Topic report No 9/2000

Emissions of atmospheric pollutants in Europe, 1980-1996

Prepared by ETC/AE and PTL/AE

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Legal notice

Printed in

Printed on recycled and chlorine-free bleached paper

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Executive summary

1. Policy relevance of emission inventories and indicators

Atmospheric pollution contributes to various important environmental issues, due to emissions to the atmosphere (air emissions) from a variety of mainly anthropogenic (man-made) activities. This report covers air emissions that contribute to the following issues:

- Climate change (emissions of greenhouse gases)
- Acidification and eutrophication (emissions of acidifying and eutrophying pollutants)
- Tropospheric ozone and urban air quality (emissions of ozone precursors, particulate matter and other pollutants)
- Long-range dispersion of hazardous substances (emissions of heavy metals and persistent organic pollutants or POPs)

Reliable (accurate), consistent, comparable, transparent, complete and timely data and indicators on air emissions are important for policymaking and policy implementation:

- To identify and quantify the pressures on the environment and to assess the impacts on the state of the environment, on human health and on materials;
- To develop abatement strategies and prioritise policies and measures for the main source categories (sectors) in a cost-effective way;
- To monitor the effects of implemented policies and measures in terms of reduced or avoided emissions. This includes monitoring of internationally agreed emission reduction targets (EC legislation and/or international conventions);
- To inform the public, by means of air emission indicators (which are an aggregation of more detailed data).

Emission reporting is required by a number of international conventions, protocols and directives:

- The United Nations Framework Convention on Climate Change (UNFCCC) Kyoto Protocol aims to reduce emissions of greenhouse gases from developed (Annex 1) countries by at least 5 % during the commitment period till 2008-2012, using 1990 as a base year.
- The UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP), and its various Protocols with emission reduction targets. In particular the Protocols on heavy metals and persistent organic pollutants of 1998 and the multi-pollutant Procotol adopted on 1 December 1999 are relevant (with emission reduction targets for each EU Member State for SO_2, NO_X, NMVOC and NH_3 to be achieved by 2010);
- Within the EU, a number of Directives (Large Combustion Plants; Solvents; Integrated Pollution Prevention and Control) are in force aiming at emissions control. The European Commission has in 1999 proposed a National Emission Ceiling Directive, which lays down emission reduction targets for each EU Member State for SO_2, NO_X, NMVOC and NH_3 to be achieved by 2010. These proposed targets are for various countries stricter than those in the CLRTAP multi-pollutant Protocol (December 1999).

2. This report

This report has been prepared jointly by the European Topic Centre and PHARE Topic Link on Air Emissions (ETC/AE and PTL/AE) as part of their work programme for EEA (further in this report ETC/AE is referred to, as meaning to include also the activities of PTL/AE). The report provides information available by the end of 1999 and thus provides an update of information provided in earlier CORINAIR reports prepared by ETC/AE.

ETC/AE assists member countries to collect and report emission data. ETC/AE compiles from these country data a European emissions database (CORINAIR) and from this is able to provide air emissions data and indicators for the main EEA assessment reports. The data and indicators presented in this report are fully consistent with the data and indicators presented in the most recent EEA indicator-based report *Environmental signals 2000* (EEA, 2000) and the EEA Transport and Environment Reporting Mechanism report *Are we moving in the right direction?* (EEA, 2000).

Data used for this report are the official data submitted by countries, by October 1999, to the various international reporting obligations as mentioned above.

This Topic Report provides more detail than the indicator-based reports and presents all the main air emission indicators in a comparable and consistent way in one single report.

This report includes EEA member countries, as well as central and eastern European countries, through the EEA-PHARE programme.

In addition to trends in national total emissions, emission indicators are also presented by main economic sector (energy, industry, transport, agriculture) showing the different contributions to the environmental issues described in this report.

The report shows that improvements have been made in the quality and timeliness of inventory estimates, and that these data can be used for preparation of useful emission indicators at the European level. However it is also shown that improvements are still required on all relevant quality aspects (*accuracy, consistency, comparability, transparency, completeness)* and in particular *timeliness.* The work done within the IPCC Programme on Inventories on guidance for *Good Practices* and on *Managing Uncertainties* is expected to be useful in improving these quality aspects.

It is also expected that coordinated national emission databases will improve the quality of the estimates because of the consistent use of the required socio-economic statistics and of other common elements. Also increased cooperation between national organisations responsible for compiling the inventories and the national statistical offices is important.

Uncertainties are however inevitable in any estimate of national emissions or removals. It is important that these uncertainties are understood, properly communicated and where possible reduced to improve effective policymaking and performance monitoring.

3. Targets and actual emission trends

Climate change (emissions of greenhouse gases)

The EU and its Member States are committed to a reduction of 8 % below the 1990 level in the period 2008 to 2012, while Central and Eastern European (CEE) countries are committed to reductions of 5-8 %.

Total EU greenhouse gas emissions have decreased slightly (1 %), against rising GDP, from 1990 to 1996 as a result of significant emission reductions in Germany (economic restructuring in the new Länder and increased energy efficiency) and the UK (switch from coal to natural gas). In all other EU Members States greenhouse gas emissions have increased from 1990. Further reductions in EU emissions, and additional policies and measures, will be necessary to achieve the UNFCCC Kyoto Protocol target. In Central and Eastern European PHARE countries general emission reductions occurred from 1990 to 1996, mainly due to the economic restructuring process.

Total EU carbon dioxide emissions in 1996 were in line with the target to stabilise emissions at 1990 levels by 2000.

Total EU methane emissions have fallen 12 % from 1990 to 1996. Total EU nitrous oxide emissions have fallen slightly (2 %) from 1990 to 1996. Total fluorocarbon emissions in 1995 are 1 % of total EU greenhouse emissions. Trends are uncertain but emissions most likely have increased since 1990

Acidification, tropospheric ozone and urban air quality (emissions of acidifying pollutants and ozone precursors)

Within CLRTAP in December 1999 national emission ceilings were agreed in a new multi-pollutant Protocol for SO_2, NMVOC, NO_x and for the first time for ammonia (NH_3), for many European countries, including EU Member States. These targets are much more strict than the previously agreed targets. In May 1999 the European Commission prepared a proposal for a Directive on national emission ceilings (NECD) for the same pollutants. This proposal has not yet been adopted by the Council, but a common position was reached in June 2000. For a number of Member States, the proposed NECD targets are more strict than those agreed within CLRTAP.

Emissions of acidifying pollutants

Total EU emissions of acidifying gases have decreased significantly (45 % from 1980 to 1996), despite rising showing a de-coupling of emissions from GDP growth. This is mainly due to SO_2 emission reductions.

