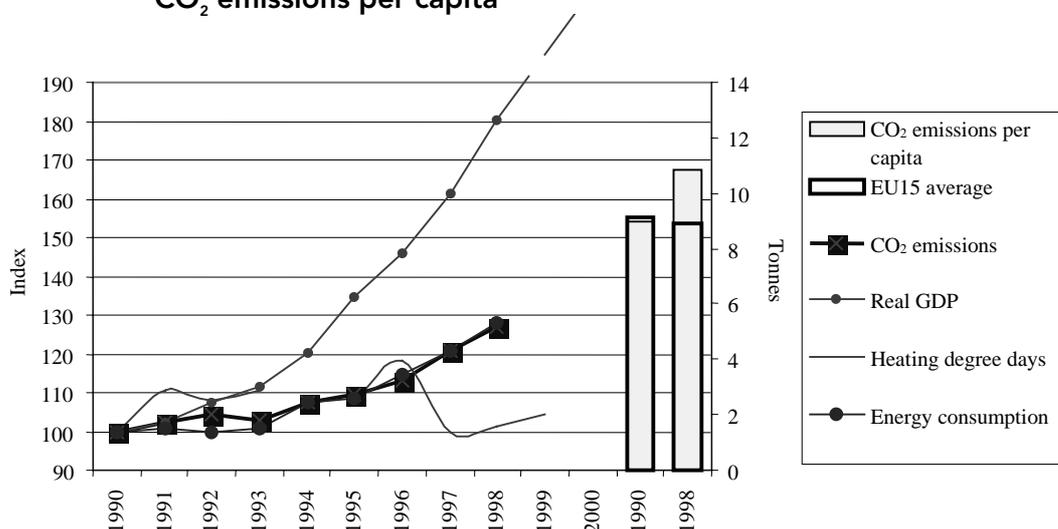
### *Sectoral breakdown of CO<sub>2</sub> emissions*

More than 94 % of Irish CO<sub>2</sub> emissions come from fossil fuel combustion. Within fossil fuel combustion, CO<sub>2</sub> emissions from transport and energy industries increased rapidly between 1990 and 1998, whereas CO<sub>2</sub> emissions from manufacturing industries and small combustion almost stabilised (Figure 48).

**Energy industries:** As in many other Member States, energy industry is the largest emitter in Ireland. Its share in CO<sub>2</sub> emissions increased from 35 % in 1990 to 37.6 % in 1998. In absolute terms, CO<sub>2</sub> emissions from energy industries rose by

4 Tg (36.1 %) between 1990 and 1998. The Irish energy industry is characterised by a high reliance on fossil fuels and peat in power generation with almost 95 % of power production.

**Figure 47: Irish CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were obtained from Eurostat, figures for 1994 were not available.

**Small combustion:** The second largest emitting sector is small combustion with 24.9 % of CO<sub>2</sub> emissions in 1998, down 5.9 percentage points. In absolute terms, CO<sub>2</sub> emissions from small combustion stabilised between 1990 to 1998 (+0.2 Tg).

**Transport:** Third is transport with much increasing CO<sub>2</sub> emissions (+76.8 % or 3.8 Tg) between 1990 and 1998. Its share in total CO<sub>2</sub> emissions has increased from 15.7 % in 1990 to 21.9 % in 1998. Fuel consumption by road transport grew by 51.6 % between 1990 and 1997. Car ownership increased by 35.2 % to 307 cars per inhabitant in 1997 but is still well below EU15 average (454 cars). Person kilometers in passenger cars rose by 24 % from 1990 to 1997 (EU15 average: 14.7 %) and passengerkilometers per person were with 12,162 pkm after Denmark the second highest in EU15 (EC, 1999). But, surprisingly, according to EC (1999) road haulage growth was only 7.8 % lagging considerably behind EU15 average growth (29.4 %).

**Manufacturing industries:** CO<sub>2</sub> emissions from manufacturing industry stabilised (+0.1 Tg) over the period 1990-1998 despite of rapidly growing economic activity. This indicates that economic growth was driven by growth in services and manufacturing industries with low energy intensities. The share of industrial CO<sub>2</sub> emissions decreased from 12.1 % in 1990 to 9.8 % in 1998.

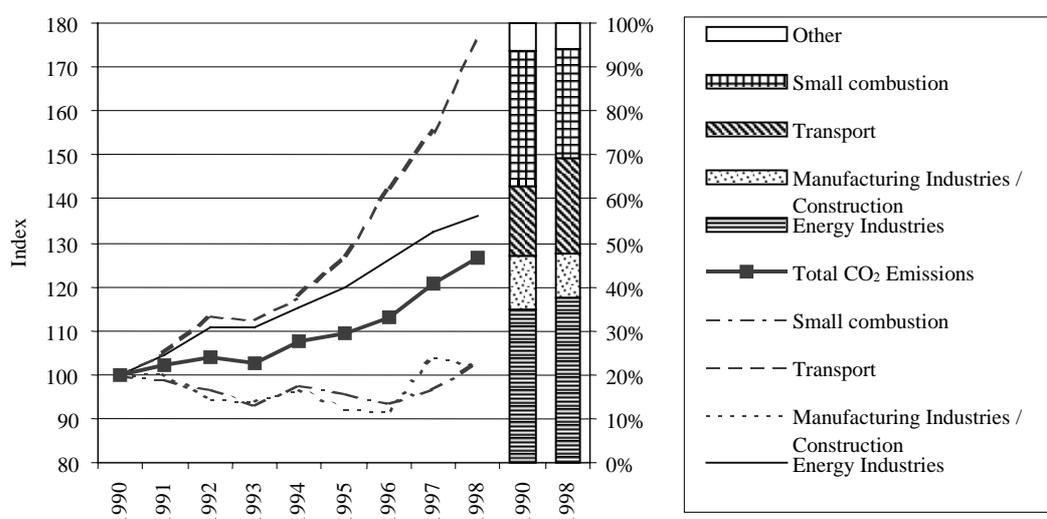
### *Energy supply, by fuel*

Gross inland energy consumption stabilised until 1993 but then increased to 20.7 % above 1990 levels. Accordingly, energy consumption per capita rose from 2.9 toe in 1990 to 3.4 toe in 1997, but stayed below EU15 average of 3.8 toe per

person. Energy intensity of GDP declined from 284 toe per MECU to 213 toe (EU15 average: 237 toe).

Ireland has the highest share of fossil fuels (including peat) in energy consumption (98.2 %) amongst EC Member States. This share has stabilised between 1990 and 1998, but the energy mix shifted from solid fuels to oil and gas (Figure 49). Import dependency of Irish energy supply was 76.4 % in 1997; domestic fuels are natural gas and peat. Latter accounts for about 26% of domestic energy production and is used for power generation, non-energy use and residential heating. Therefore, peat plays an important role in reducing the high import dependency and in creating employment, but at high cost (IEA, 1999b).

**Figure 48: Sectoral CO<sub>2</sub> emissions of Ireland (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

**Oil:** Oil is the largest energy source in Ireland accounting for 52.3 % of gross inland consumption in 1997, up 7.2 percentage points. One reason for this expansion was rapid growth of fuel consumption by road transport between 1990 and 1997. A second reason was oilfired power production which more than doubled.

**Solid fuels:** Solid fuels were second in 1997, but decreased their shares from 34.7 % in 1990 to 23.3 % in 1997. Especially the use of solid fuels in industry and small combustion declined, whereas the consumption of solid fuels in power plants increased.

**Natural gas:** Gas is the third energy source accounting for 22.5 % of gross inland consumption in 1997, up 3.9 percentage points. About two thirds of gross inland gas consumption are domestic production; About 50 % of gas consumption is used for power generation. about 18 % in services and households. Gas use in households more than doubled between 1990 and 1997.

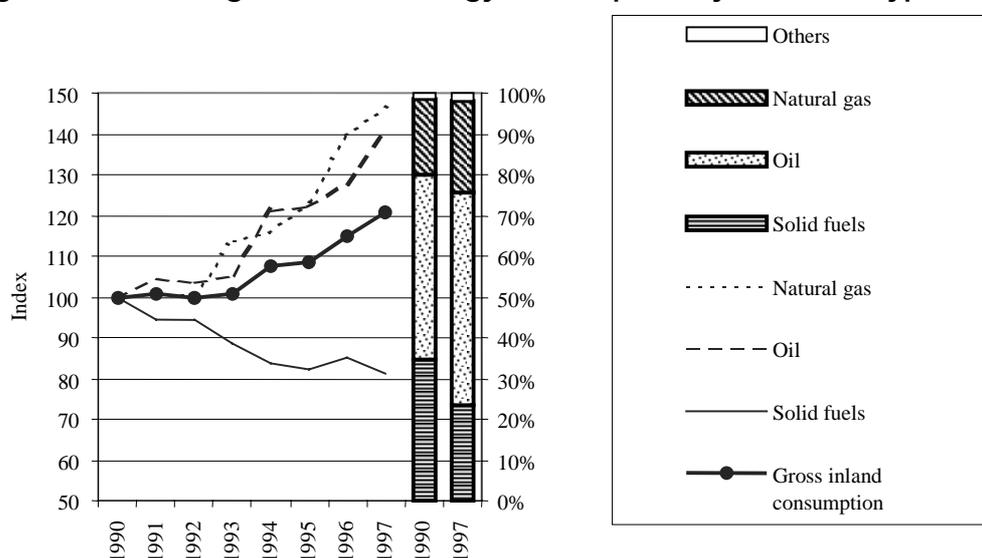
**Renewable energies:** Renewable energies increased by 34.3 % between 1990 and 1997 and accounted for 1.8 % of gross inland energy consumption in 1997. Biomass (1.3 %) and hydro power (0.5 %) are the largest renewable energy sources. Biomass increased by more than 50 % between 1990 and 1997.

## Electricity generation

Gross electricity generation increased by 37.6 % between 1990 and 1997. Per capita electricity production increased from 4,138 kWh in 1990 to 5,466 kWh in 1997, which was below EU15 average (6,483 kWh).

Irish power generation is characterised by a high share of thermal power production: 95 % of gross electricity was produced by combustion plants in 1997, up 1.8 percentage points; 4.7 % came from hydro power plants and 0.3 % from fledgling wind power. Solid fuels accounted for 44.3 % of power generation in 1997 with a high share of peat. However, solid fuels are in decline: in 1990, more than 55 % of power production came from solid fuels. The share of natural gas in power production increased from 27.1 % in 1990 to 32.9 % in 1997. Oil jumped from 9.9 % of gross electricity generation in 1990 to 17.4 % in 1997.

**Figure 49: Irish gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include renewable energy sources and net electricity imports.

## Summary on actual progress for Ireland

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☹	☹
	<b>Variations 1990/1998 in Tg of CO<sub>2</sub> equivalents and percent</b>	
Greenhouse gases	+10.2 Tg	+19.1 %
CH <sub>4</sub>	+0.8 Tg	+6.2 %
N <sub>2</sub> O	+1.0 Tg	+10.8 %
CO <sub>2</sub>	+8.5 Tg	+26.8 %
Energy industries	+4.0 Tg	+36.1 %
Manufacturing industries	+0.1 Tg	+2.2 %
Transport	+3.8 Tg	+76.8 %
Small combustion	+0.2 Tg	+2.5 %

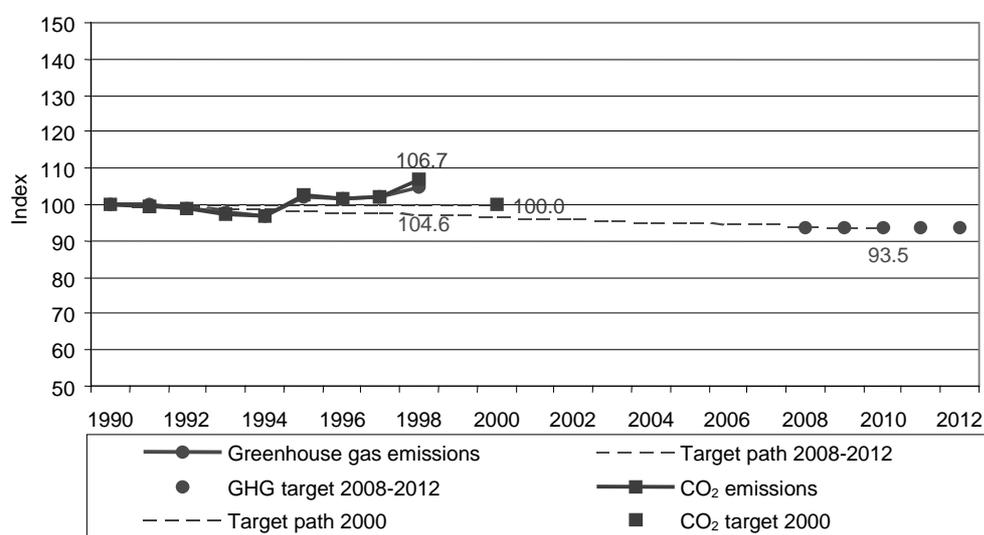
### 4.1.9. Italy

#### Actual progress in Italy

In the burden sharing agreement, Italy agreed to reduce its greenhouse gas emissions by 6.5 % from 1990 levels by 2008-2012. In 1998, Italian greenhouse gas emissions were 538.2 Tg. This was 4.6 % (23.5 Tg) above 1990 levels, thus deviating from the linear Kyoto target path by 7.2 index points (Figure 50). If industrial F-gases are included, Italian greenhouse gas emissions increased by 4.8 % between 1990 and 1998. Italy accounted for 13.3 % of EU15 greenhouse gas emissions in 1998.

For CO<sub>2</sub> emissions, Italy set a stabilisation target by 2000. In 1998, CO<sub>2</sub> emissions were 458.3 Tg, which was 6.7 % (28.6 Tg) above 1990 levels. Therefore, in 1998, Italian CO<sub>2</sub> emissions were 6.7 index points above the target path for 2000.

**Figure 50: Italian greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

#### Greenhouse gas emission trends

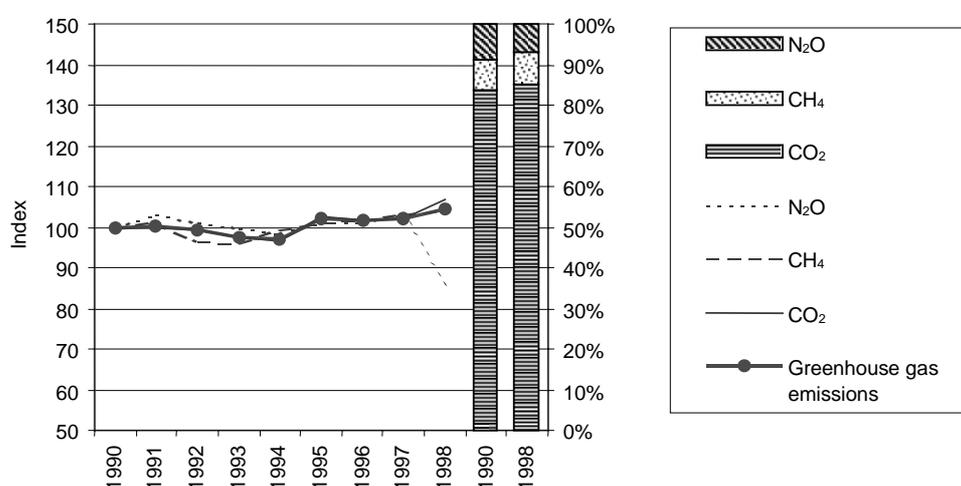
Figure 51 illustrates that all greenhouse gas emissions were comparatively stable until 1997, in 1998 this picture changed: CO<sub>2</sub> emissions increased noticeably, whereas N<sub>2</sub>O emissions decreased sharply. In 1998, CO<sub>2</sub> emissions accounted for 85.2 % of Italian greenhouse gas emissions, up 1.7 percentage points from 1990. CH<sub>4</sub> emissions stabilised at a share of 7.7 %, whereas the share of N<sub>2</sub>O in greenhouse gas emissions declined from 8.8 % in 1990 to 7.2 % in 1998.

**CH<sub>4</sub> emissions:** After a small decline in 1992 and 1993, CH<sub>4</sub> emissions increased almost steadily and were 4 % (1.6 Tg of CO<sub>2</sub> equivalents) above 1990 levels in 1998. CH<sub>4</sub> emissions from agriculture accounting for the largest share in CH<sub>4</sub> emissions declined slightly in absolute terms between 1990 and 1998. Accordingly, their share in CH<sub>4</sub> emissions reduced from 48.1 % in 1990 to 45.4 % in 1998.

Emissions from waste increased substantially after 1993 and were 18 % above 1990 levels in 1998. Therefore, their share in total CH<sub>4</sub> emissions increased from 30.7 % in 1990 to 34.9 % in 1998. Fugitive emissions of oil and gas reduced their share from 17.5 % in 1990 to 14.4 % in 1998.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions fluctuated only slightly around 1990 levels, but decreased sharply in 1998 to 14.8 % (6.7 Tg of CO<sub>2</sub> equivalents) below 1990 levels. The main reason for this was a sharp decline of N<sub>2</sub>O emissions from fuel combustion (in particular in energy industries, which were not outweighed by emission increases from transport). As agricultural N<sub>2</sub>O emissions stabilised in absolute terms, they extended their share in N<sub>2</sub>O emissions from 53.1 % in 1990 to 65.4 % in 1998. Fuel combustion reduced its share from 30.5 % in 1990 to 18.1 % in 1998, whereas the share of industrial processes in N<sub>2</sub>O emissions stabilised at 16.1 %.

**Figure 51: Italian greenhouse gas emissions (excl. LUCF)**



Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

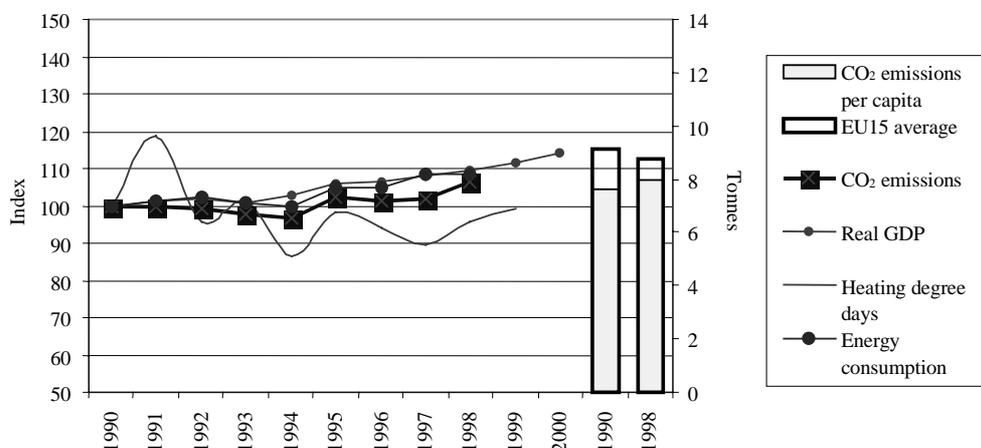
### *CO<sub>2</sub> emission trends and driving forces*

Between 1990 and 1998, CO<sub>2</sub> emissions increased by 6.7 %. CO<sub>2</sub> emissions decreased slightly until 1994, jumped in 1995, stabilised until 1997 and increased again in 1998. One reason for restrained performance of CO<sub>2</sub> emission has been slow economic growth in the 1990s: between 1990 and 1998, Italian real GDP grew by 9.6 % compared to an average growth of EU15 of 17.4 % (Figure 52).

Energy consumption pattern was very close to CO<sub>2</sub> emission pattern but increased at a slightly faster pace. As both, growth rates of economic activity and energy consumption, were very close to the CO<sub>2</sub> emission growth rate for 1990-1998, carbon intensity of GDP and of energy consumption was stable.

Italy has low levels of CO<sub>2</sub> emissions per capita and per GDP. Reasons for this are mild climate, high energy prices mainly due to high energy taxes and a low share of energyintensive industries. CO<sub>2</sub> emissions per capita increased from 7.6 tonnes in 1990 to 8 tonnes in 1998 (EU15 average in 1998: 8.9 tonnes). CO<sub>2</sub> emissions per GDP decreased from 499 kg per 1000 ECU in 1990 to 486 kg in 1998 which is amongst the lowest in the EU.

**Figure 52: Italian CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were obtained from Eurostat.

### *Sectoral breakdown of CO<sub>2</sub> emissions*

More than 93 % of Italian CO<sub>2</sub> emissions come from fossil fuel combustion. CO<sub>2</sub> emissions from transport grew steadily between 1990 and 1998, whereas CO<sub>2</sub> emissions from energy industries increased sharply in 1998. (Figure 53). In general, within fossil fuel combustion, a shift from small combustion and manufacturing industries to transport and energy industries can be observed.

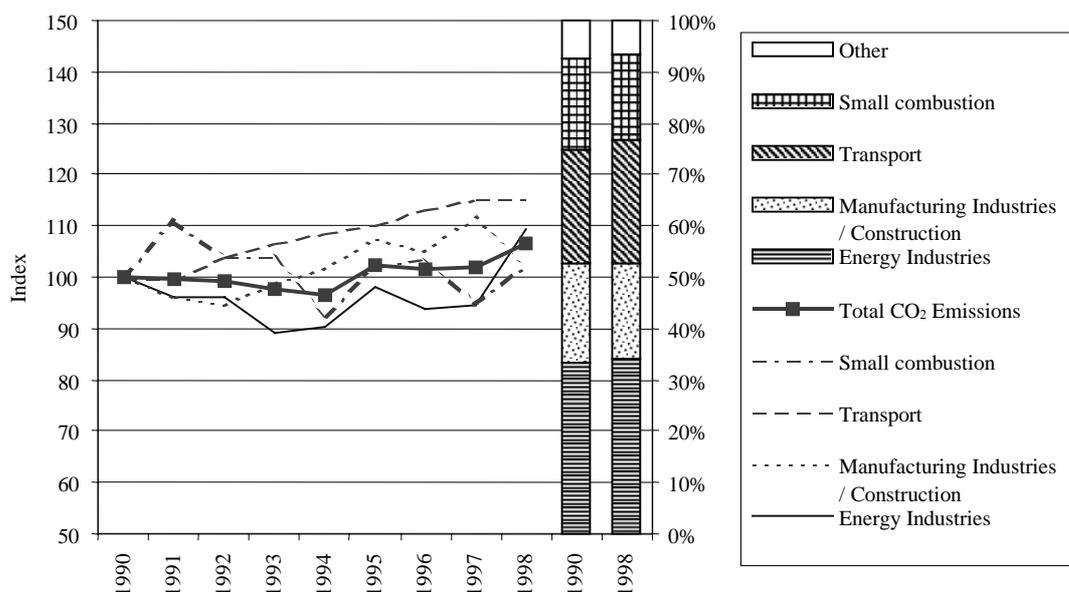
**Energy industries:** As in most Member States, energy industries are the largest emitters in Italy. CO<sub>2</sub> emissions in this sector accounted for 34 % in 1998, up 0.7 percentage points from 1990. In absolute terms, CO<sub>2</sub> emissions from energy industries increased by 13.1 Tg. The energy industries are characterised by a high share of fossil fuels in electricity generation (almost 80 %) but fuel switch is taking place gradually. Figure 53 illustrates that energy industries were mainly responsible for the increase in CO<sub>2</sub> emissions in 1998. Monthly Eurostat data indicates that power production from hard coal and gas increased significantly in 1998.

**Transport:** The second sector is transport growing by 14.6 Tg and increasing its share from 22.3 % in 1990 to 24 % in 1998. Car ownership grew from 483 cars per inhabitant in 1990 to 577 cars in 1997 (EU15 average: 454 cars) and is one of the highest in the World. In addition, passenger-km travelled per person were 11,012 km in 1997 compared to the EU15 average of 10,128 passenger-km. But road haulage growth was with 16.5 % between 1990 and 1997 below EU15 average growth (29.4 %) (EC, 1999).

**Manufacturing industries:** Third is the manufacturing industry sector accounting for 18.5 % of CO<sub>2</sub> emissions in 1998, down 0.9 percentage points from 1990. In the early 1990s, when economic growth was low, CO<sub>2</sub> emissions from manufacturing industry decreased, but from 1992 on rose almost steadily. In 1998, CO<sub>2</sub> emissions from manufacturing industry were 1.6 Tg above 1990 levels.

**Small combustion:** Small combustion showed considerable variations mainly due to temperature variations. In 1998 however, CO<sub>2</sub> emissions from small combustion were almost at 1990 levels decreasing its share in total CO<sub>2</sub> emissions from 17.6 % in 1990 to 16.9 % in 1998. In absolute terms, CO<sub>2</sub> emissions from small combustion increased by 1.8 Tg.

**Figure 53: Sectoral CO<sub>2</sub> emissions of Italy (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### *Energy supply, by fuel*

Gross inland energy consumption went up 8.6 % between 1990 and 1997. However, energy intensity of GDP (in terms of gross inland energy consumption per unit of GDP) was with 181 toe per MECU in 1997 the second lowest in EU15 (after Denmark). As mentioned above, this is due to high energy prices, mild climate and Italy's small number of energyintensive industries.

High energy taxes in Italy in comparison with most EC Member States, in particular for household energy consumption, have contributed to high energy prices and to maintaining energy consumption at low levels. Italy has many small industries with low energy intensity, and many energy intensive goods are imported. In addition, structural changes and efficiency improvements in energyintensive industries (especially in the steel and glass industry) contributed to low energy intensity in the industrial sector (IEA, 1999c).

Energy production increased in the 1990s but remained low compared with energy consumption. Gas is the most important energy source produced in Italy, accounting for about one third of gross inland consumption. Therefore, Italy's dependency on energy imports is high: in 1997, net imports were 78.8 % of gross inland consumption (compared to an EU15 average of 47.7 %). Italy has one of the largest shares of fossil fuel consumption: in 1997, 90.1 % of gross inland energy consumption was based on fossil fuels, down 2.6 percentage

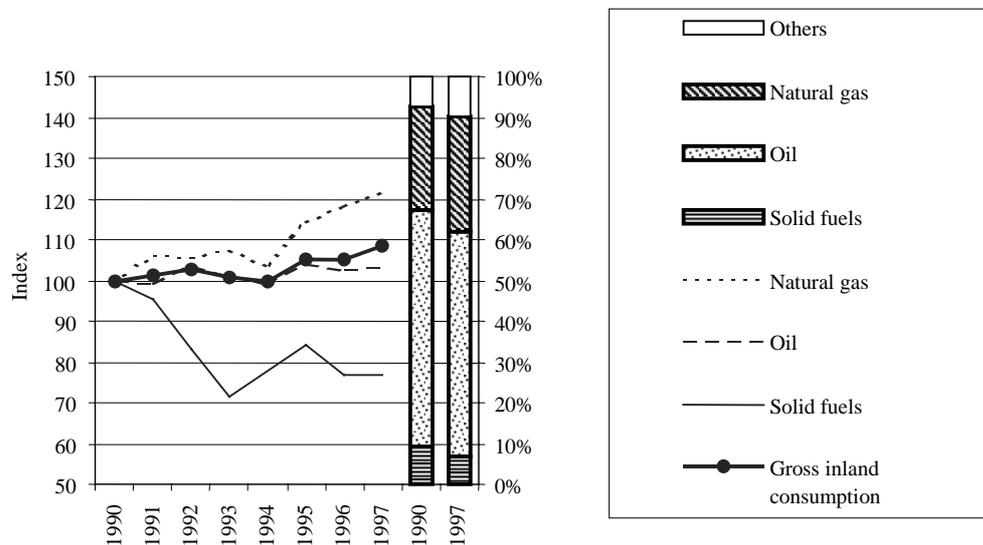
points from 1990 (Figure 54). In recent years energy sources have switched from coal and oil to gas and renewable energies (hydro and biomass).

**Oil:** Oil is the most important energy source accounting for 55,1 % of gross inland consumption in 1997, down 2.9 percentage points. About 40 % of inland market consumption of oil was used for transport in 1997, 27 % for power generation.

**Natural gas:** Gas is the second energy source with 28.3 % gross inland consumption in 1997, up 3.1 percentage points. Households are the largest consumers of gas accounting for more than 40 % of gas inland market consumption in 1997. Industry and power production account for about 32 % and 25 % of gas inland market consumption respectively.

**Solid fuels:** The use of solid fuels declined by 23.4 % between 1990 and 1997; their share in gross inland consumption decreased from 9.5 % in 1990 to 6.7 % in 1997. Power production from hard coal declined by 34 % and the use of lignite for power production almost vanished parallel to closing lignite production.

**Figure 54: Italian gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include renewable energy sources and net electricity imports.

**Renewable energies:** Renewable energy consumption increased by 58.2 % between 1990 and 1997 and accounted for 7.7 % of gross inland energy consumption in 1997. Biomass (4 %), hydro power (2.1 %) and geothermal energy (1.6 %) are the largest renewable energy sources. Biomass consumption doubled between 1990 and 1997.

### *Electricity generation*

Gross electricity generation has increased by 15.6 % from 1990 to 1997. Similarly per capita electricity generation increased from 3,825 kWh per capita in 1990 to 4,364 kWh in 1997, which was well below the EU15 average (6,483 kWh).

Electricity generation relies heavily on fossil fuel combustion. In 1998, 79.8 % of electricity was produced in conventional thermal power stations, 18.6 % in hydro

power stations and 1.6 % in geothermal plants. Italy accounts for almost 100 % of geothermal power production in the EU.

Oil is the most important fuel accounting for 45.2 % of gross electricity generation in 1997, down 2.2 percentage points from 1990. Whereas the share of coal in electricity production went down from 14.2 % in 1990 to 8.1 % 1997, the share of gas increased from 18 % to 24.4 %.

A feature of Italian electricity supply is high import dependency. After phasing out nuclear electricity generation in the late 1980s, electricity demand has been met by increased domestic production and by imports. Italy is the largest net electricity importer in the EU with 39 TWh in 1997. This was about 16 % of net electricity generation in 1997 and came mainly from France.

Electricity production from renewable resources has increased significantly since 1990. Most of this was due to a rise in hydro power production (which was exceptionally low in 1990). A reason for growing power production from other renewable sources were favourable buyback tariffs for electricity (IEA, 1999c).

***Summary on actual progress for Italy***

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☹	☹
	Variations 1990/1998 in Tg of CO <sub>2</sub> equivalents and percent	
Greenhouse gases	+23.5 Tg	+4.6 %
CH <sub>4</sub>	+1.6 Tg	+4.0 %
N <sub>2</sub> O	-6.7 Tg	-14.8 %
CO <sub>2</sub>	+28.6 Tg	+6.7 %
Energy industries	+13.1 Tg	+9.2 %
Manufacturing industries	+1.6 Tg	+2.0 %
Transport	+14.6 Tg	+15.2 %
Small combustion	+1.8 Tg	+2.4 %

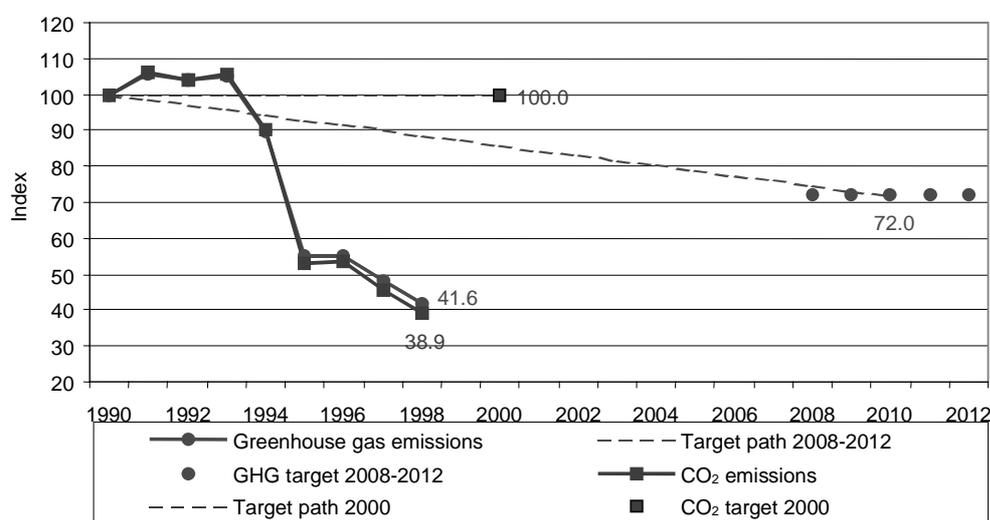
#### 4.1.10. Luxembourg

##### Actual progress in Luxembourg

In the burden sharing agreement, Luxembourg agreed to reduce its greenhouse gas emissions by 28 % at basis 1990 by 2008-2012. In 1998, Luxembourg's greenhouse gas emissions were 5.9 Tg. This was 58.4 % (8.2 Tg) below 1990 levels and 47.2 index points below the linear target path for 2008-2012 (Figure 55).

Luxembourg accounted for 0.1 % of EU15 greenhouse gas emissions in 1998. For CO<sub>2</sub> emissions, Luxembourg set a stabilisation target for 2000. In 1998, CO<sub>2</sub> emissions were 5.2 Tg, which was 61.1 % (8.1 Tg) below 1990 levels. Therefore, in 1998, Luxembourg's CO<sub>2</sub> emissions were 61.1 index points below the target path for 2000.

**Figure 55: Luxembourg's greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

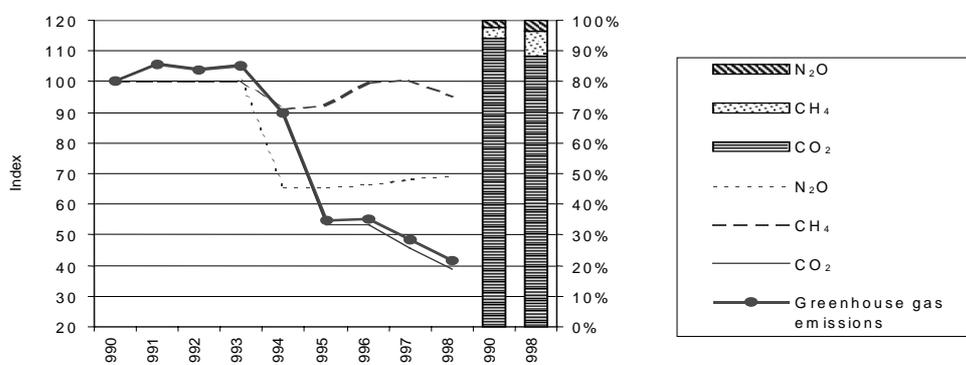
##### Greenhouse gas emission trends

Figure 56 illustrates that all greenhouse gas emissions reduced between 1990 and 1998, but CO<sub>2</sub> emissions reduced most. Therefore, their share in greenhouse gas emissions declined from 94.2 % in 1990 to 88.2 % in 1998. In contrast to that, the shares of CH<sub>4</sub> and N<sub>2</sub>O increased to 8.2 % and 3.6 % respectively.

**CH<sub>4</sub> emissions:** Between 1990 and 1998, CH<sub>4</sub> emissions declined by 4.8 %, which was basically due to a 23.2 % decline of CH<sub>4</sub> emissions from waste. Agriculture is the largest emitter of CH<sub>4</sub> emissions accounting for 74 % of total CH<sub>4</sub> emissions in 1998, down 1 percentage point from 1990. Waste is second with a share of 13.4 % in 1998, down 3.3 percentage points from 1990.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions declined by 31 % (0.1 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. Sectoral data on N<sub>2</sub>O emissions suggests that emissions from industrial processes – the largest source in 1990 – were cut totally, and agriculture turned into the largest emitter. In 1998, agriculture accounted for 69.3 % of N<sub>2</sub>O emissions followed by transport with 20.3 %.

**Figure 56: Luxembourg's greenhouse gas emissions (excl. LUCF)**

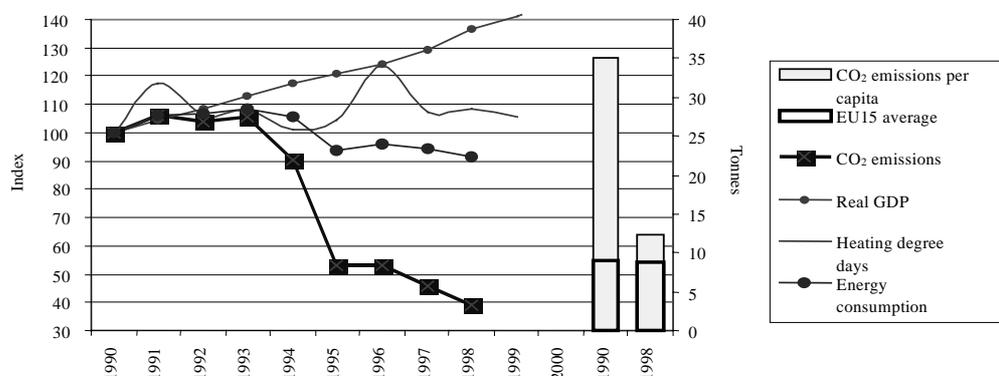


Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

### CO<sub>2</sub> emission trends and driving forces

Despite of fast economic growth in the 1990s, CO<sub>2</sub> emissions and – to a smaller extent – energy consumption decreased considerably. GDP rose by 36.6 % between 1990 and 1998, whereas gross energy consumption declined by 8.5 % and CO<sub>2</sub> emissions dropped by 61.1 % (Figure 57). Accordingly, CO<sub>2</sub> emissions per GDP dropped from 1,572 kg per 1000 ECU in 1990 to 448 kg in 1998 (EU15 average: 545 kg.). And energy intensity of GDP declined from 420 toe per MECU in 1990 to 307 toe in 1997, which was still above EU15 average of 237 toe. CO<sub>2</sub> emissions per capita fell from 35.1 tonnes to 12.2 tonnes.