Since 1980, EU Member States have reduced their sulphur dioxide emissions by over 60 %. Reduction targets for 2000 have already been achieved for the EU as a whole. The proposed NECD and agreed CLRTAP targets for 2010 appear to be attainable for the EU, although additional measures will be required in some EU Member States. For most PHARE Central and Eastern European countries, SO_2 emissions decreased between 1990 and 1996 (up to 60 %), and emissions are below the 2010 CRLTAP targets. This is due to economic restructuring, fuel switching, desulphurisation of emissions from power plants and other measures. In some countries additional measures will be required.

The CLRTAP target of stabilised nitrogen oxide emissions at 1987 levels, has been achieved by the EU as a whole. Emissions decreased by 14 % from 1990 to 1996. However, the EU 5EAP target is unlikely to be reached by 2000. To achieve the proposed NECD and agreed CLRTAP targets for 2010 additional measures will be required in various EU Member States. For most PHARE Central and Eastern European countries, NO_x emissions decreased between 1990 and 1996 (30 to 60 %). This is due to economic restructuring, fuel switching, deNOx installations for power plants and other measures. In various countries additional measures will be required to achieve the CRLTAP targets for 2010.

EU ammonia emissions have decreased slightly (7 %) from 1990 to 1996, with substantial decreases (15 to 35 %) in a few Member States. Ammonia emission reduction targets have been defined for the first time. The proposed NECD and agreed CLRTAP targets for 2010 will be difficult to achieve for the EU and additional measures will be required in various countries. Emissions from all PHARE countries decreased (between 10 % and 80 %), probably due to the economic restructuring process. However, Poland and Slovenia need further reductions to meet the CLRTAP targets for 2010.

Emissions of ozone precursors

EU emissions of ozone precursors have decreased 15 % from 1990 to 1996 against increasing economic growth demonstrating a de-coupling of emissions from GDP.

Total EU emissions of NMVOCs fell by 13 % between 1990 and 1996, with substantial decreases (30 to 40 %) in Ireland and Germany. However, emissions from some other Member States have increased. Further reductions in EU emissions will be necessary to achieve the EU 5EAP target for 2000 and the proposed NECD and agreed CLRTAP targets for 2010. Emissions from most PHARE countries decreased from 1990 to 1996 (10 % to 70 %,) probably due to the economic restructuring process. The Czech Republic and Slovenia need further reductions to meet the CLRTAP targets for 2010 and additional measures will be required.

Emissions of particulates and toxic/hazardous substances (heavy metals, POPs)

In 1998 CLRTAP Protocols were adopted that require reductions in the use and emissions of a number of heavy metals (such as mercury, cadmium) and persistent organic pollutants (POPs, such as dioxins). Furthermore in the EU air quality targets for PM10 have been adopted in 1999.

Uncontrolled combustion of coal in stationary sources and diesel in transportation contribute significantly to PM_{10} emissions in Europe. EU15 urban area PM_{10} emissions are dominated by road transport. PHARE countries' urban area PM_{10} emissions are influenced by high emissions from industry and energy production within the urban area.

The use of leaded petrol contributed to about 75 % of lead emissions across the EU in 1990. The phase-out of leaded petrol has reduced emissions dramatically over recent years. Significant EU emissions of cadmium and mercury originate from industrial processes.

Waste treatment and industry are primary source of dioxins and furans in the EU. PAH emissions from wood treatment and wood combustion contribute significantly to EU and PHARE accession countries' emissions.

Emissions by main source sectors (energy, industry, transport, agriculture)

Energy sector: emissions of acidifying gases, tropospheric ozone precurors and carbon dioxide from the energy sector decreased between 1990 and 1996 by 26 %, 15 % and 5 % respectively, while primary energy demand increased by 7 %. Reductions are due to implementation of end-of-pipe abatement measures, increased efficiency in power generation strategies and the increased share of natural gas.

Industry sector: emissions of acidifying gases, tropospheric ozone precursers and greenhouse gases from the industry sector decreased between 1990 and 1996 by 36 %, 10 % and 8 % respectively, while industrial production and energy use in 1996 were on 1990 levels. This suggests a positive development of eco-efficiency in industry. Emission reductions are due to a range of abatement measures and end-of-pipe technology, increased energy efficiency and a trend from solid and liquid fuel to natural gas. The Large Combustion Plant (LCP), the Integrated Pollution Prevention and Control (IPPC) and the 'Solvents' Directives are expected to contribute to further emission reductions.

Transport sector: emissions of acidifying gases and ozone precursors from transport decreased by 11 % and 18 % respectively between 1990 and 1996, while in the same period transport activity increased (passenger road transport by 12 %). The emission reductions are mainly due to an increasing share (30 % in 1996) of petrol driven passenger cars fitted with catalytic converters. Greenhouse gas emissions resulting from transport have increased by 10 % from 1990 to 1996. However there has been little or no improvement in energy efficiency of transport. The negotiated agreement between the European Commission and the car industry is expected to reduce CO_2 emissions of new passenger cars.

Agricultural sector: Emissions of ammonia, nitrous oxide and methane from agriculture have reduced by 1-2 %, 4 % and 5 % respectively between 1990 and 1996, mainly due to reductions in livestock numbers. Changes in agricultural practices will be necessary to reduce EU emissions further.

Contents

1. Introduction

1.1. Scope of this report

This report presents data, indicators and information on emissions to the atmosphere relevant for four main global or European environmental issues, having adverse effects on human health, ecosystems or materials. These issues are also included in recent EEA main state of the environment reports, such as *Environment in the European Union at the turn of the century* (EEA, 1999) and the indicator-based report *Environmental signals 2000* (EEA, 2000):

1. Climate change (emissions of greenhouse gases)
2. Acidification and eutrophication (emissions of acidifying and eutrophying pollutants)
3. Tropospheric ozone and urban air quality (emissions of ozone precursors, particulate matter and other pollutants)
4. Long-range dispersion of hazardous/toxic substances (emissions of heavy metals and persistent organic pollutants or POPs)

The report has been prepared jointly by ETC/AE and PTL/AE (PHARE Topic Link on Air Emissions) as part of the EEA work programme. The report provides information available by the end of 1999 and thus provides an update of information provided in earlier CORINAIR reports prepared by ETC/AE (EEA, 1996; EEA, 1997).

The report is part of an annual cycle of EEA reports on air emissions. Thus by the beginning of 2001 an update will be produced covering the period 1980 to 1998.

The report fits into the DPSIR assessment framework used by the EEA, for structuring, presenting and reporting the causal chain of different environmental issues. The DPSIR approach consists in general of describing the main indicators for Driving forces (main societal and socio-economic trends), Pressures (emissions to air, generation of waste), State (global temperature increase, air quality, deposition), Impact (adverse effects on human health, ecosystems, materials) and Responses (existing and/or proposed policies and measures and progress towards environmental targets).

Much of the policy action at EU or Member State level is at the D and P side of the causal chain, therefore many policy-relevant indicators show developments in Driving forces and Pressures. This Topic Report has a specific focus on emissions of atmospheric pollutants and the progress towards emission reduction targets and emission ceilings. This report aims at providing transparent, consistent, comparable, complete and reliable indicators of emissions of atmospheric pollutants, or 'air emissions'.