**Figure 57: Luxembourg's CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were obtained from Eurostat.

### *Sectoral breakdown of CO<sub>2</sub> emissions*

In 1998, about 90 % of Luxembourg's CO<sub>2</sub> emissions came from fossil fuel combustion. Only CO<sub>2</sub> emissions from small combustion grew between 1990 and 1998, whereas CO<sub>2</sub> emissions from the other sectors related to fossil fuel combustion decreased sharply (Figure 58). In general, within fossil fuel combustion, a shift from energy and manufacturing industries to small combustion and transport can be observed.

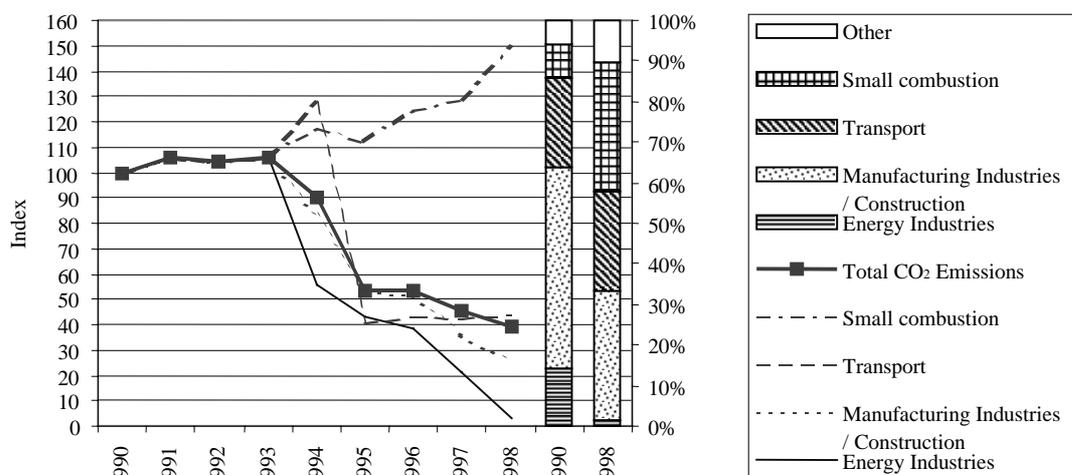
**Manufacturing industry:** Industry is the largest emitter of CO<sub>2</sub> in Luxembourg despite a 74.8 % drop (4.9 Tg) between 1990 and 1998. In 1998, still 32.1 % of CO<sub>2</sub> emissions came from manufacturing industries, down from 49.6 % in 1990. Coke consumption decreased sharply mainly due to the conversion of the steel industry to electric arc furnaces.

**Small combustion:** Small combustion was the only growing sector related to fossil fuel combustion and, therefore, became the second largest CO<sub>2</sub> emitter in Luxembourg. In absolute terms, CO<sub>2</sub> emissions from small combustion increased by 0.5 Tg. Their share in total CO<sub>2</sub> emissions grew from 8.3 % in 1990 to 31.7 % in 1998.

**Transport:** CO<sub>2</sub> emissions from transport decreased in absolute terms (1.6 Tg), but increased their share in total CO<sub>2</sub> emissions slightly from 21.8 % in 1990 to 24.5 % in 1998. The sharp decline of CO<sub>2</sub> emissions from transport in 1995 and their opposing trends compared with general transport figures are the most striking features of Luxembourg's transport sector. This is due to the fact that fuels for the transport sector sold in Luxembourg but consumed abroad are only considered up to 1994. In comparison fuel consumption by road transport rose by 38.4 % between 1990 and 1997 (Eurostat, 1999b). In addition, road passenger transport and road haulage grew by 20 % and 46.2 % respectively between 1990 and 1997 (EC, 1999).

**Energy industries:** CO<sub>2</sub> emissions from energy industries almost vanished. This was due to reductions in thermal power generation (42.4 %) and increases in electricity imports (+29.3 %) between 1990 and 1997. In 1997, net electricity imports were about 4 times domestic electricity production, but Luxembourg has always been a large electricity importer. Within thermal power production a fuel switch from oil to gas took place.

**Figure 58: Sectoral CO<sub>2</sub> emissions of Luxembourg (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### *Energy supply, by fuel*

Gross inland energy consumption decreased by 5.6 % from 1990 to 1997. Energy consumption per capita decreased from 9.4 toe in 1990 to 8 toe in 1997, but remained highest within the EU (EU15 average 3.8 toe). Luxembourg's share of fossil fuels in energy consumption declined from 89.2 % in 1990 to 85.3 % in 1997<sup>10</sup> (Figure 59). Within fossil fuels a switch from solid fuels to oil and gas took place.

**Oil:** The largest energy source is oil accounting for 57.3 % of gross inland energy consumption in 1998, up 12 percentage points from 1990. Transport used about three quarters of oil inland market consumption in 1998.

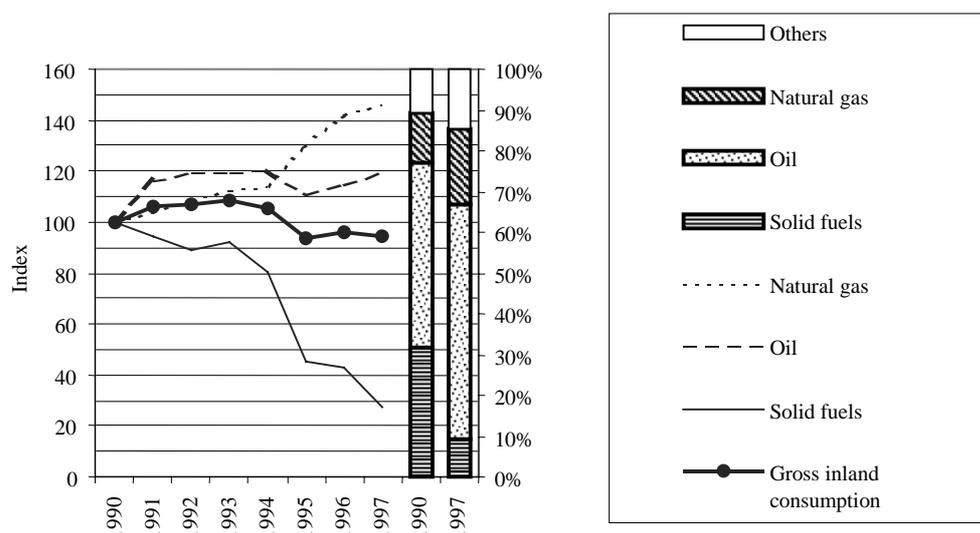
**Natural gas:** Natural gas consumption increased by 45.7 % between 1990 and 1997 and increased its share in gross inland energy consumption by 6.6 percentage points to 18.7 % in 1997. Most of this increase – in absolute terms – was due to rising gas consumption by industry. Natural gas use in industry grew by 37 % between 1990 and 1997; more than 60 % of natural gas was consumed in industry in 1997. Gas consumption in small combustion grew by about 43 % and accounted for about 32 % of total gas consumption.

**Solid fuels:** The use of solid fuels dropped by 72.4 % between 1990 and 1997. In 1997, the share of solid fuels in gross inland energy consumption was less than one third of the share in 1990. This was mainly due to a 84 % decline of coke use in the iron and steel industry.

<sup>10</sup> In case of Luxembourg, fossil fuel or renewable energy shares in gross inland energy consumption are misleading as Luxembourg is a considerable net importer of electricity. Net imports of electricity increase gross inland consumption, so the shares are lower than if Luxembourg did not import electricity.

**Renewable energies:** Renewable energies accounted for 1.4 % of gross inland energy consumption in 1997. Biomass (1.2 %) and hydro power (0.2 %) are the largest renewable energy sources. Biomass consumption was almost stable between 1990 and 1997, whereas hydro power use increased by 17.2 %.

**Figure 59: Luxembourg's gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include renewable energy sources and net electricity imports.

**Summary on actual progress for Luxembourg**

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☺	☺
	<b>Variations 1990/1998 in Tg of CO<sub>2</sub> equivalents and percent</b>	
Greenhouse gases	-8.2 Tg	-58.4 %
CH <sub>4</sub>	-0.02 Tg	-4.8 %
N <sub>2</sub> O	-0.1 Tg	-31.0 %
CO <sub>2</sub>	-8.1 Tg	-61.1 %
Energy industries	-1.8 Tg	-96.5 %
Manufacturing industries	-4.9 Tg	-74.8 %
Transport	-1.6 Tg	-56.2 %
Small combustion	+0.5 Tg	+49.3 %

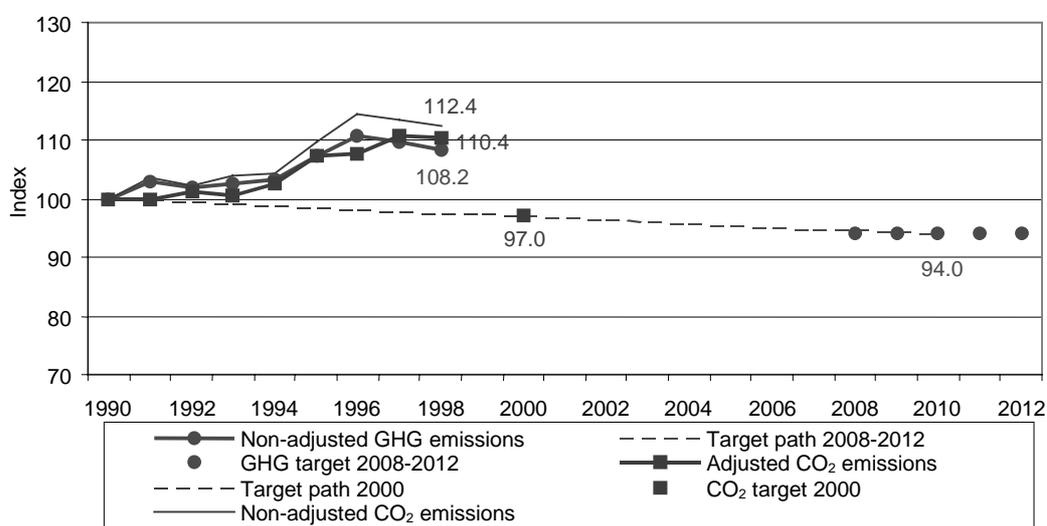
#### 4.1.11. The Netherlands

##### Actual progress in the Netherlands

In the burden sharing agreement, the Netherlands agreed to a 6 % reduction of greenhouse gas emissions by 2008-2012. In 1998, Dutch greenhouse gas emissions were 226 Tg. This was 8.2 % (17 Tg) above 1990 levels and 10.6 index points above the linear target path for 2008-2012 (Figure 60). The Netherlands accounted for 5.6 % of EU15 greenhouse gas emissions in 1998.

CO<sub>2</sub> emissions were 181.4 Tg in 1998, which was 12.4 % (20 Tg) above 1990 levels. For CO<sub>2</sub> emissions, the Netherlands set a 3 % reduction target for 2000 *corrected for temperature variations*. Temperature corrected CO<sub>2</sub> emissions grew by 10.4 % between 1990 and 1998. This was 12.8 index points above the target path for 2000.

**Figure 60: Dutch greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. For the Netherlands temperature corrections are taken into account, because the Dutch CO<sub>2</sub> emission target for 2000 refers to adjusted data.

##### Greenhouse gas emission trends

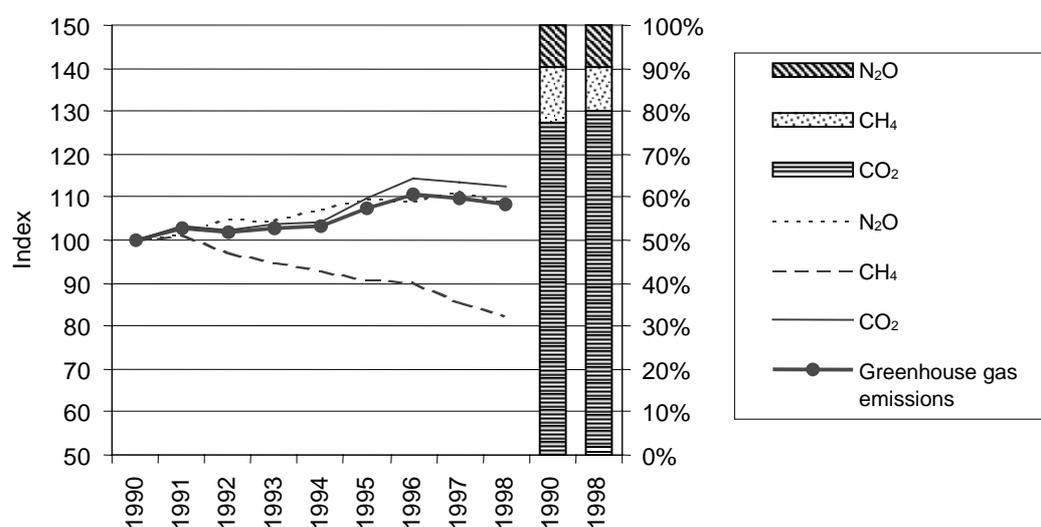
CO<sub>2</sub> and N<sub>2</sub>O emissions increased whereas CH<sub>4</sub> emissions declined from 1990 to 1998. Figure 61 illustrates that the share of CO<sub>2</sub> in greenhouse gas emissions increased from 77.2 % in 1990 to 80.3 % in 1998. CH<sub>4</sub> reduced its share from 13 % in 1990 to 9.9 % in 1998, whereas the share of N<sub>2</sub>O in greenhouse gas emissions was stable at 9.8 %.

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions declined almost steadily and were 17.6 % (4.8 Tg of CO<sub>2</sub> equivalents) below 1990 levels in 1998. Main sources of CH<sub>4</sub> emissions are waste, agriculture and fugitive emissions of oil and natural gas. As CH<sub>4</sub> emissions from all major sources show almost the same declining trend, shares did not change significantly. Waste accounted for 41.9 % of CH<sub>4</sub> emissions in 1998, down

2.1 percentage points from 1990. Agriculture increased its share from 39.1 % in 1990 to 40.8 % in 1998. And the share of fugitive emissions of oil and natural gas stabilised at around 14 %.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions increased by 8.8 % (1.8 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. The major sources of N<sub>2</sub>O emissions, industrial processes and agriculture, increased by 7.3 % and 16.7 % respectively. In contrast to many other Member States, N<sub>2</sub>O emissions from transport did not grow in the 1990s, but were even slightly below 1990 levels in 1998. The major source of N<sub>2</sub>O emissions are industrial processes accounting for 47.2 % of total N<sub>2</sub>O emissions in 1998, down 0.7 percentage points from 1990. Agriculture increased its share from 33.7 % in 1990 to 36.2 % in 1998.

**Figure 61: Dutch greenhouse gas emissions (excl. LUCF)**



Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

### ***CO<sub>2</sub> emission trends and driving forces***

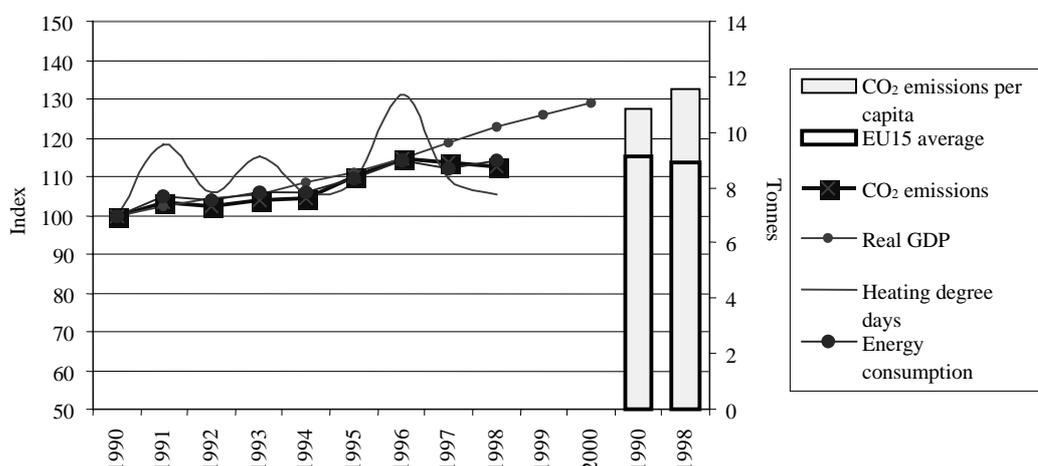
CO<sub>2</sub> emissions increased by 12.4 % from 1990 to 1998. In general, development of CO<sub>2</sub> emissions, gross inland energy consumption and GDP went more or less parallel until 1996. In 1997 and 1998, CO<sub>2</sub> emissions and energy consumption seem to have decoupled from GDP growth (Figure 62). As a consequence, carbon intensity of energy consumption has not improved whereas CO<sub>2</sub> emissions per GDP decreased from 725 kg per 1000 ECU in 1990 to 663 kg in 1998. This was still well above the EU15 average of 545 kg per 1000 ECU in 1998.

Per capita CO<sub>2</sub> emissions are also high, growing from 10.8 tonnes in 1990 to 11.6 tonnes in 1998 (EU15 average in 1998: 8.9 tonnes). The reason for high per capita CO<sub>2</sub> emissions (only Belgium, Finland and Luxembourg have higher ratios) is the high dependence on fossil fuels.

Temperature variations have considerable impacts on CO<sub>2</sub> emissions from small combustion. According to data submitted by the Netherlands (Olivier et al., 1999), CO<sub>2</sub> emissions corrected for temperature variations increased by 10.4 % between 1990 and 1998, i.e. 2 percentage points less than unadjusted CO<sub>2</sub> emissions.

Temperature adjusted s illustrate an almost steady increase in CO<sub>2</sub> emissions from 1991 to 1998, thus modifying, to a certain extent, the decrease of unadjusted data in 1997 and 1998.

**Figure 62: Dutch CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were taken from Olivier et al. (1999).

### *Sectoral breakdown of CO<sub>2</sub> emissions*

More than 95 % of Dutch CO<sub>2</sub> emissions come from fossil fuel combustion. Within fossil fuel combustion, no sector reduced CO<sub>2</sub> emissions in absolute terms between 1990 and 1998 (Figure 63). In relative terms, a shift from small combustion and manufacturing industries to transport can be observed.

**Energy industries:** The largest CO<sub>2</sub> emitter is the energy industry which accounted for 32.2 % of total CO<sub>2</sub> emissions in 1998. This share stabilised between 1990 and 1998, as the increase in CO<sub>2</sub> emissions from energy industry (+11.3 % or 6 Tg) was almost the growth rate of total CO<sub>2</sub> emissions. The growth in this sector was mainly due to electricity production, not to oil refining. The latter accounted for 25 % of the sector total in 1990.