The data and indicators presented in this report are fully consistent with the data and indicators presented in the most recent EEA indicator-based report *Environmental signals 2000* (EEA, 2000) and the EEA TERM report (Transport and Environment Reporting Mechanism) (EEA, 2000), see section 1.2 below. The added value of this Topic Report is that it provides more detail and that it presents all main air emission indicators in a comparable and consistent way in one single report.

The geographic scope of this report is EEA member countries as well as Central and Eastern European Countries.

In addition to trends in national total emissions, emission indicators are also presented by main economic sector (energy, industry, transport, agriculture) showing the different contributions to the environmental issues, described in this report. By also presenting trends in emissions and some key socio-economic indicators combined in various graphs, this report provides some insights in the development of links between human activities and the pressures on the environment and presents some information on the eco-efficiency of main socio-economic sectors. This is done consistently with the approaches used in the EEA report *Environmental signals* (EEA, 2000).

Data used for this report are the official data submitted by countries, by the end of 1999, to the various international reporting obligations:

- Acidifying pollutants, ozone precursors, heavy metals, persistent organic pollutants (POPs): Convention on Long-range Transboundary Air Pollution (CLRTAP, including various Protocols),
- Greenhouse gases: UN Framework Convention on Climate Change (UNFCCC) and EU Council Decision on a Monitoring Mechanism of Community CO_2 and other greenhouse gas emissions.

Copies of the data that have been officially reported by countries are compiled into a central database, maintained by ETC/AE, the CORe INventory for AIR emissions (CORINAIR) database. This database was used for the preparation of this report. Since October 1999, most of these data are also publicly available on the EEA website (http://service.eea.eu.int/).

In addition these data have been complemented, in this report, by more detailed data, submitted directly by various countries to the European Topic Centre on Air Emissions (ETC/AE) through the CORINAIR programme. Furthermore, for some pollutants (heavy metals, POPs and particulate matter (PM)) additional data, originating from other sources of information, are presented. This was done because of lack of complete data from some countries, while other useful information was available.

1.2. Relation to main periodical indicator-based EEA reports

The DPSIR approach is followed in EEA's main comprehensive reports, such as the report *Environment in the European Union at the turn of the century*, which are produced approximately every five years, but also in the more regular *Indicator Reports*. The EEA reporting approach is increasingly being built on indicators. The EEA main indicator-based reports are aimed at policy-makers in EEA member countries and the European Union. These reports make use of environmental indicators to report on progress in a number of policy areas, and also on the reasons behind the rate of progress made in some of the main environmental policy areas and in some countries. After completion of the report *Environment in the European Union at the turn of the century*, EEA has prepared its first general indicator-based report *Environmental signals 2000* (EEA, 2000).

In addition EEA contributes, together with Eurostat, to the development and reporting of sector indicators, in line with the aim of the EU of broadening of policy towards integration of environmental issues in other policy fields. Sector indicators show links between the activities of societal sectors (transport, energy, forestry, etc.) and the environment. As well as showing the sector's absolute burden on the environment and the development in its eco-efficiency, sector indicators also deal with a sector's development in size and character and its specific responses to environmental issues. Sector indicators are in various stages of development; those for air emissions are amongst the most advanced.

For *transport and the environment* a list of around 30 indicators has been agreed, the indicators have been developed and Eurostat is producing a report with supporting statistics. Amongst the most advanced environmental indicators are those on air emissions. The European Environment Agency produced an assessment of the progress made in integrating environment in transport policies, making use of the statistics reported by Eurostat: the first Transport and Environment Reporting Mechanism report 'Are we moving in the right direction?' (EEA, 2000).

The air emissions data presented in the TERM report, and in this topic report are fully consistent.

1.3. Environmental policies and policy targets

1.3.1. Climate change (UNFCCC, EU)

The mounting scientific evidence of the occurrence of global climate change resulting from increasing emissions of greenhouse gases led to the adoption of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. Developed countries made a commitment to return their emissions of greenhouse gases, not controlled by the Montreal Protocol, to 1990 levels by 2000. By September 1999, 180 countries or groups of countries had ratified the Convention, including the European Community, all 15 Member States and most other European countries.

At the Third Conference of the Parties of UNFCCC held in Kyoto in December 1997, developed countries agreed to reduce their emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons[1] (HFCs), perfluorocarbons[1] (PFCs) and sulphur hexafluoride (SF_6) by an overall 5 % from 1990 levels by 2008-2012, expressed in carbon dioxide equivalents (using global warming potentials with a 100 year time horizon). The amount each country is allowed to emit between 2008 and 2012 is determined by its carbon dioxide equivalent emissions of the six greenhouse gases in the base year 1990 (the base year is 1990 or 1995 for HFCs, PFCs and sulphur hexafluoride). Each Party is required to make demonstrable progress in achieving its commitments by 2005.

According to the Kyoto Protocol, net changes in carbon stocks due to changes in forest area since 1990 (so-called 'Kyoto forests') and some other carbon sinks can be used to meet reduction targets. However, the Parties still have to agree relevant definitions and accounting rules, particularly for other types of carbon sinks such as soil.

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[1] HFCs and PFCs are in fact groups of gases and their GWP varies according to their composition

The EU and its Member States are committed to a reduction of 8 % below the 1990 level in the period 2008 to 2012, while Central and Eastern European (CEE) countries are committed to reductions of 5-8 %. In June 1998, a system of 'burden sharing' or 'target sharing' was agreed by EU Member States, resulting in very different commitments for each Member State.

By September 1999, 84 Parties to the UNFCCC – including the European Union and the Member States – had signed the Kyoto Protocol. However, only 16 Parties have ratified it and, as yet, no major developed country has ratified. To become binding in international law, it has to be ratified by 55 Parties and the developed countries that have ratified have to account for at least 55 % of total carbon dioxide emissions from developed countries in 1990.

The UNFCCC's aim is to reach atmospheric concentrations that would prevent dangerous anthropogenic interference with the climate system but that would allow sustainable economic development. The EU Council of Ministers has adopted a provisional 'sustainable' target of a global average temperature increase of 2°C by 2100 above the 1990 levels. The increase by 1990 from pre-industrial levels is 0.5°C. Provisional sustainable targets consistent with the EU Council approach have been proposed: limiting temperature rise to 0.1°C per decade and sea level rise to 2cm per decade. Achieving such provisional targets would imply substantial reductions of all greenhouse gases, in the order of 35 % by 2010 from 1990 levels, rather than the 8 % required under the UNFCCC Kyoto Protocol. To stabilise carbon dioxide concentrations in the atmosphere at the 1990 level by 2100 would require even larger reductions of global carbon dioxide emissions by 50 to 70 % from the 1990 levels. The latest scientific knowledge on climate change will be described in the IPCC Third Assessment Report, expected to be published in 2001.