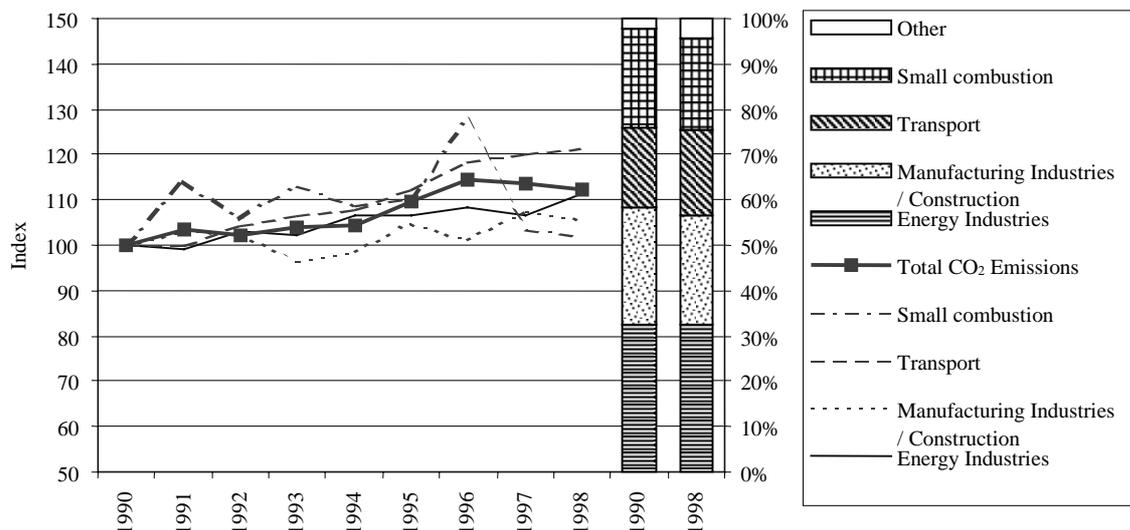
**Manufacturing industries:** Second largest emitter is the industry sector with a share of 24.2 % in total CO<sub>2</sub> emissions. This is a comparatively high share (EU15 average 18 %). One reason for this is the large share of the petrochemical industries due to the large number of oil refineries in the country. CO<sub>2</sub> emissions from energy carriers used as chemical feedstock, which are included in this sector, account for about 30 % of the industry total. In absolute terms, CO<sub>2</sub> emissions from manufacturing industries increased by 2.4 Tg.

**Transport:** In transport CO<sub>2</sub> emissions increased by 21.6 % (6.2 Tg). One reason for this seems to be high growth of goods transport: road haulage increased by 41.5 % between 1990 and 1997 compared to an average of 29.4 % in EU15. Passenger transport grew by 11 % from 1990 to 1997 (less than EU15 average

growth of 14.7 %). In absolute terms, passengerkilometers per person are below EU15 average and cycling is at a record high level: in the early 1990s, 27 % of all trips were made by bicycle, and in 1995, each Dutch person travelled 853 km by bicycle (EU15 average: 186 km) (EC, 1999).

**Small combustion:** Small combustion grew slowly by 2.1 % (0.8 Tg) from 1990 to 1998, but showed considerable fluctuations according to temperature variations.

**Figure 63: Sectoral CO<sub>2</sub> emissions of the Netherlands (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### *Energy supply, by fuel*

Gross inland energy consumption increased by 12 % from 1990 to 1997. Both energy consumption per capita and energy intensity of GDP are higher than EU15 average: energy consumption per capita increased from 4.5 toe in 1990 to 4.8 toe in 1997 (EU15 average 3.8), but energy intensity of GDP decreased from 301 toe per MECU in 1990 to 284 toe in 1997 (EU15 average 237 toe).

The Netherlands has one of the highest shares of fossil fuels in energy consumption. Figure 64 illustrates that in 1997, 95.8 % of gross inland consumption were fossil fuels; a share which has stabilised since 1990.

**Natural gas:** A striking feature of the Dutch energy consumption is the high reliance on natural gas. Gas was the largest energy source in 1998 accounting for 47.2 % of gross inland consumption. No other Member State has a comparable high share of gas. One reason for this is that gas is the only significant domestic energy source. The Netherlands is the second natural gas producer in the EU producing about one third of EU production and the largest exporter of gas (about 50 % of primary gas production is exported).

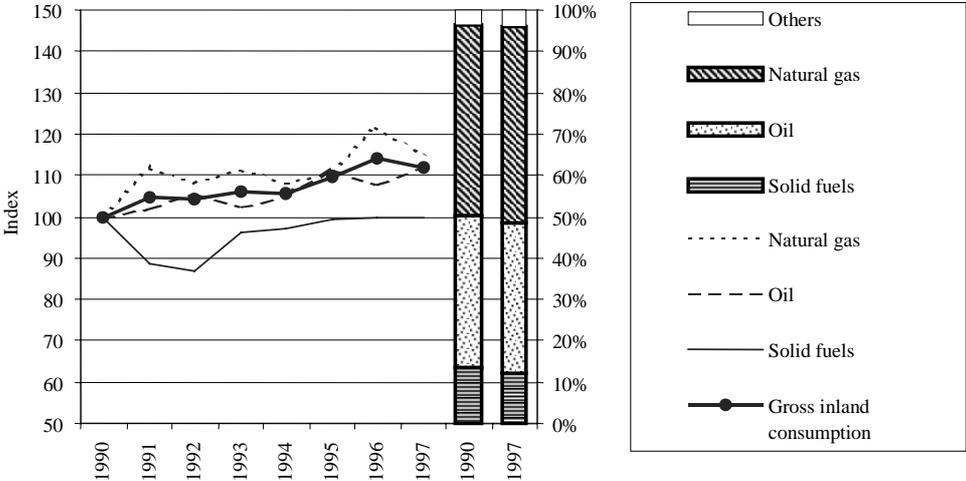
Figure 64 illustrates that the gas consumption curve is very similar to the temperature variation curve in Figure 62. In fact, about 70 % of final energy consumption of small combustion is natural gas and about 45 % of total gas inland market consumption is used in this sector.

**Oil:** Oil is the second most important energy source with a share of 36.4 % in gross inland consumption in 1997. About 58 % of oil inland market consumption is used in transport, second is non-energy use with a share of 28 %.

**Solid fuels:** The use of solid fuels decreased in the early 1990s but recovered and stabilised in absolute terms over the period 1990-1997. About 60 % of hard coal gross inland consumption is used in power stations, 27 % in coking plants.

**Renewable energies:** Renewable energy consumption increased by 71.6 % between 1990 and 1997 and accounted for 2 % of gross inland energy consumption in 1997. Biomass (1.9 %) and wind power (0.1 %) are the largest renewable energy sources. Wind power increased by a factor 8.5 between 1990 and 1997, solar energy more than trebled.

**Figure 64: Dutch gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include nuclear power, renewable energy sources and net electricity imports.

**Electricity generation**

Electricity gross generation increased by 20.4 % from 1990 to 1997. Per capita production increased from 4,833 kWh in 1990 to 5,567 kWh in 1997. This was below EU15 average of 6,483 kWh per capita. One explanation for this rather low figure is the Netherlands being a considerable electricity importer (mainly from Germany and France): in 1997, net electricity imports were 15 % of Dutch net electricity production.

Similar to overall energy consumption, Dutch electricity generation relies heavily on fossil fuels: in 1997, 58.3 % of electricity was produced in gas fired power stations with rising trends. Second is coal fired electricity generation which decreased its share from 34.8 % in 1990 to 26.5 % in 1997. Oil has a constant share of about 4.5 % whereas nuclear power production decreased from 4.9 % in 1990 to 2.8 % in 1997. Renewable energy sources play a minor role, but growth rates are considerable: biomass use for power production almost trebled between 1990 and 1997 and wind power production increased by more than 800 %.

Strong growth in CHP capacity has been a feature of the Dutch electricity sector. In addition, ambitious energy efficiency programmes, renewable energy targets and energy tax schemes have been developed.

*Summary on actual progress for the Netherlands*

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☹ (1)	☹
	Variations 1990/1998 in Tg of CO <sub>2</sub> equivalents and percent	
Greenhouse gases	+17.0 Tg	+8.2 %
CH <sub>4</sub>	-4.8 Tg	-17.6 %
N <sub>2</sub> O	+1.8 Tg	+8.8 %
CO <sub>2</sub> <sup>(2)</sup>	+17.5 Tg (+20.0 Tg)	+10.4 % (+12.4 %)
Energy industries	+6.0 Tg	+11.3 %
Manufacturing industries	+2.4 Tg	+5.7 %
Transport	+6.2 Tg	+21.6 %
Small combustion	+0.8 Tg	+2.1 %

(1) For the Netherlands temperature corrections are taken into account, because the Dutch CO<sub>2</sub> emission target for 2000 refers to adjusted data.

(2) Dutch variations of CO<sub>2</sub> emissions refer to data adjusted for temperature variations; unadjusted data is given in brackets

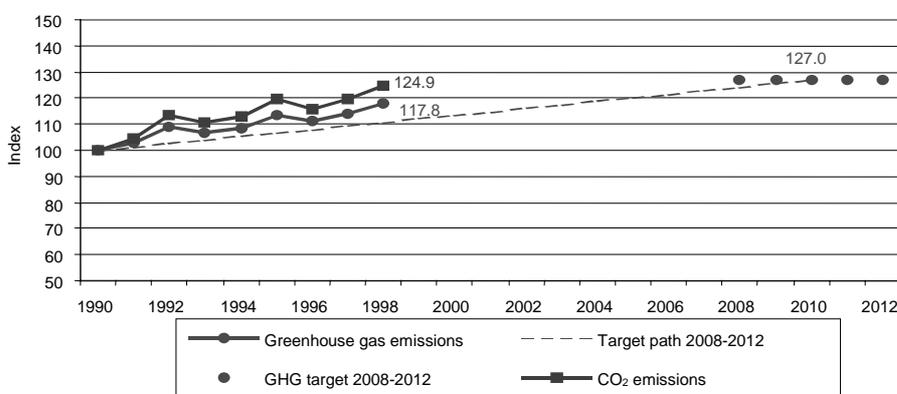
#### 4.1.12. Portugal

##### Actual progress in Portugal

In the burden sharing agreement, Portugal agreed to limit its greenhouse gas emissions to a 27 % increase by 2008-2012. In 1998, greenhouse gas emissions were 73.8 Tg. This was 17.8 % (11.1 Tg) above 1990 levels and 7 index points above the linear target path for 2008-2012 (Figure 65). Portugal accounted for 1.8 % of greenhouse gas emissions of the EU in 1998.

CO<sub>2</sub> emissions were 53.9 Tg, which was 24.9 % (10.8 Tg) above 1990 levels in 1998. Portugal did not set a CO<sub>2</sub> limitation target for 2000.

**Figure 65: Portuguese greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

##### Greenhouse gas emission trends

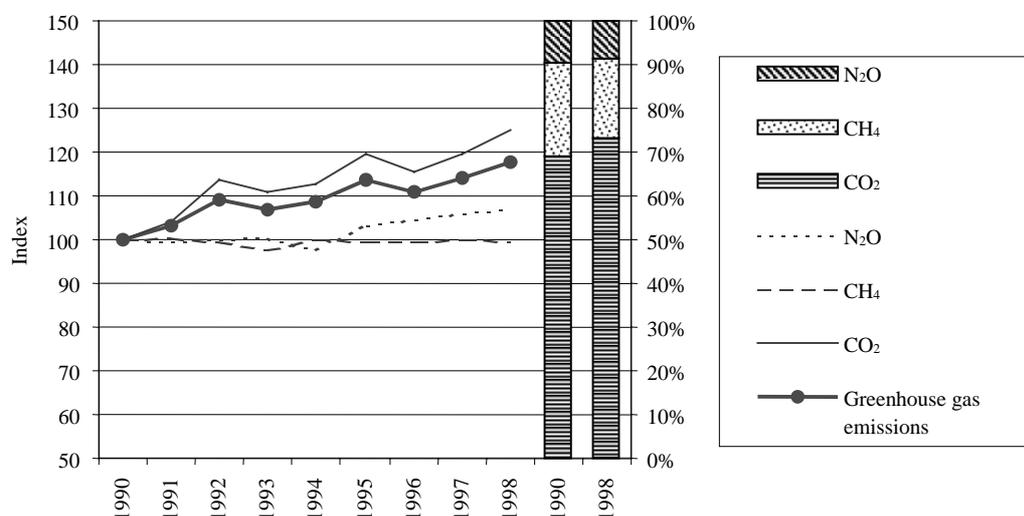
The share of CO<sub>2</sub> emissions in Portuguese greenhouse gas emissions is relatively low indicating that agriculture is still an important economic sector. Figure 66 illustrates that in 1998, 73.1 % of greenhouse gas emissions were CO<sub>2</sub> emissions, up 4.2 percentage points from 1990 (EU15 average in 1998: 82.2 %). CH<sub>4</sub> emissions were second accounting for 18.1 % of greenhouse gas emissions in 1998, down 3.2 percentage points from 1990. N<sub>2</sub>O also reduced its share from 9.8 % in 1990 to 8.9 % in 1998.

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions were almost stable between 1990 and 1998. Waste and agriculture account for more than 95 % of CH<sub>4</sub> emissions, but the two main sources showed opposite trends. Whereas CH<sub>4</sub> emissions from waste increased by 10.8 % between 1990 and 1998, emissions from agriculture reduced by 9.6 %. In 1998, the shares of waste and agriculture in Portuguese CH<sub>4</sub> emissions were 53.5 % and 42.9 % respectively.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions increased by 6.8 % (0.4 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. Major sources of N<sub>2</sub>O emissions are agriculture and waste. The share of agriculture in N<sub>2</sub>O emissions decreased from 42.8 % in 1990 to 36.4 % in 1998. A special feature of Portuguese N<sub>2</sub>O emissions is a large share of

N<sub>2</sub>O emissions from waste: in 1998, they accounted for 36.8 %, up 5.6 percentage points from 1990. (In EU15, 1.6 % of N<sub>2</sub>O emissions came from waste in 1998). N<sub>2</sub>O emissions from transport increased much by 179.7 % between 1990 and 1998.

**Figure 66: Portuguese greenhouse gas emissions (excl. LUCF)**



Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

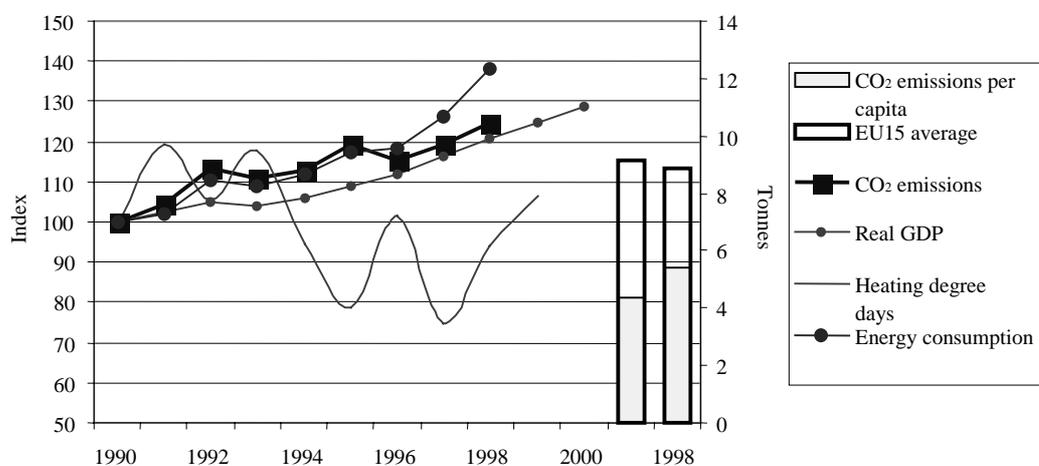
### *CO<sub>2</sub> emission trends and driving forces*

Figure 67 illustrates that up to 1995, the CO<sub>2</sub> emission index went very close to the index of gross inland consumption; in recent years, CO<sub>2</sub> emissions decoupled slightly and came closer to the index of economic growth. Therefore, over the whole period 1990-1998, CO<sub>2</sub> emissions per GDP increased slightly to 821 kg per 1000 ECU in 1998, which was well above EU15 average (545 kg). Apart from Greece, Portugal has the highest CO<sub>2</sub> emissions per unit of GDP. In contrast to this, CO<sub>2</sub> emissions per capita are the lowest in EU15 because of low GDP and mild temperatures. In 1998, per capita CO<sub>2</sub> emissions were 5.4 tonnes compared with the EU15 average of 8.9 tonnes.

Energy consumption increases more rapidly than economic activity leading to increasing energy intensity of economic activity: energy consumption per GDP increased from 310 toe per MECU in 1990 to 338 toe in 1997 (EU15 average in 1997: 237 toe). Again, Portuguese energy intensity of GDP is amongst the highest in the EU.

Temperature variations do not seem to influence CO<sub>2</sub> emissions. Similar to Spain, cooling degree days might be a more significant variable for Portugal than heating degree days.

**Figure 67: Portuguese CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were obtained from Eurostat.

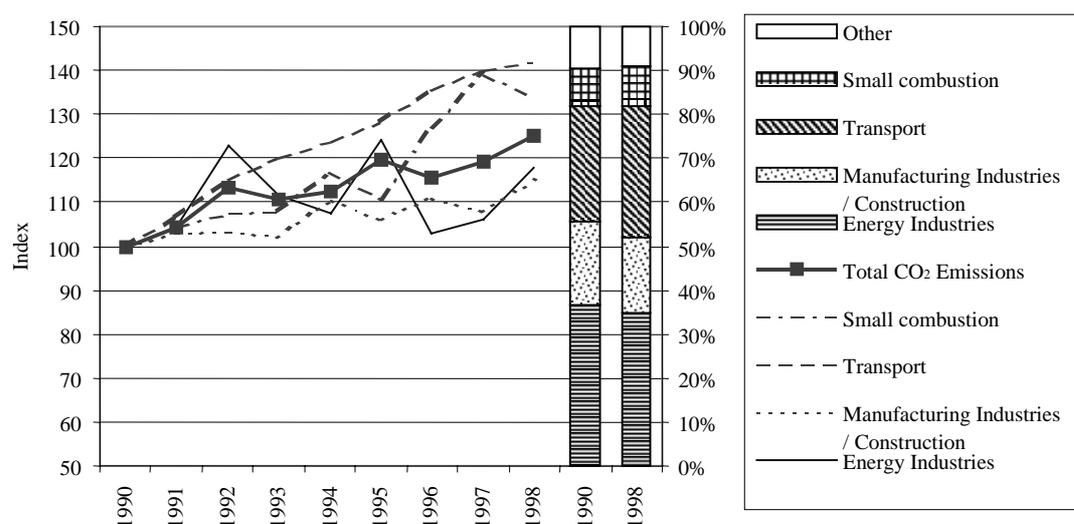
### *Sectoral breakdown of CO<sub>2</sub> emissions*

About 91 % of Portuguese CO<sub>2</sub> emissions come from fossil fuel combustion. Within fossil fuel combustion, CO<sub>2</sub> emissions from all sectors grew between 1990 and 1998 with transport at the top (Figure 68). In general, a shift from energy and manufacturing industries to transport and small combustion can be observed.