Table 1: EU15 and PHARE MS reduction targets under the Kyoto Protocol and the EU burden sharing agreement.

Country	% reduction to be achieved by 2008-2012 from 1990*
EU15	
Austria	-13
Belgium	-7.5
Denmark**	-21
Finland	0
France	0
Germany	-21
Greece	25
Ireland	13
Italy	-6.5
Luxembourg	-28
The Netherlands	-6
Portugal	27
Spain	15
Sweden	4
United Kingdom	-12.5
EU15	**-8**
PHARE	
Romania *	-8 %
Hungary *	-6 %
Estonia	-8 %
Slovak Republic	-8 %
Bulgaria *	-8 %
Latvia	-8 %
Poland *	-6 %
Czech Republic	-8 %

Note:

* Base year is different from 1990: Hungary (average of 1985-1987), Bulgaria, Poland (1988), Romania (1989).

** The burden-sharing target for Denmark applies to emission estimates, adjusted for imports and exports of electricity.

A number of existing EU and Member State policies and measures aim to either reduce greenhouse gas emissions or to enhance carbon sinks, these include:

- Energy/carbon dioxide taxes in various Member States (Austria, Denmark, Finland, Sweden and the Netherlands), although no agreement has been reached on a comprehensive EU-wide energy products tax;
- A negotiated agreement (1998) between the European Commission and the car industry to reduce carbon dioxide emissions from new passenger cars by 25 % (to 140 g/km) between 1995 and 2008;
- An (amended) monitoring mechanism for CO_2 and other greenhouse gas emissions (European Commission, 1999) to monitor progress towards the EU UNFCCC and Kyoto Protocol targets;
- The requirement of the Integrated Pollution Prevention and Control (IPPC) Directive to use Best Available Technology and to improve energy efficiency;
- The requirement of the Landfill Directive to reduce the amount of organic waste landfilled (thus reducing methane emissions) and to collect landfill gas for energy use;
- EU energy-efficiency demonstration programmes (ALTERNER, SAVE and JOULE-THEMIE);
- Several Directives on energy-efficiency requirements for appliances and various agreements with manufacturers and importers on minimum energy standards.

- A Communication (European Commission, 1999) on the preparations for implementing the Kyoto Protocol, noting the need for reinforcement of national and common and coordinated policies and measures that will be necessary to achieve the Kyoto commitment.

1.3.2. Air Pollution (UNECE/CLRTAP, EU)

Air quality is affected by emissions to the atmosphere from energy use, industry, transport and other sources. Harm to human health, the acidification and eutrophication of water and soils, and damage to natural ecosystems and crops are the main environmental issues associated with air emissions. The effects of air pollution are inter-related and have a significant transboundary contribution.

The first international treaty with strategies for reducing transboundary air pollution was the United Nations Economic Commission for Europe (UNECE) Convention on Long Range Transboundary Air Pollution (CLRTAP), which was signed in 1979 and entered into force in 1983. The need to establish air pollution abatement strategies and in addition monitor progress towards emission reduction targets within CLRTAP was a stimulus to develop European emission inventories. Originally CLRTAP was aimed at reducing acidification and ground-level ozone, resulting in several Protocols that are in force for most European countries, including the EU and its Member States, requiring reductions of emissions of sulphur dioxide (SO_2), non-methane volatile organic compounds (NMVOC) and nitrogen oxides (NO_x), expressed in national emission ceilings or percentage reductions. The Second Sulphur Protocol of CLRTAP (1994) for the first time used the approach of closure of the gap between the actual deposition levels and the critical level for such deposition for ecosystems. This Protocol thereby resulted in national emission reduction commitments that are quite different for each country, according to the ecosystems' sensitivity.

In 1998 CLRTAP Protocols were adopted that require reductions in the use and emissions of a number of heavy metals (such as mercury, cadmium) and persistent organic pollutants (POPs, such as dioxins).

Within CLRTAP in December 1999 national emission ceilings were agreed in a new multi-pollutant Protocol for SO_2, NMVOC, NO_x and for the first time for ammonia (NH_3) for many European countries, including EU Member States. These targets are much more strict than the previously agreed targets. In May 1999 the European Commission prepared a proposal for a Directive on national emission ceilings (NECD) for the same pollutants. The proposal is not yet adopted by the Council, but a common position was reached in June 2000. For a number of Member States, the NECD targets are more strict than those agreed within CLRTAP.

Table 2 provides an overview of all current and proposed emission reduction targets and/or emission ceilings, for the EU15.

Table 2: Air emissions reduction targets for the EU15 and the EU Member States

Policy/Pollutant	Base year	Target year	Reduction (%)
UNECE-CLRTAP			
Sulphur dioxide[1]	1980	2000	62
Sulphur dioxide[4]	1990	2010	75
Nitrogen oxides[2]	1987	1994	stabilisation
Nitrogen oxides[4]	1990	2010	50
Non-methane VOCs[3]	1987	1999	30
Non-methane VOCs[4]	1990	2010	58
Ammonia [4]	1990	2010	12
5EAP			
Sulphur dioxide	1985	2000	35
Nitrogen oxides	1990	2000	30
Non-methane VOCs	1990	1999	30
NECD (proposed targets)[5]			
Sulphur dioxide	1990	2010	78
Nitrogen oxides	1990	2010	55
Non-methane VOCs	1990	2010	62
· Ammonia	1990	2010	21

Notes:

1 Target from the 1994 Second Sulphur Protocol. The different emission ceilings for each Member State correspond to a 62 % emission reduction for the EU.

2 Targets from first NO_x Protocol. These are the same for individual Member States and for the EU.

3 Targets from NMVOCs Protocol. These are the same for individual Member States and for the EU.

4 Targets from the multi-pollutant Protocol (1 December 1999). The emission reduction target for the EU is shown, which corresponds with the overall effect of the different emission ceilings for each Member State.

5 Targets from the European Commission's 1999 proposal for a national emission ceilings directive (NECD). The emission reduction target for the EU is shown, which corresponds with the overall effect of the different emission ceilings for each Member State.

Table 3 and table 4 provide the most recent emission ceilings that are respectively proposed (NECD, May 1999) or agreed (CLRTAP, December 1999) for the EU Member States as well as Central and Eastern European countries (PHARE countries).