**Energy industries:** Energy industries still is the largest emitting sector in Portugal, but its share decreased from 36.9 % in 1990 to 34.8 % in 1998. Variations were high with peaks in 1992 and 1995 due to comparatively low hydro power production and increased thermal power generation in these years. In absolute terms, CO<sub>2</sub> emissions from energy industries increased by 2.8 Tg.

**Transport:** CO<sub>2</sub> emissions from transport grew by 41.9 % (4.8 Tg) between 1990 and 1998. Therefore, transport increased its share in CO<sub>2</sub> emissions by 3.6 percentage points to 30 % in 1998. Fuel consumption by road transport increased by 49.6 % and motor vehicles in use by more than 55 % between 1990 and 1997. Nevertheless, car ownership, with 297 cars per inhabitant far below EU15 average of 454 in 1997. Transport growth rates seem to be driven by passenger transport: person kilometers driven in passenger cars increased by 67.7 % (EU15 average: 14.7 %) between 1990 and 1997. In contrast to that, road haulage increased by 10.7 % which was well below EU15 average of 29.4 % (EC, 1999).

**Figure 68: Sectoral CO<sub>2</sub> emissions of Portugal (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

**Manufacturing industry** reduced its share in CO<sub>2</sub> emissions although increasing in absolute terms (+1.2 Tg). CO<sub>2</sub> emissions from **small combustion** experienced dynamic growth rates (+34 % or 1.2 Tg), increasing its share from 8.3 % in 1990 to 8.9 % in 1998.

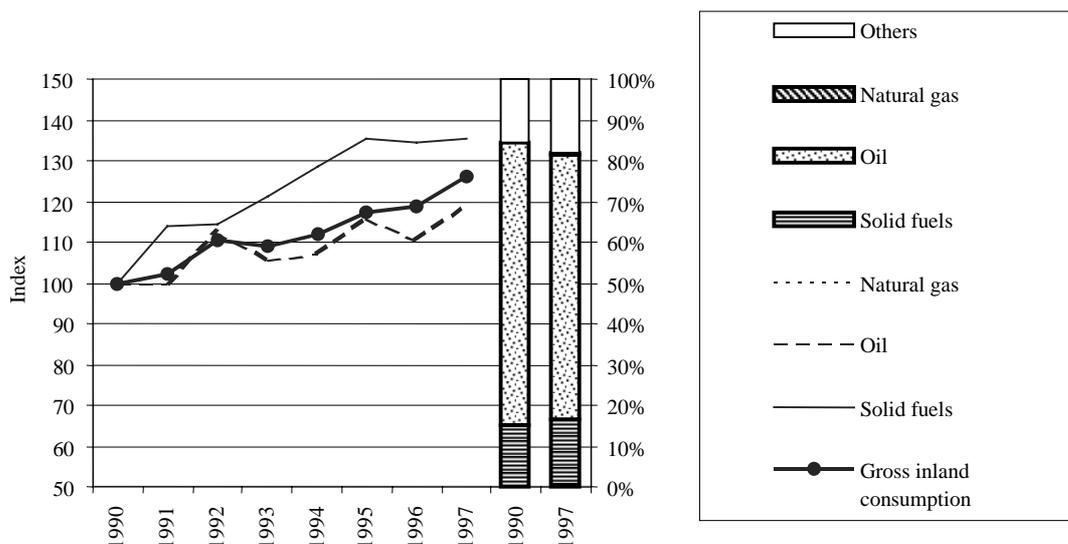
#### *Energy supply, by fuel*

Portugal showed the fastest growth rates of energy consumption in the EU: between 1990 and 1997, Portuguese gross inland energy consumption grew by 26.3 %. Energy consumption per capita is the lowest in the EU, but rapidly rising. Energy consumption per GDP is the second highest in the EU (after Greece). Figure 69 illustrates that the share of fossil fuels slightly declined from 84.2 % in 1990 to 81.9 % in 1997. Biomass and hydro power account for 11.3 % and 5.3 % of gross inland consumption respectively. Import dependency is high as Portugal has no domestic fossil fuel production.

**Oil:** Oil is by far the largest energy source in Portugal accounting for 65.1 % of gross inland consumption in 1998, down 3.8 percentage points. This is the largest share of EC Member States. Oil consumption increased by 19.4 % between 1990 and 1997. Transport and industry are the major oil consumers accounting for about 40 % and 19 % of inland market consumption respectively in 1997. The peaks in 1992 and 1995 indicate that a considerable share of power was generated in oil fired power plants, which balanced declines of hydro power production in these years.

**Solid fuels:** Portugal is one of the few Member States where coal consumption increased considerably in the 1990s. Figure 69 illustrates that coal use grew almost steadily between 1990 and 1995 and then stabilised at about 35 % above 1990 levels. Accordingly, coal's share in gross inland energy consumption increased from 15.3 % in 1990 to 16.4 % in 1997. Coal consumption in power plants increased by 38 % between 1990 and 1997; about 80 % of coal is used in power plants.

**Figure 69: Portuguese gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include renewable energy sources and net electricity imports.

**Natural gas:** Up to 1996, Portugal had no natural gas consumption. A gas pipeline started operation in February 1997; almost half of gas is used in industry. Power generation from gas is expected to increase substantially.

**Renewable energies:** Renewable energy consumption increased by 35.3 % between 1990 and 1997 and accounted for 16.9 % of gross inland energy consumption in 1990. About two thirds of renewable energies is biomass use, one third is hydro power. Geothermal and solar energy grew at a fast pace in the 1990s and together accounted for 0.3 % of gross inland energy consumption in 1997.

### *Electricity generation*

Gross electricity generation grew by 20 % between 1990 and 1997. Per capita electricity generation amounted to 3,441 kWh in 1997 and was well below EU15 average (6,483 kWh). In 1997, 61.2 % of power was produced in thermal combustion plants, 38.5 % in hydro power plants.

Oil and hard coal account for the bulk of thermal power production but show opposing trends. whereas oil decreased its share in total power generation from 33 % in 1990 to 19.8 % in 1997, coal increased from 31.8 % to 37.9 %. As hydro power production fluctuates considerably, coal and oil fired power plants act as swing producers. CO<sub>2</sub> emissions from energy industries fluctuate according to the balancing power production from thermal power plants.

*Summary on actual progress in Portugal*

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	No target	☹
	Variations 1990/1998 in Tg of CO <sub>2</sub> equivalents and percent	
Greenhouse gases	+11.1 Tg	+17.8 %
CH <sub>4</sub>	-0.03 Tg	-0.2 %
N <sub>2</sub> O	+0.4 Tg	+6.8 %
CO <sub>2</sub>	+10.8 Tg	+24.9 %
Energy industries	+2.8 Tg	+17.8 %
Manufacturing industries	+1.2 Tg	+15.1 %
Transport	+4.8 Tg	+41.9 %
Small combustion	+1.2 Tg	+34.0 %

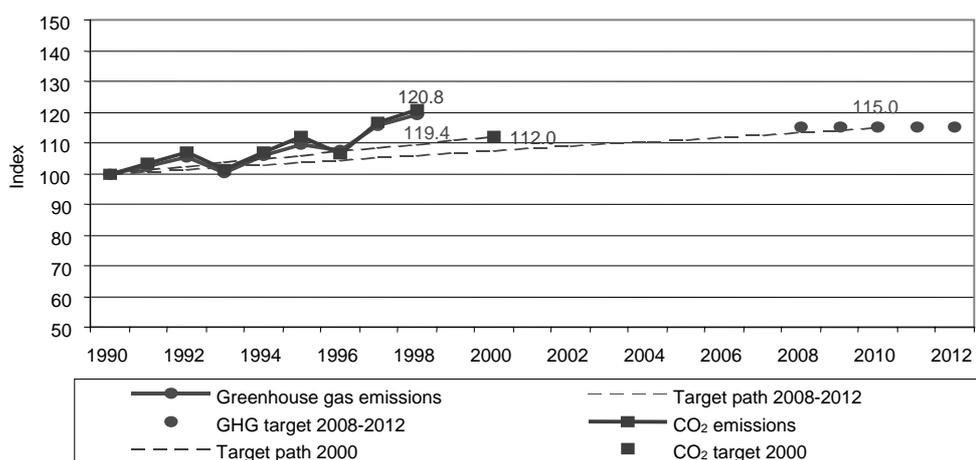
### 4.1.13. Spain

#### Actual progress in Spain

In the burden sharing agreement, Spain agreed to limit its greenhouse gas emissions to a 15 % increase by 2008-2012 based on 1990 levels. In 1998, greenhouse gas emissions were 360.5 Tg. This was 19.4 % (58.6 Tg) above 1990 levels and 13.4 index points above the linear target path for 2008-2012 (Figure 70). If industrial F-gases are included, Spanish greenhouse gas emissions increased by 21 % between 1990 and 1998. Spain accounted for 8.9 % of EU15 greenhouse gas emissions in 1998.

Spain aims at limiting its CO<sub>2</sub> emissions increase to 11 to 13 % between 1990 and 2000 (as average value a 12 % increase has been taken in Figure 70). In 1998, Spanish CO<sub>2</sub> emissions were 273 Tg, which was 20.8 % (47 Tg) above 1990 levels. Therefore, in 1998, CO<sub>2</sub> emissions were 11.2 index points above the target path for 2000.

**Figure 70: Spanish greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

#### Greenhouse gas emission trends

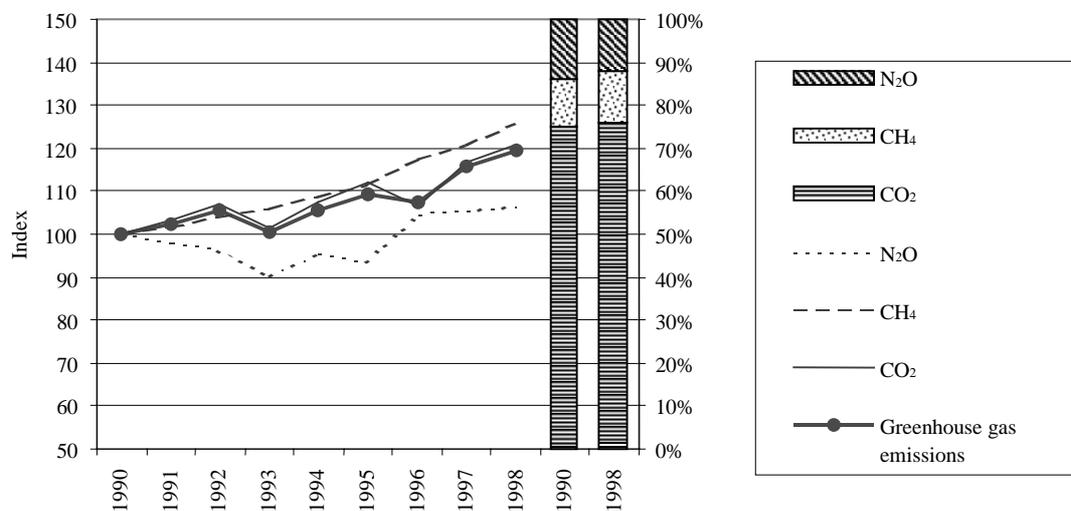
The share of CO<sub>2</sub> emissions in Spanish greenhouse gas emissions is below EU15 average illustrating the importance of agriculture for the Spanish economy. CO<sub>2</sub> emissions made up for 75.7 % of Spanish greenhouse gas emissions in 1998, up 0.8 percentage points. The share of N<sub>2</sub>O emissions decreased from 13.7 % in 1990 to 12.2 % in 1998, whereas CH<sub>4</sub> increased in absolute and relative terms: in 1998, 12.1 % of greenhouse gas emissions were CH<sub>4</sub> emissions (Figure 71).

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions showed a constant rise and were 26 % (9 Tg of CO<sub>2</sub> equivalents) above 1990 levels in 1998. This increase was mainly due to growth rates in waste with a 71.5 % increase between 1990 and 1998. Emissions from agriculture increased by 6.3 % and fugitive emissions from oil and gas increased

much by 106.7%, but only accounted for 5 % of CH<sub>4</sub> emissions in 1998. Accordingly, emissions from agriculture and waste still make up for almost 90 % of CH<sub>4</sub> emissions in Spain but shares have shifted: agriculture reduced its share from 57 % in 1990 to 48.1 % in 1998, whereas waste increased from 29.8 % to 40.5 %.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions declined between 1990 and 1993 but increased since then and were 6.3 % (2.6 Tg of CO<sub>2</sub> equivalents) above 1990 levels in 1998. Agriculture dominates N<sub>2</sub>O emissions accounting for 80.2 % of N<sub>2</sub>O emissions in 1998, down 1.1 percentage point from 1990. The share of fuel combustion increased from 10.4 % in 1990 to 13.2 % in 1998 (transport more than doubled in absolute terms), whereas industrial processes reduced their share from 7 % in 1990 to 5 % in 1998.

**Figure 71: Spanish greenhouse gas emissions (excl. LUCF)**



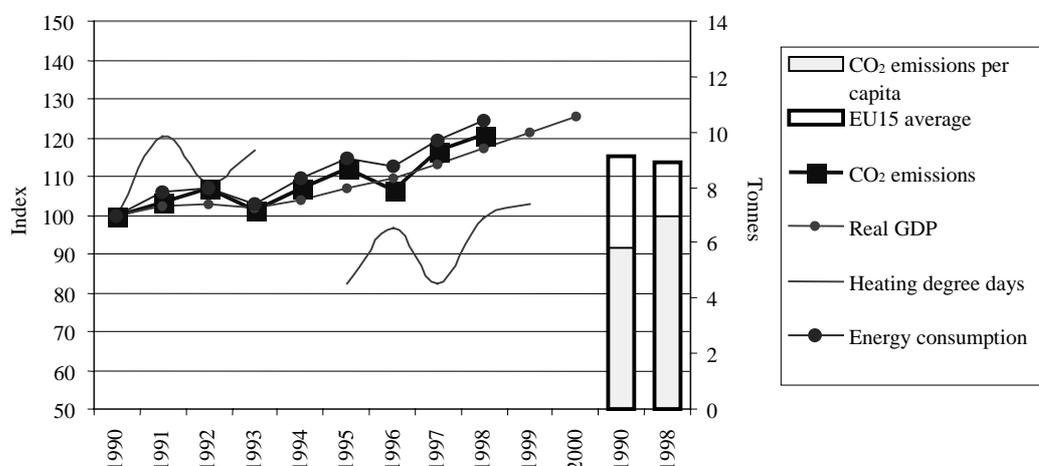
Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

### **CO<sub>2</sub> emission trends and driving forces**

Spanish CO<sub>2</sub> emissions increased almost steadily between 1990 and 1998 with two dips in 1993 and 1996. In 1993, economic recession contributed to lower CO<sub>2</sub> emissions, whereas one reason for the 1996 slump was large hydro power production in this year. Figure 72 seems to indicate that temperature variations have opposite effects in Spain than in the northern Europe: in Spain, colder years seem to reduce energy consumption, therefore, cooling degree days might be the more appropriate reference curve.

In general, CO<sub>2</sub> emissions rose slightly faster than economic activity but slightly slower than gross inland energy consumption. This means that carbon intensity of GDP increased and carbon intensity of energy consumption decreased. For example, CO<sub>2</sub> emissions per unit GDP increased from 568 kg per 1000 ECU in 1990 to 584 kg in 1998, which was slightly above EU15 average in 1998 (545 kg). As Spanish GDP per capita still lags behind EU15 average, CO<sub>2</sub> emissions per capita do so as well: they increased from 5.8 tonnes per inhabitant in 1990 to 6.9 tonnes in 1998, compared with the EU15 average of 8.9 tonnes.

**Figure 72: Spanish CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were obtained from Eurostat, figures for 1994 were not available.

### *Sectoral breakdown of CO<sub>2</sub> emissions*

Figure 73 illustrates that in 1998 90 % of Spanish CO<sub>2</sub> emissions came from fossil fuel combustion. CO<sub>2</sub> emissions from all sectors related to fossil fuel combustion grew between 1990 and 1998 with transport at the top. In general, a shift from energy industries to transport can be observed.

**Energy industries:** The largest CO<sub>2</sub> emitter are energy industries accounting for 29 % of CO<sub>2</sub> emissions in 1998, down 4.1 percentage points from 1990. CO<sub>2</sub> emissions from energy industries fluctuated considerably but, in absolute terms, increased slightly by 4.4 Tg (5.9 %) between 1990 and 1998. One reason for the trough in 1996 is the decline of coal-fired power production due to increased hydro power generation in that year.

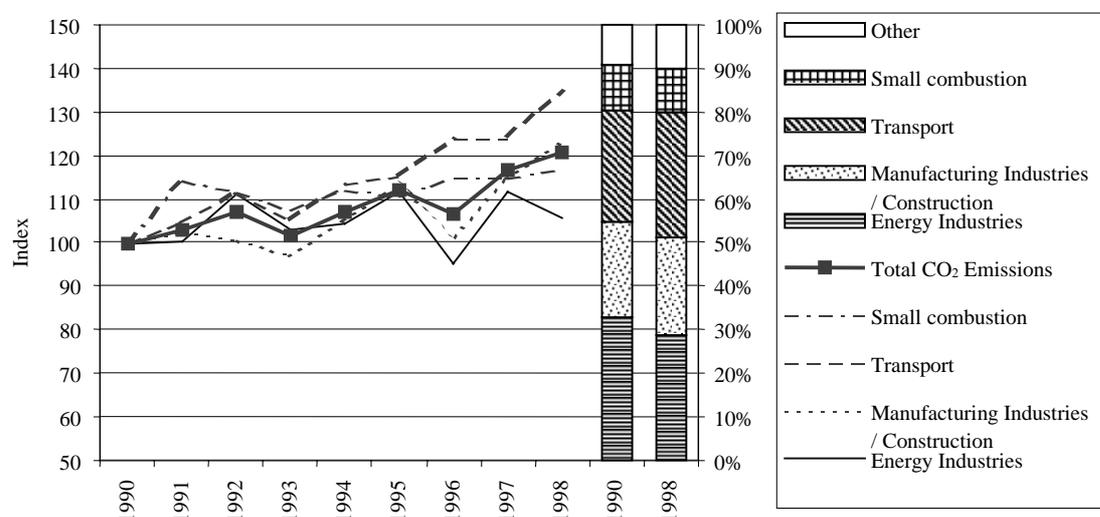
**Transport:** CO<sub>2</sub> emissions from transport were growing at a fast pace between 1990 and 1998 and were 35.1 % above 1990 levels in 1998. With an absolute increase of 20.4 Tg, Spain accounted for the highest increase in CO<sub>2</sub> emissions from transport (in absolute terms) of all EC Member States. Fuel consumption by road transport rose by 24.1 % between 1990 and 1997. Person kilometers driven in passenger cars increased by 24.1 % as well and road haulage grew by 21.9 % between 1990 and 1997. Although car ownership grew by 26.6 % to 390 cars per inhabitant, it was still below EU15 average of 454 cars in 1997 (EC, 1999).

**Manufacturing industry:** CO<sub>2</sub> emissions from manufacturing industries grew by 23 % (11.2 Tg) between 1990 and 1998. Their share in total CO<sub>2</sub> emissions increased slightly to 22 % in 1998.

**Small combustion:** CO<sub>2</sub> emissions from small combustion are of relatively minor importance mainly due to climatic reasons. In 1998, they accounted for 10.3 % of

total CO<sub>2</sub> emissions. Nevertheless, in absolute terms, CO<sub>2</sub> emissions from small combustion increased by 4 Tg (16.7 %) between 1990 and 1998.

**Figure 73: Sectoral CO<sub>2</sub> emissions of Spain (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### *Energy supply, by fuel*

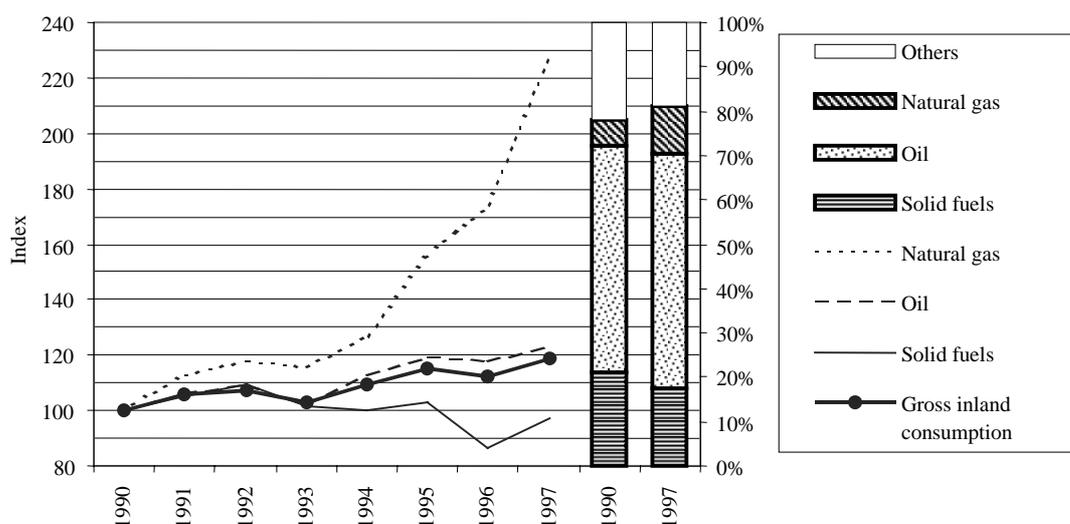
Gross inland consumption grew by 19.1 % between 1990 and 1997. The share of fossil fuel use in gross inland consumption rose from 78 % in 1990 to 81 % in 1997 (Figure 74). Nuclear power accounted for 12.7 % in 1997; the remainder is renewable energy (mainly biomass and hydro power).

**Oil:** Oil is by far the largest primary energy source in Spain accounting for 52.9 % of gross inland consumption in 1997, up 1.8 percentage points. As Spain has hardly any domestic oil production, import dependency is high. The driving force of oil consumption is transport accounting for more than half of oil inland market consumption.

**Solid fuels:** The share of solid fuels (hard coal and lignite) in gross inland consumption declined from 21.3 % in 1990 to 17.4 % in 1997. Spain is a substantial hard coal producer: about 15 % of EU hard coal is produced in Spain; 55 % of Spanish hard coal consumption is produced domestically. Spanish lignite production has almost halved between 1990 and 1997. About 85 % of hard coal and almost 100 % of lignite are used in power stations. Coal subsidies are substantial. The International Energy Agency estimates that in 1996 about 152 million Ptas were paid to Spanish coal producers; annual per tonne subsidy increased from 3,255 in 1990 to 8,568 Ptas in 1996; provisional estimates show a slight decline for 1997 (IEA, 1998a).

**Natural gas:** The use of natural gas has increased much especially since 1994. In 1997, natural gas consumption was 127.5 % above 1990 levels. More than half of gas inland market consumption is used by industry, about 25 % in power stations. In 1997, gas consumption in power stations was more than ten times higher than in 1990; gas use in households increased by almost 170 %.

**Figure 74: Spanish gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include nuclear power, renewable energy sources and net electricity imports.

**Renewable energies:** Renewable energy consumption increased by 16.5 % between 1990 and 1997 and accounted for 6.5 % of gross inland energy consumption in 1997. Biomass (3.6 %) and hydro power (2.8 %) are the largest sources of renewable energies. Wind power increased by a factor of 53 between 1991 and 1997 and accounted for 0.1 % of gross inland energy consumption in 1997.

### *Electricity generation*

Gross electricity generation grew by 23 % between 1990 and 1997 (EU15 average: 17.5 %), but Spanish per capita electricity production (4,749 kWh) is still well below EU15 average (6,483 kWh). About 50 % of electricity is produced in thermal power plants, nuclear power accounts for about 30 % and hydro for 20 %. Within thermal power production, fuel mix switched from solid fuels to gas and oil: In 1997, 30.3 % of gross electricity generation was produced in hard coal fired power generation, down 1.7 percentage points. The share of power production from lignite declined from 7.4 % in 1990 to 3.2 %. In contrast to this, the share of gas fired power production in gross electricity generation shot up from 1 % in 1990 to 8.7 % in 1997, and oil's share grew by 1.5 percentage points to 7.2 % in 1997. This means that, in 1997, about two thirds of electricity from conventional thermal power plants were produced by coal-fired power plants, whereas gas and oil accounted for about one third.

Biomass use for thermal power production and wind power grew at high rates in the 1990s.

### Summary on actual progress in Spain

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☹	☹
	<b>Variations 1990/1998 in Tg of CO<sub>2</sub> equivalents and percent</b>	
Greenhouse gases	+58.6 Tg	+19.4 %
CH <sub>4</sub>	+9.0 Tg	+26.0 %
N <sub>2</sub> O	+2.6 Tg	+6.3 %
CO <sub>2</sub>	+47.0 Tg	+20.8 %
Energy industries	+4.4 Tg	+5.9 %
Manufacturing industries	+11.2 Tg	+23.0 %
Transport	+20.4 Tg	+35.1 %
Small combustion	+4.0 Tg	+16.7 %

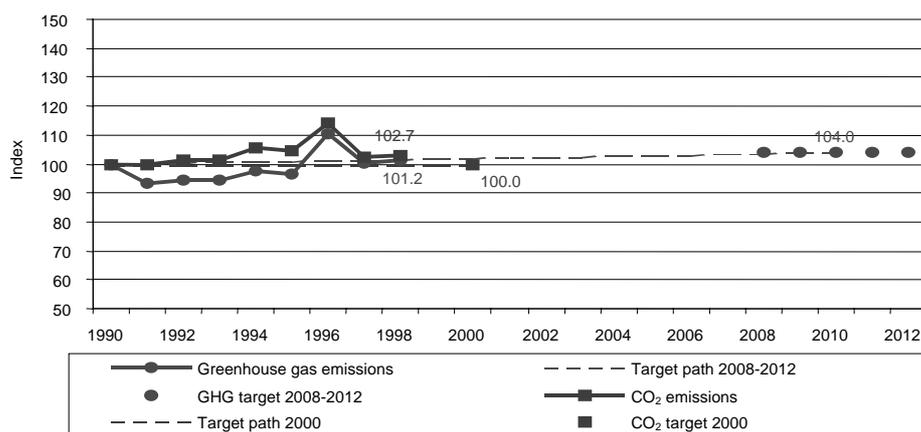
#### 4.1.14. Sweden

##### Actual progress in Sweden

In the burden sharing agreement, Sweden agreed to limit its greenhouse gas emissions to a 4 % increase on basis 1990 by 2008-2012. In 1998, Swedish greenhouse gas emissions were 70.3 Tg. This was 1.2 % (0.8 Tg) above 1990 levels or 0.4 index point below the linear target path for 2008-2012 (Figure 75). Sweden accounted for 1.7 % of EU15 greenhouse gas emissions in 1998.

For CO<sub>2</sub> emissions, Sweden set a stabilisation target by 2000. In 1998, CO<sub>2</sub> emissions were 57 Tg, which was 2.7 % (1.5 Tg) above 1990 levels. Therefore, in 1998, Swedish CO<sub>2</sub> emissions were 2.7 index points above the linear target path for 2000.

**Figure 75: Swedish greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

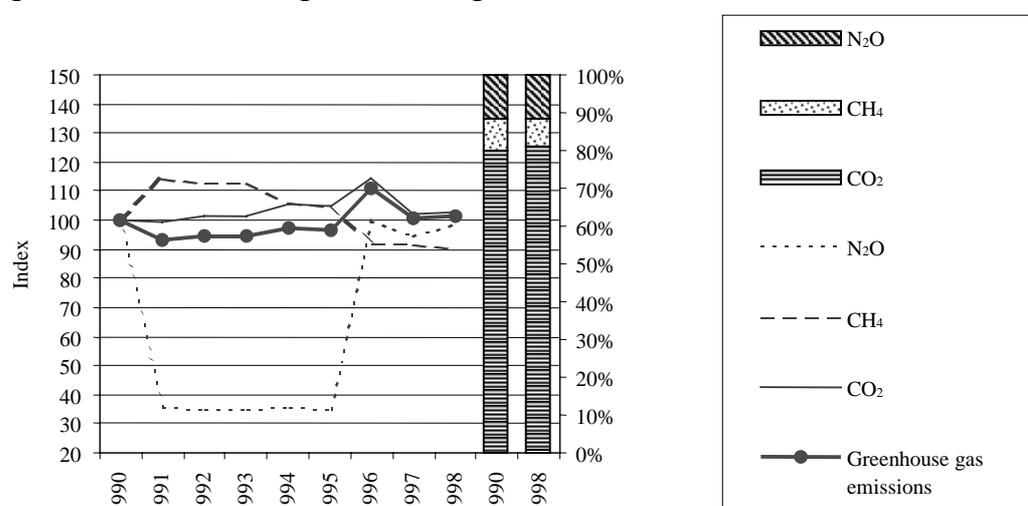
## Greenhouse gas emission trends

CO<sub>2</sub> accounted for 81 % of greenhouse gas emissions in 1998, up 1.2 percentage points from 1990. N<sub>2</sub>O emissions were second with a share of 11.3 % in 1998. CH<sub>4</sub> emissions accounted for 7.6 % of Swedish greenhouse gas emissions. Figure 76 illustrates why the curves of greenhouse gas and CO<sub>2</sub> emissions deviate considerably between 1991 and 1995. For these years N<sub>2</sub>O emissions from agriculture are not comparable with the emissions for the years 1990 and 1996-1998 due to use of different methodologies. The emissions for the years 1991-1995 will be recalculated. Sweden expects agricultural N<sub>2</sub>O emissions to be in the same range as 1990.

**CH<sub>4</sub> emissions:** After a sharp increase in 1991, CH<sub>4</sub> emissions decreased gradually and were 9.9 % (0.6 Tg of CO<sub>2</sub> equivalents) below 1990 levels in 1998. The largest CH<sub>4</sub> emitter is agriculture increasing its share from 56.3 % in 1990 to 62.3 % in 1998. Waste is second and accounted for 23.8 % of CH<sub>4</sub> emissions in 1998, down 6.1 percentage points from 1990.

**N<sub>2</sub>O emissions:** Between 1990 and 1998, Swedish N<sub>2</sub>O emissions decreased slightly by 1.2 % (0.1 Tg of CO<sub>2</sub> equivalents). Agriculture is the largest emitter accounting for 61.2 % of N<sub>2</sub>O emissions in 1998 having slightly reduced from 1990. Second was fuel combustion increasing its share to 28.6 % in 1998, but transport's share decreased (in contrast to many other Member States). The share of industrial processes in N<sub>2</sub>O emissions decreased slightly to 10.2 % in 1998.

**Figure 76: Swedish greenhouse gas emissions (excl. LUCF)**



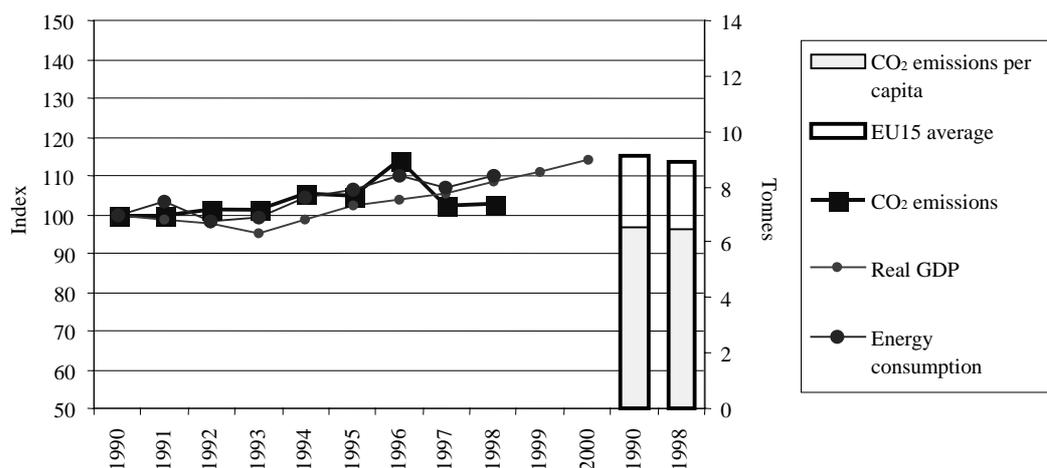
Note: The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure). For 1991-1995, agricultural N<sub>2</sub>O emissions are not comparable with the emissions for the years 1990 and 1996-1998 due to use of different methodologies. N<sub>2</sub>O emissions from agriculture for the years 1991-1995 will be recalculated.

## CO<sub>2</sub> emission trends and driving forces

In the first half of the 1990s, Sweden's CO<sub>2</sub> emissions and energy consumption grew faster than the economy. CO<sub>2</sub> emissions peaked in 1996, a cold and dry year, when fossil fuel fired thermal power production had to make up for lower hydro power production. Over the whole period 1990-1998, carbon intensity of energy consumption and of GDP decreased slightly (Figure 77).

Sweden's carbon intensity is already low due to the predominance of nuclear and hydro power in the important electricity sector. CO<sub>2</sub> emissions per GDP are the lowest in the EU and decreased from 307 kg per 1000 ECU in 1990 to 290 kg in 1998 (EU15 average in 1998: 545 kg). CO<sub>2</sub> emissions per capita reduced slightly to 6.4 tonnes in 1998 and were also one of the lowest in the EU (EU15 average in 1998: 8.9 tonnes).

**Figure 77: Swedish CO<sub>2</sub> emissions and driving forces (real GDP growth, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data. For Sweden no heating degree days are available.

### *Sectoral breakdown of CO<sub>2</sub> emissions*

Figure 78 illustrates that in 1998, about 92 % of Swedish CO<sub>2</sub> emissions came from fossil fuel combustion. CO<sub>2</sub> emissions from transport and energy industries increased, whereas emissions from small combustion and manufacturing declined in absolute terms between 1990 and 1998.

**Transport:** Transport is by far the largest CO<sub>2</sub> emitter in Sweden accounting for 37.1 % of CO<sub>2</sub> emissions in 1998, up 3.5 percentage points. CO<sub>2</sub> emissions from transport grew by 13.3 % (2.5 Tg) which is almost EU average. Whereas car ownership stabilised, fuel consumption by road transport increased by 5.8 % between 1990 and 1997.

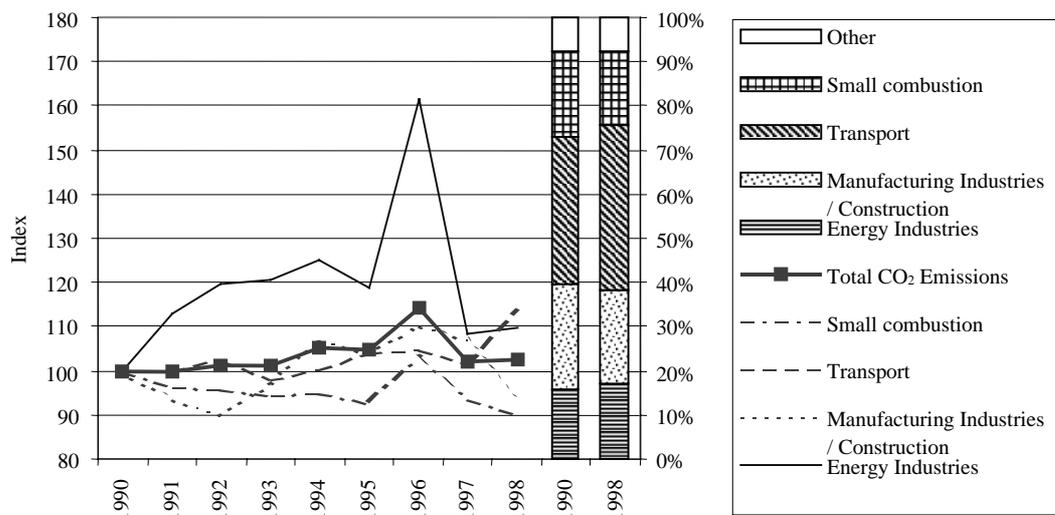
**Manufacturing industries:** The second largest emitter was industry with a share of 21.4 % in CO<sub>2</sub> emissions, down 2.1 percentage points from 1990. Sweden's industrial structure is characterised by a large share of energy intensive primary industries like pulp and paper, iron and steel, and chemicals (partly due to comparatively low energy prices for industry). In absolute terms, however, CO<sub>2</sub> emissions from manufacturing industries declined slightly by 0.9 Tg between 1990 and 1998.

**Energy industries:** The energy industries had a low share of 17.1 % in CO<sub>2</sub> emissions in 1998 compared with most other EC Member States. This is due to the large share of nuclear power and renewable energies in Swedish energy

consumption. Figure 78 illustrates large variations of CO<sub>2</sub> emissions from energy industries, mainly depending on the share of fossil fuels in power production. In 1996 low hydro power production was balanced by coal and oil fired power generation (apart from electricity imports). Between 1990 and 1998, CO<sub>2</sub> emissions from energy industries increased by 0.9 Tg.