Table 3: Proposed national emission ceilings for SO_2, NO_x, NMVOC and NH_3 to be achieved by 2010 (EU NECD, May 1999) (kTonnes)

Country	SO_2	NO_x	NMVOC	NH_3
Austria	40	91	129	67
Belgium	76	127	102	57
Denmark	77	127	85	71
Finland	116	152	110	31
France	218	679	932	718
Germany	463	1051	924	413
Greece	546	264	173	74
Ireland	28	59	55	123
Italy	566	869	962	430
Luxembourg	3	8	6	7
Netherlands	50	238	156	104
Portugal	141	144	102	67
Spain	746	781	662	353
Sweden	67	152	219	48
UK	496	1181	964	264
TOTAL EU	**3633**	**5923**	**5581**	**2827**

Table 4: National emission ceilings for SO_2, NO_x, NMVOC and NH_3 to be achieved by 2010 (Protocol to CLRTAP, December 1999) (kTonnes)

Country	SO_2	NO_x	NMVOC	NH_3
Austria	39	107	159	66
Belgium	106	181	144	74
Denmark	55	127	85	69
Finland	116	170	130	31
France	400	860	1100	780
Germany	550	1081	995	550
Greece	546	344	261	73
Ireland	42	65	55	116
Italy	500	1000	1159	419
Luxembourg	4	11	9	7
Netherlands	50	266	191	128
Portugal	170	260	202	108
Spain	774	847	669	353
Sweden	67	148	241	58
UK	625	1181	1200	297
TOTAL EU	**4044**	**6648**	**6600**	**3129**

Country	SO_2	NO_x	NMVOC	NH_3
Bulgaria	856	266	185	108
Czech Republic	283	286	220	101
Estonia	-	-	-	-
Hungary	550	198	137	90
Latvia	107	84	136	44
Lithuania	145	110	92	84
Poland	1397	879	800	468
Romania	918	437	523	210
Slovenia	27	45	40	20
Slovak Republic	110	130	140	39

To help reach the EU MS targets, current European Community legislation aimed at reducing acidifying pollutants and ozone precursors includes:

- A Directive on large combustion plants (88/609/EEC), including a proposal (1998) for its revision.
- A Directive on the sulphur content of certain liquids.
- Directives resulting from the first Auto Oil programme: on emissions from passenger cars and light commercial vehicles (70/220/EEC, as last amended by 98/69/EEC); on quality of petrol and diesel fuels (98/70/EC); on emissions from non-road mobile machinery (97/68/EC), for heavy duty vehicles (Common Position on amending Directive 88/77/EEC).
- The Directive on 'stage 1' controls on gasoline storage and distribution (94/63/EC).
- The 'Solvents Directive' (Directive on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations (March 1999).

Currently there is no EU legislation in place to reduce ammonia emissions.

The second Auto Oil programme is expected to result in new proposals in 2000 for emission limit values on new cars, other technical measures as well as non-technical measures such as a move towards more environmentally friendly modes of transport. Further measures for other sectors could be developed as well.

In addition, measures to reduce greenhouse gas emissions (particularly carbon dioxide) could, as a side effect, reduce acidifying substances and ozone precursors. One such measure is fuel switching to natural gas.

1.4. Air emission inventories and indicators

The estimation, collection and presentation of data on air emissions are important aspects of policy making and policy implementation aimed at reducing air pollution and tackling the issue of climate change. The main aims of air emission inventories and indicators are:

- to identify and quantify the pressures on the environment and to assess the impacts on the state of the environment, on human health and on materials;
- to develop abatement strategies and prioritise policies and measures for the main source categories (sectors) in a cost-effective way. This is increasingly done by making use of integrated assessment models;
- to monitor the effects of implemented policies and measures in terms of reduced or avoided emissions. This includes monitoring of internationally agreed emission reduction targets (EC legislation and/or international conventions);
- to inform the public, by means of air emission indicators (which are derived from more detailed data). Despite the limitations of emission inventory data from countries, as described below, EEA believes these data have sufficient quality to use for the preparation of the main indicators on air emissions for it's reports.

To fulfil these aims there is an increasing demand for *reliable (accurate)* detailed emission estimates for the national total emissions and for the main source categories. These estimates should be *consistent* over time and should be *comparable* between countries. To increase consistency the same methodologies should be used by a country for the complete time series of data. This can mean recalculation of the complete time series when better methodologies become available. To increase comparability it is important that all countries use the same source categories. Furthermore emission estimates should be *transparent*, meaning that the assumptions and methodologies used should be clearly explained. This is essential for successful communication of information. Inventories should also be *complete*, meaning that all relevant sources are covered of the geographic area of concern (often a country, although also regional and local inventories are prepared).

For each pollutant the potential sources are identified and listed in a hierarchical nomenclature comprising major categories and several levels of sub-categories. Except for large industrial or other 'point sources', most emissions data are estimated rather than measured directly. It is important to realise that the emission estimates are always based on a number of assumptions, complex methodologies and often incomplete data. Uncertainties are therefore inevitable in any estimate of national emissions or removals (mainly relevant for carbon dioxide). It is important that these uncertainties are understood, properly communicated and where possible reduced to improve effective policymaking and performance monitoring.

For some gases uncertainties can be large (Eggleston, et. al., 1998), ranging broadly as follows for the total national emissions, on a gas-by-gas basis:

- CO_2: 10 % (fuel related CO_2: 3-5 %)
- CH_4: 20 %
- N_2O: 50 %
- HFCs and SF_6: 50 %; PFCs: 100 %
- SO_2: 10 %
- NO_x: 30 %
- NMVOC, NH_3: 50 %
- PM10: 50-100 %
- heavy metals, POPs: factor 2 to 3

However it should be noted that uncertainties in trends are likely to be (much) smaller than uncertainties in absolute numbers (Eggleston et. al. 1998). Furthermore within the IPCC work currently experiences are collected and new approaches are being developed aimed at providing better quantitative estimates of uncertainty than currently are available (IPCC, 1999).

On the international level the following approaches and methodologies exist for compiling and reporting national air emission inventories:

- CLRTAP/EMEP guidelines and EMEP/CORINAIR guidebook (acidifying and eutrophying pollutants, ozone precursors, heavy metals and persistent organic pollutants or POPs);
- UNFCCC guidelines, EU Monitoring Mechanism guidelines and IPCC guidelines (greenhouse gases).

Parties to CLRTAP are required to submit annual national emissions of SO_2, NO_x, NMVOC, CH_4, CO and NH_3 and various heavy metals and POPs using the 11 main source categories (level 1 of SNAP, Selected Nomenclature for sources of Air Pollution) by 31 December following each year (from 31 Dec. 1999 onwards also SNAP level 2). Parties are also required to provide EMEP periodically with emission data within grid elements of 50km x 50km, as defined by EMEP and known as the EMEP grid. Parties should use the EMEP/CORINAIR Atmospheric Emission Inventory Guidebook both as a reference book on good emission estimation practice and as a check-list to ensure that all relevant activities are considered and their emissions quantified. In December 1999 the second edition of this Guidebook has been made available on the Internet, EEA website: http://themes.eea.eu.int/theme.php/state

Parties to UNFCCC are required to report emissions and sink estimates by 15 April for the last year but one of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6). UNFCCC requires Parties to use the UNFCCC reporting guidelines on annual inventories, which refer to the use by Parties of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 1997).