**Small combustion:** CO<sub>2</sub> emissions from small combustion accounted for 16.9 % of total CO<sub>2</sub> emissions in 1998, down 2.3 percentage points from 1990. In absolute terms, CO<sub>2</sub> emissions from small combustion decreased by 1.1 Tg (9.9 %) between 1990 and 1998.

**Figure 78: Sectoral CO<sub>2</sub> emissions of Sweden (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

### *Energy supply, by fuel*

Gross inland energy consumption grew by 6.9 % between 1990 and 1997. Energy intensity per GDP unit is slightly higher than EU15 average and was 263 toe per MECU in 1997. As GDP per capita is high, per capita energy consumption is amongst the highest in the EU and amounted to 5.7 toe per inhabitant in 1997 (EU15 average: 3.8 toe).

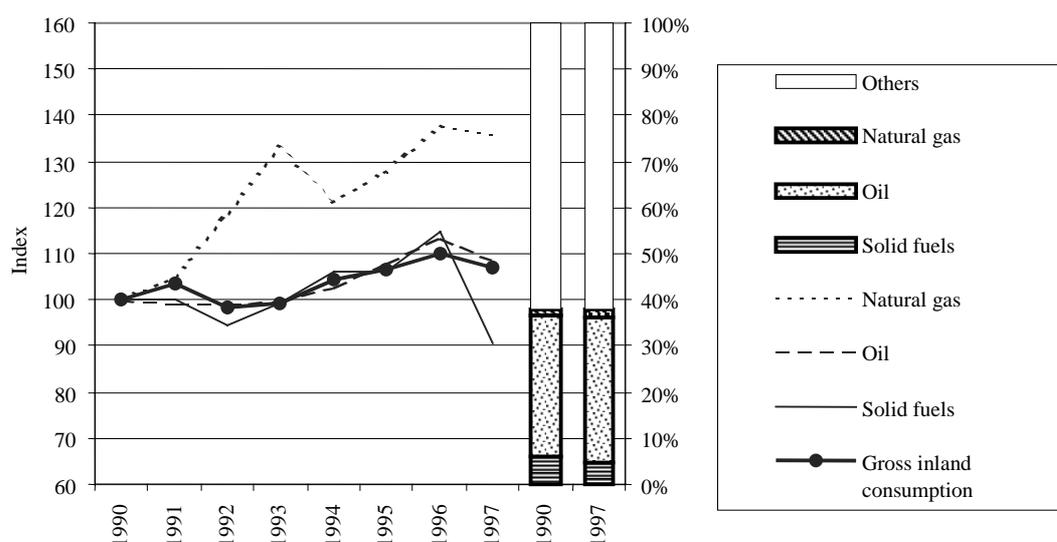
Sweden has the lowest share of fossil fuels in the EU due to high reliance on nuclear power and renewable energies: in 1997, 37.8 % of gross inland consumption came from fossil fuels. In addition, the low share of natural gas is a striking feature of Swedish energy consumption.

Nuclear power is the largest energy source accounting for 35.9 % of energy consumption in 1997, down 1.9 percentage points. After the 1973 oil crisis, Sweden focussed on nuclear power to reduce dependence on oil imports by promoting i.a. electric heating. (Sweden has hardly any fossil fuel production). As a consequence, Sweden has by far the highest per capita electricity production in the EU. However, based on a referendum in 1980, the Parliament decided to phase out nuclear power by 2010.

**Oil:** The second largest energy source is oil with a share of 31.4 % in 1997, up 0.5 percentage points. All oil has to be imported as Sweden has no domestic oil production. About 47 % of inland market consumption is used in the transport sector, about 20 % in small combustion.

**Solid fuels:** After a sharp decline in 1997, solid fuel consumption was 9.5 % below 1990 levels in 1997. (Figure 79). This reduction was mainly due to the fall of thermal coal fired power production in this year. Coal consumption in power stations fluctuated between 1990 and 1997 according to the need for balancing hydro power production, but showed an overall decline.

**Figure 79: Swedish gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include nuclear power, renewable energy sources and net electricity imports.

**Natural gas:** The use of gas increased by 36 % between 1990 and 1997. Natural gas use in power stations more than doubled and consumption in households increased by about 30 %.

**Renewable energies:** Renewable energy consumption increased by 15.9 % between 1990 and 1997 and accounted for 26.7 % of gross inland energy consumption in 1997. This is the highest share of renewable energies amongst EC Member States. Biomass increased its share in gross inland energy consumption to 14.9 % in 1997. Sweden has one of the largest biomass shares in the EU, basically due to the use of wood and wood waste in industry. Hydro power had a share of about 11.8 % in 1997, but production fluctuates considerably according to temperature and rain fall.

### *Electricity production*

Gross electricity generation increased by 1.7 % between 1990 and 1997 and is the highest in terms of per capita production in the EU: in 1997, per capita power production was 16,897 kWh per capita compared with the EU15 average of 6,483 kWh. This is due to Sweden's shift of energy mix after the 1973 oil crisis favouring electricity to reduce import dependency of fossil fuels.

The electricity generation pattern is characterised by a high share of nuclear power and hydro power and low, but increasing thermal power production.

Nuclear power accounted for 46.8 % of electricity generation in 1997, almost the same share as in 1990. Hydro power decreased from 49.7 % in 1990 to 46.2 % in 1997, but is dependent on weather conditions. Conventional thermal power plants as swing producers for losses in hydro power production increased its share from 3.9 % in 1990 to 6.9 %. The role of swing production is illustrated by oil fired power production: in 1990, a wet and mild year with high hydro power production, 0.8 % of power was produced in oil fired power stations; in 1996, this share increased to 5.1 % but declined in 1997 to 2.1 %. In addition, in 1996, Sweden as a traditional net exporter of electricity turned into a net importer. Energy efficiency plays a central role in Sweden's energy policy given the countries climatic conditions and energy intensive industry. But relatively low energy prices reduce incentives for energy efficiency investments.

***Summary on actual progress for Sweden***

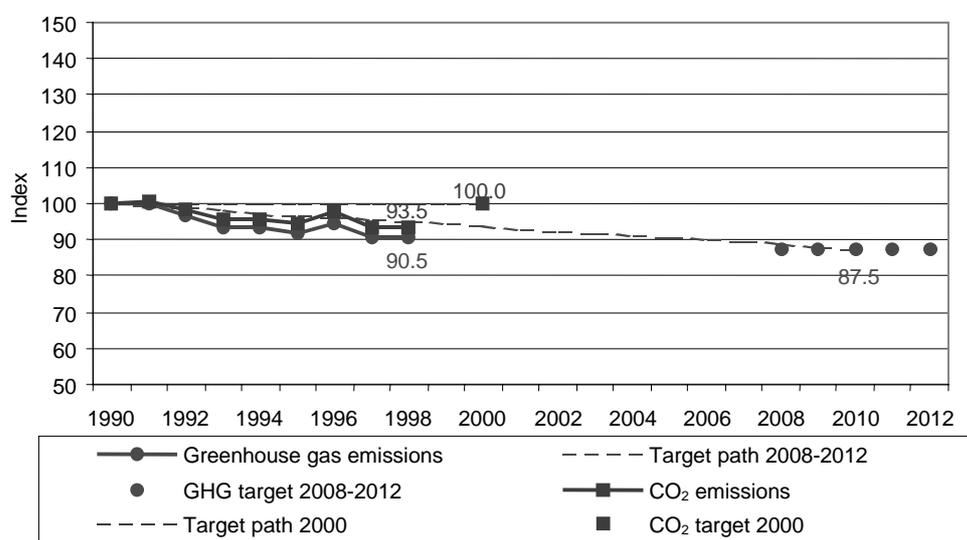
	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target path in 1998	☹	☹
	<b>Variations 1990/1998 in Tg of CO<sub>2</sub> equivalents and percent</b>	
Greenhouse gases	+0.8 Tg	+1.2 %
CH <sub>4</sub>	-0.6 Tg	-9.9 %
N <sub>2</sub> O	-0.1 Tg	-1.2 %
CO <sub>2</sub>	+1.5 Tg	+2.7 %
Energy industries	+0.9 Tg	+9.9 %
Manufacturing industries	-0.9 Tg	-6.5 %
Transport	+2.5 Tg	+13.3 %
Small combustion	-1.1 Tg	-9.9 %

#### 4.1.15. United Kingdom

##### Actual progress in the United Kingdom

In the burden sharing agreement, the United Kingdom agreed to a 12.5 % reduction of greenhouse gas emissions by 2008-2012. In 1998, greenhouse gas emissions were 657.7 Tg. This was 9.5 % (69.4 Tg) below 1990 levels or 4.5 index points below the linear target path for 2008-2012 (Figure 80). If industrial F-gases are included, UK greenhouse gas emissions decreased by 9.3 % between 1990 and 1998. UK accounted for 16.3 % of EU15 greenhouse gas emissions in 1998. For CO<sub>2</sub> emissions, the United Kingdom set a stabilisation target for 2000. In 1998, CO<sub>2</sub> emissions were 546.4 Tg, which was 6.5 % (37.8 Tg) below 1990 levels. Therefore, in 1998, CO<sub>2</sub> emissions were 6.5 index points below the linear target path for 2000.

**Figure 80: UK greenhouse gas emissions compared with targets for 2000 and 2008-2012 (excl. industrial F-gases and LUCF)**



Note (1): The linear target path is not intended as an approximation of past and future emission trends. Therefore, it does not deliver a measure of (possible) compliance of the Member States with their greenhouse gas targets in 2008-2012, but aims at evaluating the contribution of the Member States to overall EC greenhouse gas emissions in 1998.

Note (2): Greenhouse gas emission data includes neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

##### Greenhouse gas emission trends

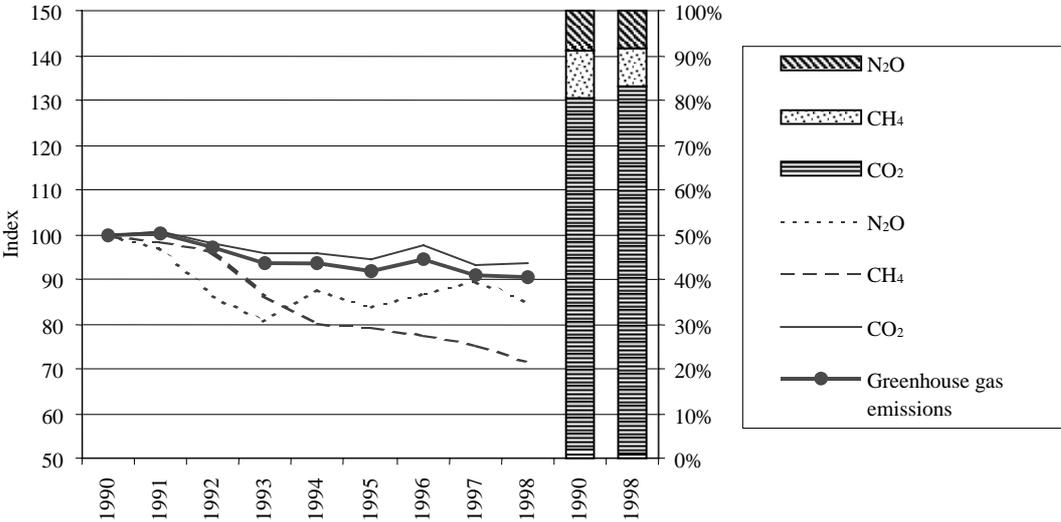
Figure 81 illustrates that all greenhouse gas emissions were reduced in the 1990s. The share of CO<sub>2</sub> in greenhouse gas emissions increased from 80.3 % in 1990 to 83.1 % in 1998. N<sub>2</sub>O emissions accounted for 8.5 % in greenhouse gas emissions in 1998, down 0.5 percentage points from 1990. CH<sub>4</sub> emissions were third with a share of 8.4 %, down 2.2 percentage points.

**CH<sub>4</sub> emissions:** CH<sub>4</sub> emissions decreased by 28.3 % (21.9 Tg of CO<sub>2</sub> equivalents) between 1990 and 1998. Agriculture, waste and fugitive emissions from fuels account for more than 95 % of CH<sub>4</sub> emissions. All these emissions decreased in absolute terms, the smallest reduction experienced CH<sub>4</sub> emissions from agriculture (-4.1 %). Accordingly, agriculture increased its share in CH<sub>4</sub> emissions from 28.2 % in 1990 to 37.7 % in 1998. Waste is the second largest source of CH<sub>4</sub>

emissions with a share of 30.7 % in 1998. The share of fugitive emissions from fuels decreased from 37.2 % in 1990 to 28 % in 1998, mainly due to the decline of coal mining.

**N<sub>2</sub>O emissions:** N<sub>2</sub>O emissions reduced by almost 20 % between 1990 and 1993, then started to increase but were 14.8 % (9.7 Tg of CO<sub>2</sub> equivalents) below 1990 levels in 1998. The main reason for the decrease in the early 1990s was a 36.8 % decline of N<sub>2</sub>O emissions from industrial processes. Agriculture, industrial processes and fuel combustion account for almost all N<sub>2</sub>O emissions. N<sub>2</sub>O emissions from agriculture reduced only slightly (-4.7 %) between 1990 and 1998. The share of agriculture in N<sub>2</sub>O emissions increased from 47.4 % in 1990 to 53 % in 1998. The share of industrial processes declined by 11.4 percentage points to 32.9 %, whereas the share of fuel combustion increased considerably to 13.8 % of N<sub>2</sub>O emissions. As in many other Member States this is due to a large increase in N<sub>2</sub>O emissions from transport (+216 %).

**Figure 81: UK greenhouse gas emissions (excl. LUCF)**



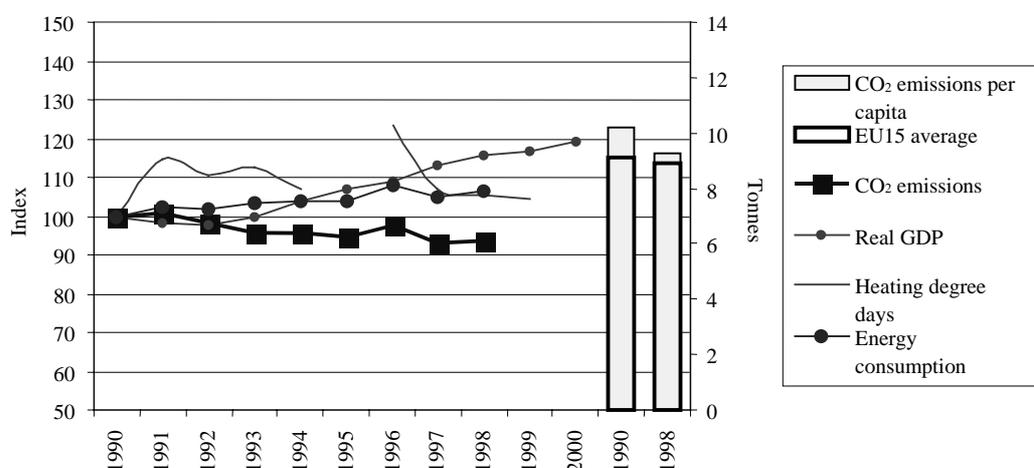
*Note:* The figure shows the trend in greenhouse gas emissions as an index, with 1990=100 (left side of the figure) and the percentage contribution of the three main greenhouse gases to the total emissions in 1990 and 1998 (right side of the figure).

**CO<sub>2</sub> emission trends and driving forces**

CO<sub>2</sub> emissions reduced almost steadily from 1990 to 1998 and were 6.5 % below 1990 levels in 1998. Only in 1991, 1996 and 1998, CO<sub>2</sub> emissions increased partly due to cold weather. Accordingly, CO<sub>2</sub> emissions per capita declined from 10.2 tonnes in 1990 to 9.2 tonnes in 1998 approaching the EU15 average of 8.9 tonnes (Figure 82).

As gross inland energy consumption increased by 6.3 %, the carbon intensity of energy consumption decreased considerably. GDP increased steadily after the recession in the early 1990s and was 15.4 % above 1990 levels in 1998. Therefore, carbon intensity of GDP decreased even more so: CO<sub>2</sub> emissions per GDP reduced from 766 kg per 1000 ECU in 1990 to 620 kg per 1000 ECU in 1998 (EU15 average 545 kg). As Figure 82 illustrates energy intensity of GDP seems to decrease only in recent years.

**Figure 82: UK CO<sub>2</sub> emissions and driving forces (real GDP growth, heating degree days, gross inland energy consumption) and CO<sub>2</sub> emissions per capita**



Note: The figure shows the trends of CO<sub>2</sub> emissions, real GDP, heating degree days and gross inland energy consumption as an index, with 1990=100 (left side of the figure) and the CO<sub>2</sub> emissions per capita in tonnes (right side of the figure). Real GDP figures for 1998-2000 are estimates; the index of energy consumption for 1998 has been calculated on the basis of monthly data; heating degree days were obtained from Eurostat, figures for 1995 were not available.

### *Sectoral breakdown of CO<sub>2</sub> emissions*

Figure 83 illustrates that in 1998, about 95 % of UK CO<sub>2</sub> emissions came from fossil fuel combustion. CO<sub>2</sub> emissions from energy and manufacturing industries declined between 1990 and 1998, whereas emissions from transport and small combustion increased.

**Energy industries:** Despite of considerable emission reductions (39.3 Tg or 17.1 %), the energy industries still hold the largest share in CO<sub>2</sub> emissions. In 1998, 34.7 % of CO<sub>2</sub> was emitted in this sector, down 4.5 percentage points from 1990. Figure 83 illustrates that most of the reductions were achieved until 1993. A substantial shift from coal to gas in thermal electricity production is the main reason for decreasing CO<sub>2</sub> emissions in this sector (see below). But also increases in nuclear power production contributed to falling CO<sub>2</sub> emissions from energy industries.

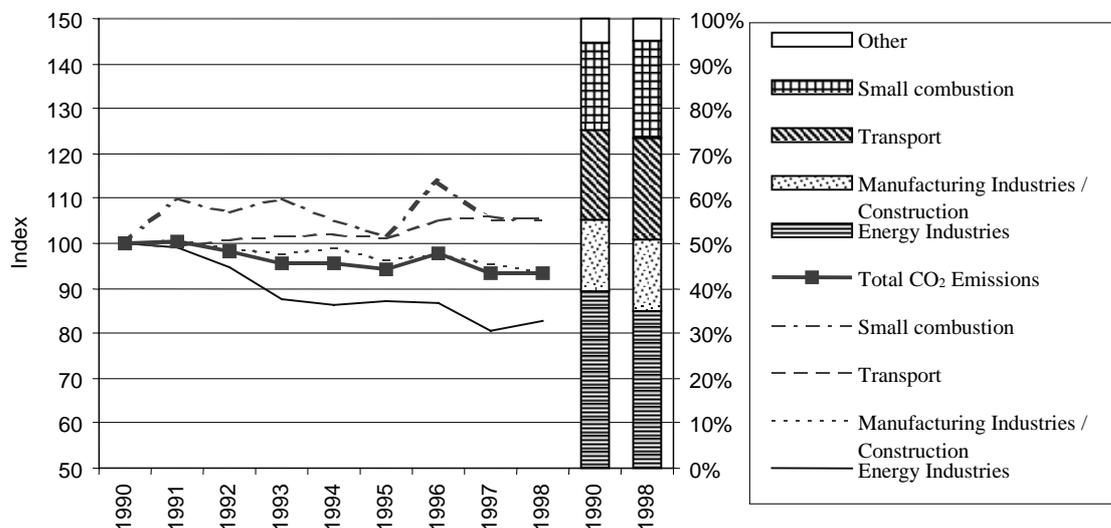
**Transport:** Transport is second increasing its share from 20 % in 1990 to 22.5 % in 1998. This meant a 5.3 % (6.2 Tg) increase over the whole period, which was 10 percentage points below EU15 growth of 15.3 %.

In UK, car ownership is rather low with 398 cars per inhabitant and behind EU15 average of 454 cars. But the modal split illustrates that the focus of UK transport policy up to 1995 lay in road building and privatisation of public transport: in 1995, cars accounted for 87.7 % of land passenger transport, which was the highest share among EC Member States (EU15 average 82.2) (EC, 1999). In recent years, however, more emphasis has been given to public transport.

One reason for rather low growth rates of CO<sub>2</sub> emissions from transport might be the fuel duty escalator introduced in 1994. Since 1994, fuel duties have been raised by an average of at least 5 % per year in real terms. In 1997, this percentage

was increased to 6 %. According to the Government, there is evidence that the fuel consumption of new gasoline powered cars has been falling since 1993 (IEA, 1998e).

**Figure 83: Sectoral CO<sub>2</sub> emissions of UK (excl. LUCF)**



Note: The figure shows the trend in sectoral CO<sub>2</sub> emissions from fossil fuel combustion as an index, with 1990=100 (left side of the figure) and the percentage contribution of the sectors to total CO<sub>2</sub> emissions 1990 and 1998 (right side of the figure). Sector names follow UNFCCC CRF source categories except 'Small combustion' (renaming CRF category 1A4) and 'Other' (including all remaining CRF categories).

**Small combustion:** CO<sub>2</sub> emissions from small combustion increased by 5.6 % (6.3 Tg) between 1990 and 1998. In 1998, their share in total CO<sub>2</sub> emissions was 21.7 %, up 2.5 percentage points from 1990. As energy efficiency standards of the building stock are very low, a high share of energy is needed for heating and warm water supply.

A special problem in UK is 'fuel poverty': 13 % of British households are not able to heat any room above 16°C; 5 % of households spend more than 30 % of their income for fuel. Therefore, the Government aims at keeping fuel prices low. This also was one reason for opposing the EC CO<sub>2</sub>/energy tax proposal in 1993 and subsequent proposals on minimum energy taxation at European level. The government tried to improve energy efficiency by promoting housing insulation but results have been poor as low energy prices reduce incentives for energy saving (Michaelowa, 1998).

**Manufacturing industry:** CO<sub>2</sub> emissions from manufacturing industry declined by 6.3 % (5.9 Tg) between 1990 and 1998. Their share in total CO<sub>2</sub> emissions was stable at around 16 %. One reason for declining CO<sub>2</sub> emissions from manufacturing industry was the fuel switch from coal to gas: between 1990 and 1997, hard coal consumption in the UK industry declined by about 30 %, whereas gas consumption increased by about 37 %.

#### *Energy supply, by fuel*

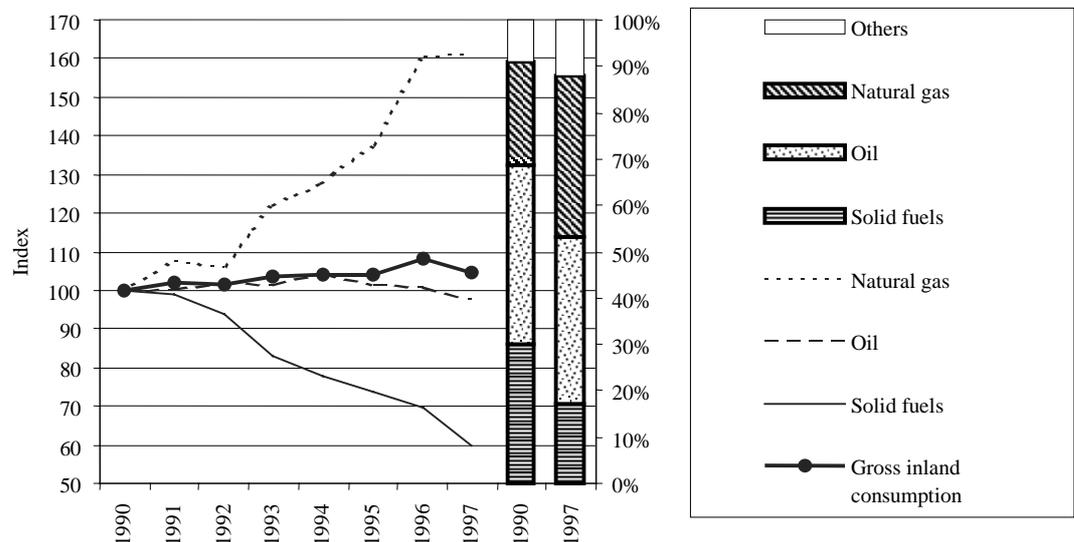
Gross inland energy consumption increased by 4.8 % from 1990 to 1997. Energy consumption per capita has been stable at around 3.8 toe which is EU15 average, whereas energy intensity of GDP has decreased. The share of fossil fuels declined slightly from 91.1 % in 1990 to 87.8 % in 1997 (Figure 84). This is due to increases of nuclear power and renewable energies.

**Oil** is the largest energy source accounting for 36.2 % of gross inland energy consumption in 1997, down 2.5 percentage points from 1990. UK is a large producer and net exporter of oil. In 1997, more than 80 % of EU15 primary oil production was produced in UK.

**Natural gas:** Gas almost caught up with oil by increasing its share in energy consumption from 22.4 % in 1990 to 34.5 % in 1997. Parallel to the growth in gas consumption, domestic production increased by almost 90 % from 1990 to 1997. Almost all natural gas produced in UK is used in the domestic market. The most important growth factor was the large increase in gasfired electricity generation, substituting a substantial part of coal-fired power generation.

**Solid fuels:** Due to a large drop in coal fired power production, the use of solid fuels reduced by 40 % between 1990 and 1997. Therefore, the share of solid fuels in gross inland energy consumption decreased from 30 % in 1990 to 17.2 % in 1997 (Figure 84).

**Figure 84: UK gross inland energy consumption by fossil fuel type**



Note: The figure shows the trend in gross inland energy consumption of fossil fuels as an index, with 1990=100 (left side of the figure) and the percentage contribution of fossil fuels to total gross inland consumption in 1990 and 1997 (right side of the figure). 'Others' include nuclear power, renewable energy sources and net electricity imports.

**Renewable energies:** Renewable energy consumption increased by 90.1 % between 1990 and 1997, but accounted for only 0.9 % of gross inland energy consumption in 1997. This is the lowest share of renewable energies amongst EU Member States. Biomass (0.7 %) and hydro power (0.2 %) are the largest renewable energy sources in UK.

### *Electricity generation*

Electricity generation grew by 8.3 % between 1990 and 1997 (EU15 17.5 %). Per capita power generation grew from 5,551 kWh in 1990 to 5,863 kWh in 1997, which was below EU15 average of 6,483 kWh. One reason for this rather low ratio are considerable net imports of electricity (about 5 % of net power production) mainly from France.

Electricity generation is dominated by conventional thermal power plants. In 1997, 69.8 % of electricity was produced by fuel combustion, down from 77.1 % in 1990. Nuclear power generation grew from 20.6 % in 1990 to 28.4 % in 1997. The massive fuel switch within fossil fuel power generation is illustrated by following figures: the share of hard coal in total power production declined from 64.2 % in 1990 to 34.7 % in 1997. Oil decreased from 10.6 % to 2.3 %. At the same time, gasfired electricity generation shot from 1 % to 31.1 %. The reason for this was the cut of coal subsidies and the electricity market liberalisation. Despite of the sharp decline, hard coal still accounted for almost 50 % of thermal power production in 1997.

Electricity production from renewable energies have been promoted by an innovative subsidy scheme. Bidders had to compete for subsidies and were only granted the price they had offered in the bid. This subsidy scheme led to 25 % lower average cost of wind power in UK compared with Germany, but installed capacity did not increase substantially (Michaelowa, 1999).

***Summary on actual progress for the United Kingdom***

	CO <sub>2</sub> emission target for 2000	Greenhouse gas emission target for 2008-2012
In line with linear target paths in 1998	☺	☺
	Variations 1990/1998 in Tg of CO <sub>2</sub> equivalents and percent	
Greenhouse gases	-69.4 Tg	-9.5 %
CH <sub>4</sub>	-21.9 Tg	-28.3 %
N <sub>2</sub> O	-9.7 Tg	-14.8 %
CO <sub>2</sub>	-37.8 Tg	-6.5 %
Energy industries	-39.3 Tg	-17.1 %
Manufacturing industries	-5.9 Tg	-6.3 %
Transport	+6.2 Tg	+5.3 %
Small combustion	+6.3 Tg	+5.6 %

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## Units and abbreviations

t	1 tonne (metric) = 1 megagram (Mg) = $10^6$ g
Mg	1 megagram = $10^6$ g = 1 tonne (t)
Gg	1 gigagram = $10^9$ g = 1 kilotonne (kt)
Tg	1 teragram = $10^{12}$ g = 1 megatonne (Mt)
toe	tonnes oil equivalent
kWh	1 kilowatt hour = $10^3$ watt hours
MWh	1 megawatt hour = $10^6$ watt hours
GWh	1 gigawatt hour = $10^9$ watt hours
TWh	1 terawatt hour = $10^{12}$ watt hours
ECU	European Currency Unit
MECU	million European Currency Units
CH <sub>4</sub>	Methane
CHP	Combined Heat and Power
CO <sub>2</sub>	Carbon dioxide
COP	Conference of the Parties
CRF	Common Reporting Format
EEA	European Environment Agency
ETC/AE	European Topic Centre on Air Emissions
GDP	Gross Domestic Production
GHG	Greenhouse gas
HFCs	Hydrofluorocarbons
IEA	International Energy Agency
Industrial F-gases	HFCs, PFCs, SF <sub>6</sub>
IPCC	Intergovernmental Panel on Climate Change
LUCF	Land Use Change and Forestry
N <sub>2</sub> O	Nitrous oxide
PFCs	Perfluorocarbons
SF <sub>6</sub>	Sulphur hexafluoride
UNFCCC	United Nations Framework Convention on Climate Change

# Annex: Summary of EC and Member States greenhouse gas data

This annex gives a short summary of the inventory data used in this report and is taken from the EEA technical report 'Annual European Community Greenhouse Gas Inventory 1990-1998, submission to UNFCCC'. This report includes all detailed emission tables and is available on the EEA web site (<http://www.eea.eu.int/>).

Greenhouse gas emission data, as referred to in this report, include neither industrial F-gases (HFCs, PFCs, SF<sub>6</sub>) nor emissions and removals from LUCF. See Chapter 2.4 for details.

## Austria

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	62.1	66.0	60.2	59.9	61.8	63.7	65.9	66.8	66.6
CH <sub>4</sub> emissions	11.3	11.1	10.8	10.7	10.5	10.3	10.1	9.9	9.6
N <sub>2</sub> O emissions	2.0	2.1	2.1	2.2	2.3	2.3	2.3	2.3	2.3
Total (without LUCF)	75.5	79.2	73.1	72.8	74.5	76.2	78.3	78.9	78.5

## Belgium

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	114.0	121.4	121.6	119.5	124.3	125.6	129.7	121.3	122.0
CH <sub>4</sub> emissions	12.7	12.7	12.8	13.0	12.4	12.4	12.4	12.3	12.2
N <sub>2</sub> O emissions	9.4	9.4	9.1	9.4	9.8	10.2	10.4	10.2	10.4
Total (without LUCF)	136.0	143.5	143.5	141.9	146.6	148.2	152.4	143.8	144.6

## Denmark

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	52.9	63.5	58.2	59.9	63.4	60.3	73.7	64.3	60.1
CH <sub>4</sub> emissions	5.8	5.9	5.9	6.0	5.9	5.9	5.9	5.7	6.0
N <sub>2</sub> O emissions	10.8	10.7	10.1	10.2	10.0	9.9	9.8	9.4	9.5
Total (without LUCF)	69.6	80.1	74.2	76.1	79.3	76.2	89.3	79.5	75.6

## Finland

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	59.3	60.4	52.4	53.1	59.3	60.9	66.4	64.6	64.0
CH <sub>4</sub> emissions	7.5	5.9	5.2	5.2	5.1	5.6	5.7	5.7	4.4
N <sub>2</sub> O emissions	5.8	7.5	3.4	3.4	5.6	5.6	5.7	5.9	7.7
Total (without LUCF)	72.6	73.8	61.0	61.7	70.0	72.2	77.8	76.2	76.0

## France

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	387.6	412.5	403.1	382.1	377.9	383.8	396.5	391.1	412.9
CH <sub>4</sub> emissions	61.4	61.4	60.6	60.3	58.9	57.6	54.9	52.9	52.2
N <sub>2</sub> O emissions	89.6	89.4	85.9	81.8	83.6	85.3	86.0	87.1	78.7
Total (without LUCF)	538.5	563.3	549.6	524.2	520.4	526.8	537.5	531.1	543.7

## Germany

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	1,014.5	977.0	927.3	917.3	904.1	902.9	923.9	892.7	886.5
CH <sub>4</sub> emissions	117.0	105.3	97.7	89.6	84.5	81.7	74.7	74.8	74.7
N <sub>2</sub> O emissions	69.6	67.5	69.1	66.3	66.8	67.3	69.1	64.1	50.5
Total (without LUCF)	1,201.1	1,149.7	1,094.2	1,073.2	1,055.4	1,051.9	1,067.6	1,031.6	1,011.7

## Greece

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	85.2	85.0	87.0	87.4	88.7	90.2	91.9	95.8	100.3
CH <sub>4</sub> emissions	9.2	9.2	9.2	9.2	9.3	9.6	9.5	9.6	9.8
N <sub>2</sub> O emissions	9.5	9.5	9.1	9.1	9.0	8.9	9.2	9.4	9.4
Total (without LUCF)	103.9	103.7	105.3	105.7	107.0	108.7	110.6	114.7	119.5

### Ireland

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	31.6	32.3	32.9	32.4	34.0	34.5	35.7	38.1	40.0
CH <sub>4</sub> emissions	12.8	13.0	13.0	13.1	13.2	13.3	13.6	13.7	13.6
N <sub>2</sub> O emissions	9.1	8.9	8.9	9.0	9.3	9.5	9.7	9.5	10.1
Total (without LUCF)	53.5	54.2	54.8	54.5	56.4	57.3	58.9	61.4	63.7

### Italy

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	429.7	428.1	426.2	419.1	415.1	440.1	436.1	438.0	458.3
CH <sub>4</sub> emissions	39.9	40.1	38.4	38.3	39.5	40.2	40.4	41.0	41.4
N <sub>2</sub> O emissions	45.3	46.6	45.8	45.2	44.4	45.7	45.8	46.7	38.5
Total (without LUCF)	514.8	514.8	510.5	502.6	499.0	526.0	522.3	525.7	538.2

### Luxembourg

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	13.3	14.1	13.8	14.0	12.0	7.1	7.1	6.1	5.2
CH <sub>4</sub> emissions	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
N <sub>2</sub> O emissions	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2
Total (without LUCF)	14.1	14.9	14.6	14.9	12.7	7.8	7.8	6.8	5.9

### Netherlands

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	161.4	166.9	165.2	167.5	168.3	177.2	184.7	183.2	181.4
CH <sub>4</sub> emissions	27.1	27.5	26.4	25.7	25.3	24.6	24.5	23.2	22.4
N <sub>2</sub> O emissions	20.4	20.7	21.5	21.3	21.9	22.4	22.3	22.7	22.2
Total (without LUCF)	208.9	215.1	213.0	214.5	215.5	224.2	231.4	229.1	226.0

### Portugal

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	43.1	45.0	48.9	47.8	48.6	51.5	49.8	51.5	53.9
CH <sub>4</sub> emissions	14.5	15.1	13.9	13.5	13.7	14.6	13.9	13.6	14.3
N <sub>2</sub> O emissions	6.2	6.3	6.2	6.2	6.0	6.5	6.4	6.5	6.6
Total (without LUCF)	63.9	66.3	69.0	67.4	68.3	72.6	70.1	71.6	74.9

### Spain

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	226.1	233.3	242.3	229.5	242.3	253.0	240.8	264.1	273.0
CH <sub>4</sub> emissions	34.6	35.2	36.1	36.7	37.7	38.6	40.7	41.9	43.6
N <sub>2</sub> O emissions	41.2	40.5	39.6	37.2	39.4	38.6	43.2	43.5	43.8
Total (without LUCF)	301.9	309.0	318.0	303.4	319.4	330.2	324.7	349.5	360.5

### Sweden

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	55.4	55.2	56.2	56.2	58.4	58.1	63.4	56.7	57.0
CH <sub>4</sub> emissions	6.0	6.8	6.7	6.7	6.4	6.2	5.5	5.5	5.4
N <sub>2</sub> O emissions	8.1	2.9	2.8	2.8	2.9	2.9	8.1	7.6	8.0
Total (without LUCF)	69.5	64.9	65.7	65.7	67.7	67.2	76.9	69.8	70.3

### United Kingdom

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	584.2	588.0	573.7	559.6	559.3	551.3	570.3	544.3	546.4
CH <sub>4</sub> emissions	77.2	76.2	74.2	66.8	61.8	61.3	59.9	58.0	55.4
N <sub>2</sub> O emissions	65.7	63.7	56.7	53.0	57.7	55.1	57.0	58.7	56.0
Total (without LUCF)	727.1	728.0	704.6	679.4	678.8	667.6	687.2	661.0	657.7

### European Union

GREENHOUSE GAS EMISSIONS (without LUCF)	1990	1991	1992	1993	1994	1995	1996	1997	1998
	CO <sub>2</sub> equivalent (Tg)								
CO <sub>2</sub> emissions	3,320.5	3,348.6	3,268.9	3,205.3	3,217.4	3,260.3	3,335.9	3,278.5	3,327.5
CH <sub>4</sub> emissions	436.3	424.2	410.9	394.8	384.3	381.2	371.4	368.0	364.3
N <sub>2</sub> O emissions	392.8	385.8	370.7	357.4	368.9	370.1	385.0	383.7	353.8
Total (without LUCF)	4,149.5	4,158.6	4,050.5	3,957.6	3,970.5	4,011.6	4,092.4	4,030.3	4,045.6