The ongoing developments in both the EMEP/CORINAIR Guidebook and the IPCC 1996 Guidelines are expected to improve inventories further, regarding all relevant quality aspects (*consistency, comparability, transparency, completeness)* and reduce the uncertainties. Section 7 and Annex 3 of this report deal with some of the current experiences on quality and timeliness. Of particular importance is the need for further work by countries, assisted by EEA, its ETC/AE, the two convention secretariats, and the relevant Task Forces to achieve consistent time series over the full period of relevance (from 1980 onwards for UNECE/CLRTAP and from 1990 onwards for UNFCCC). This can in many cases involve recalculation of (parts of) earlier estimates. As requirements for reporting of emissions data under CLRTAP and UNFCCC are getting more detailed, differentiated national databases for different purposes should merge towards a single coordinated database.

In Annex 1 and 2 the various international guidelines, their ongoing developments and the activities of the European Topic Centre on Air Emissions (ETC/AE) are described in more detail.

1.5. Definitions

1.5.1. Sectors

In this report aggregated sectors are used, based on the more detailed sectors used within UNECE/EMEP/CORINAIR and UNFCCC/IPCC. The methods used to prepare these 'EEA' sectors used in this report, and also in the main EEA assessment reports, are shown in Table 6.

Table 5: Grouping of detailed sectors into 'EEA' sectors used in this report

'EEA' sectors used in this report	**UNECE/EMEP/CORINAIR (Acidifying pollutants, ozone precursors, heavy metals, POPs)**	**UNFCCC/IPCC (Greenhouse gases)**
Energy	01: Combustion in energy and transformation industries	1A1: Energy and Transformation Industries
Industry	03: Combustion in manufacturing industry 04: Production processes	1A2: Industry 2: Industrial Processes
Transport	07: Road transport 08: Other mobile sources and machinery	1A3: Transport
Agriculture	10: Agriculture	4: Agriculture
Waste[1]	09: Waste treatment and disposal	6: Waste
Other[1]	02: Non-industrial combustion plant 05: Extraction and distribution of fossil fuels / geothermal energy 06: Solvent and other product use	1A4+5: Small Combustion + Other 1B: Energy/Fugitive emissions from Fuels 3: Solvent and other product use 5: Land-use change and Forestry 7: Other

1: Where 'Waste' is not specified 'Other' also includes 'Waste'

1.5.2. Pollutants

This report focuses on emissions, which contribute to four major environmental issues: climate change, acidification, tropospheric (ground-level) ozone and hazardous/toxic air pollution. Table 6 shows the pollutants considered in this report and links these to the relevant environmental issues to which they contribute.

Table 6: Pollutants covered in this report and their links to environmental issues

Pollutant	Acidification	Tropospheric Ozone	Toxic Pollutants	Climate Change [3]
Sulphur Dioxide, SO_2	✔			
Nitrogen Oxides (NO_2 + NO), NO_x	✔	✔	✔	
Ammonia, NH_3	✔			
Non-methane Volatile Organic Compounds, NMVOC		✔	✔[1]	
Carbon Monoxide, CO		✔	✔[2]	
Carbon Dioxide, CO_2				✔
Methane, CH_4		✔		✔
Nitrous Oxides, N_2O				✔
Hydrofluorocarbons, HFC				✔
Perfluorocarbons, PFC				✔
Sulphur Hexafluoride, SF_6				✔
Heavy Metals (Hg, Pb, Cd)			✔	
Particulate Matter <10ug			✔	
Persistent Organic Pollutants (Dioxins/Furans, PAH)			✔	

1: Some specific species such as benzene and 1,3-butadiene

2: Not toxic at general ambient concentrations

3: Ozone is also a greenhouse gases and therefore NO_x, NMVOC and CO have an indirect effect on climate change. Furthermore aerosols containing sulphates and nitrates have a local cooling effect and thereby also SO_2, and NH_3 have an indirect effect on climate change.

1.5.3. Geographic coverage

In this report the following definitions are used to enable compilation and presentation of consistent time series:

- European Union (EU15) refers to the current 15 Member States.
- EEA18 refers to the 18 members of the European Environment Agency.
- Germany includes both the former East Germany (New Länder) and West Germany.
- Central and Eastern European PHARE countries are Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovenia, Slovak Republic

1.6. Data and indicators in this report

Data used for this report are the official data submitted by countries, by October 1999, to the following international reporting obligations:

- Acidifying pollutants, ozone precursors, heavy metals, persistent organic pollutants (POPs): CLRTAP/EMEP.
- Greenhouse gases: UNFCCC and EU Council Decision on a Monitoring Mechanism of Community CO_2 and other greenhouse gas emissions.

In addition these data have been complemented, in this report, by more detailed data, submitted by various countries directly to EEA, assisted by ETC/AE. Furthermore, for some pollutants (heavy metals, POPs and particulate matter (PM)) additional data, originating from other sources of information, are presented.

Furthermore spatially detailed data reported directly to EEA/ETC-AE has been used (NUTS-3) for some years (1990 or 1994/1995). NUTS means Nomenclature des Unités Territoriales dans l'Union Européenne (Nomenclature of Territorial Units for Statistics), maintained by Eurostat. It should be noted that regions within the same NUTS level but in different EU Member States cannot be compared easily because these regions can differ greatly in terms of area, population, economic weight or administrative powers.

Some pollutants are reported to both conventions (UNFCCC and CLRTAP), which can lead to different results. This concerns NO_x, CO, NMVOC and CH_4. The use of the two different formats (EMEP/CORINAIR and IPCC) for these pollutants can lead to different national total estimates for the following reasons:

- Difference spatial coverage
- Different level of detail
- Inclusion or exclusion of emissions from ‘natural’ sources and/or sinks (only relevant in the case of CO_2)

CLRTAP only includes emissions from within the EMEP area (=Europe) while reporting to the UNFCCC can include emissions from anywhere in the world if these are judged as ‘national’. The IPCC format could be seen as helping in finding political responsibilities and therefore includes oversee territories, which e.g. in the case of France can lead to significant additional emissions. CLRTAP and EMEP are trying to link national emissions in Europe to transboundary air pollution in Europe, showing, for example, that deposition of acidifying pollutants in a certain country can often be due to emissions in other European countries. The EMEP format is therefore defined geographically to Europe only.

Another difference between the data sets is the level of detail they provide. This level of detail differs considerably between the formats. CORINAIR is the most detailed with up to 414 sub-totals. UNFCCC/IPCC has up to 36 sub-totals. CLRTAP requires 11 sub-totals and encourages reporting of approx. 75 more detailed sub-sectors.

The third relevant difference is the requirement within CLRTAP to report emissions from ‘natural’ sources, such as volcanoes (SO_2) and forests (NMVOC), which is not required by UNFCCC/IPCC.

Therefore, to avoid any problems the data submitted in the formats specifically developed for the pollutants have been used. In practice this means:

- greenhouse gases (CO_2, N_2O, CH_4, HFC, PFC and SF_6): data reported in IPCC format.
- all other pollutants (SO_2, NO_x, CO, NMVOC, NH_3, heavy metals, persistent organic pollutants): data reported in the EMEP/CORINAIR format (SNAP level 1 or 2).
- in some cases additional more detailed (SNAP level 3) data reported directly to EEA.

For the EU15 greenhouse gas data a regular annual system is operational since 1999, set up by EEA, assisted by ETC/AE, resulting in the *Annual EU greenhouse gas inventory, submission to the UNFCCC secretariat*, Technical Report 19/1999, EEA, Copenhagen (May 1999). These data and in addition more recent data, available by October 1999, have been used in this report. An update of this annual report is expected in May 2000.

For the EU15 data for other pollutants the intention is to set up a similar system. It is expected that the first Annual EU CLRTAP inventory, will be finalised in May/June 2000 and submitted to the CLRTAP secretariat.
For all countries copies of the (aggregated) data that have been officially reported by countries are compiled into a central database, maintained by ETC/AE, the CORe INventory for AIR emissions (CORINAIR) database. This database was used for the preparation of this report. Since October 1999, most of these data are also publicly available on the EEA website (http://service.eea.eu.int/).

Due to the increasing importance of emission data in policy development and in determining compliance with agreements, governments generally prefer that officially reported emissions data be used. In addition EEA, assisted by ETC/AE, is expected to work with member countries and avoid duplication and hence EEA will not produce separate emission estimates. However sometimes data reported by countries does not appear to be compatible with data from other countries or time series are not consistent. Furthermore not all countries keep to the guidelines or they may interpret them differently. Changes in methodology which affect emission data for recent years are not always applied to data for earlier years, which makes trend analyses less reliable. In some cases, the data supplied to different international bodies may be inconsistent as new updated data is submitted to one convention, but not to the other.

For this report the ETC/AE has excluded in some cases official data, that were clearly inconsistent with the relevant reporting requirements, and used, where needed for completeness, simple interpolation to fill any gaps or used the latest reported data for years for which data were missing. In Annex 4 these adjustments are shown.

2. Climate change – emissions of CO_2, CH_4, N_2O, HFC, PFC and SF_6

2.1. Total greenhouse gases

☺ Total EU greenhouse gas emissions have fallen slightly (1 %) from 1990 to 1996, while GDP has risen
☹ In most EU Members States greenhouse gas emissions have increased from 1990
☹ Further reductions in EU emissions, and additional policies and measures, will be necessary to achieve the UNFCCC Kyoto Protocol target
😐 In Central and Eastern European PHARE countries small to substantial emission reductions occurred from 1990 to 1996, mainly due to the economic restructuring process

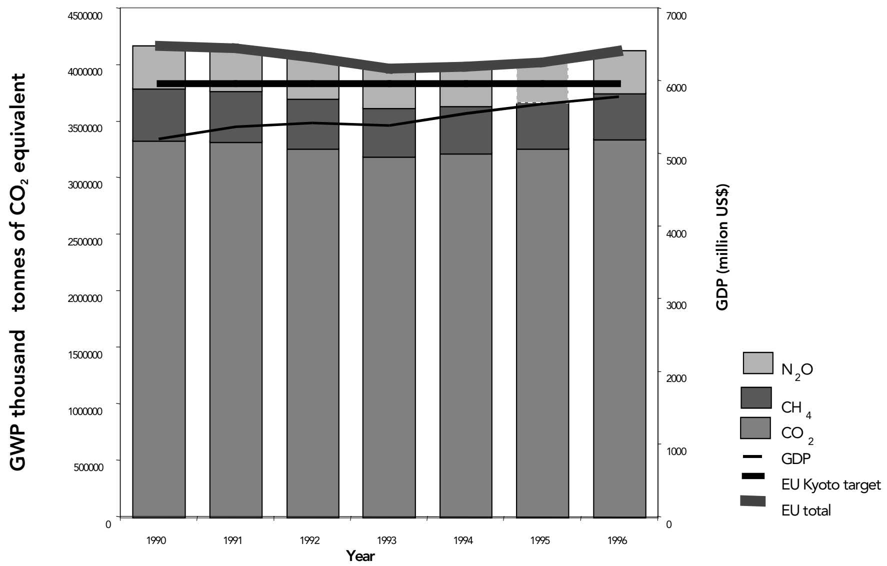


Figure 1: Total EU15 emissions of CO_2, CH_4 and N_2O (global warming potential weighted) and GDP since 1990 compared with targets.

Note: Global warming potentials used: CO_2 1, CH_4 21, N_2O 310. HFCs, PFCs and SF_6 are excluded due to lack of data. However these only account for about 1.3 % of the total. The values for Denmark are not adjusted for imports/exports of electricity for Denmark. Emissions and removals due to land-use change and forestry (LUCF) are excluded from this graph and elsewhere in this report because of major uncertainty in their estimates.

Figure 1 shows the overall emissions of the three main greenhouse gases in the EU15. These, together with HFC, PFC and SF_6 are included in the UNFCCC Kyoto Protocol, which calls for an 8 % reduction in the EU15's emissions. Total EU emissions of the three main greenhouse gases have fallen by 1 % from 1990 to 1996. The reasons for the small emission decrease are described below for the individual gases concerned.

As GDP has risen since 1990, it is clear that increases in GDP do not automatically lead to increases in carbon or greenhouse gas emissions. This suggests that there has been some de-coupling between emissions and economic growth. However, it is not clear that the emissions decrease can continue if emissions start to grow again with a growing economy, particularly with increases in traffic. Thus further actions will need to be taken to meet the Kyoto protocol targets.

The main source of CO_2 emissions is fossil fuel combustion and so energy use (in the energy sector and as well as in transport and industry) is an important contributor to climate change. Other activities that contribute to greenhouse gas emissions are agriculture, land-use changes (including deforestation), waste disposal to landfills and industrial processes such as cement production, refrigeration, foam blowing and solvent use.

Carbon dioxide makes the largest contribution to EU emissions (79 %), followed by methane (11 %) and nitrous oxide (9 %). In PHARE countries these contributions are quite similar. The Kyoto Protocol target also includes HFCs, PFCs and sulphur hexafluoride; emissions of these substances are not shown owing to lack of data from all EU Member States. Initial estimates indicate that these gases together amount to about 1.3 % of total EU greenhouse gas emissions (Figure 3).

Greenhouse Gas Equivalents

In order to estimate the relative contribution of greenhouse gases to the overall global warming impact they are weighted by their global warming potential over a 100 year time period.

Factors used (from IPCC, 1996): CO_2 1, CH_4 21 and N_2O 310, SF_6 23900, to give total GWP emissions in (million) tonnes CO_2 equivalent.

The other pollutants HFC and PFC are in fact mixture, with different GWP values depending on the circumstances. The UK uses for HFC a GWP of 6000 and for PFC 7370. In this report these factors are used for those countries reporting HFC and PFC emissions only in tonnes and not in tonnes CO_2 equivalent.

In the EU Member States have in 1998 arrived at a burden sharing agreement to allocate emission reductions to countries while keeping the overall EU15 reduction within the Kyoto target of 8 % reduction. Figure 2 shows the percentage change in total emissions of carbon dioxide, methane and nitrous oxide (weighted according to global warming potential) compared with individual country targets to meet the Kyoto Protocol. Between 1990 and 1996, total greenhouse gas emissions fell in only three EEA member countries (Germany, Luxembourg and the UK). The large emission reductions in absolute terms (tonnes) in the UK and Germany, have offset increases in the rest of the EU15. The reasons for the reductions in the UK and Germany are explained in the next sections. A large part of Luxembourg's emissions are from only a few large industrial sources, from which emissions have been reduced substantially the past years.

All Central and Eastern European countries show small to substantial emission reductions from 1990 (or another base year) onwards. This is mainly due to economic restructuring processes. The base year for the Kyoto Protocol for some of these countries is not 1990, but a few years earlier.

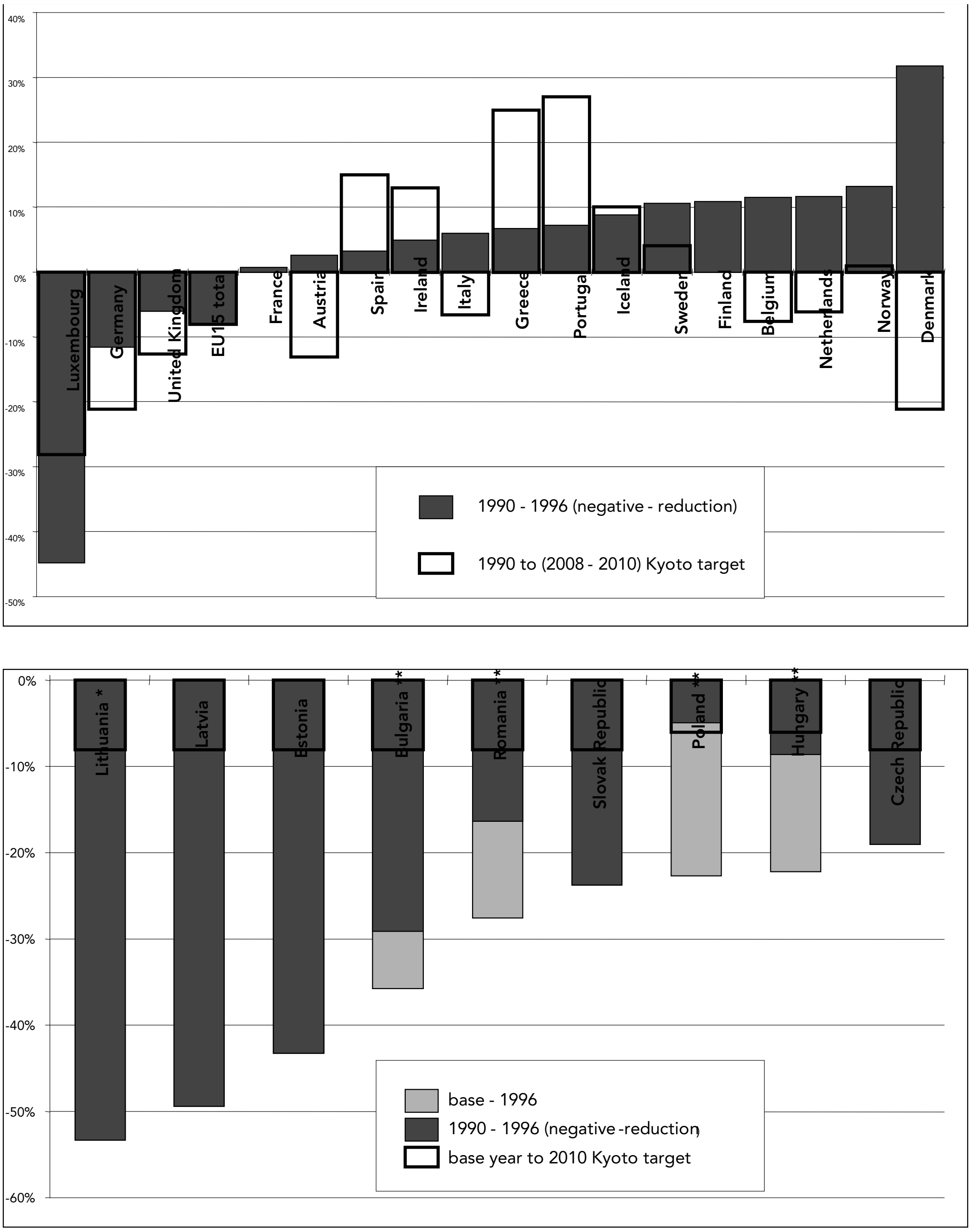


Figure 2: Percentage change in total emissions of CO_2, CH_4 and N_2O (global warming potential weighted) since their base year compared with individual country's Kyoto Protocol (and EU burden sharing) targets

Note: The values for Denmark are not adjusted for imports/exports of electricity for Denmark. The burden-sharing target for Denmark applies to adjusted emission estimates (base year and commitment years) and, if taken into account, will give a 0 % change between 1990 and 1996. The base years for various Central and Eastern European countries differ from 1990: Hungary (average of 1985-1987), Bulgaria, Poland (1988), Romania (1989). For these countries Figure 2 shows the reduction since the base year. The yellow indicates the reduction from the base year to 1990 and the red from 1990 to 1996.

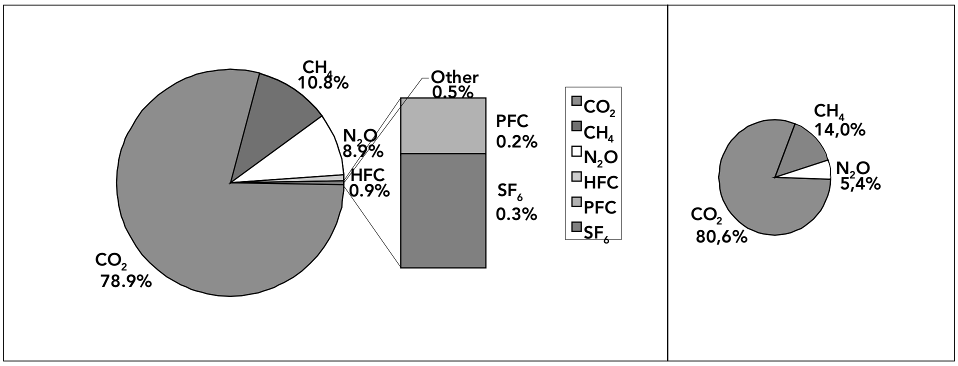


Figure 3: **EU15 (left) and PHARE countries' (right) share of greenhouse gases to total GWP emissions**

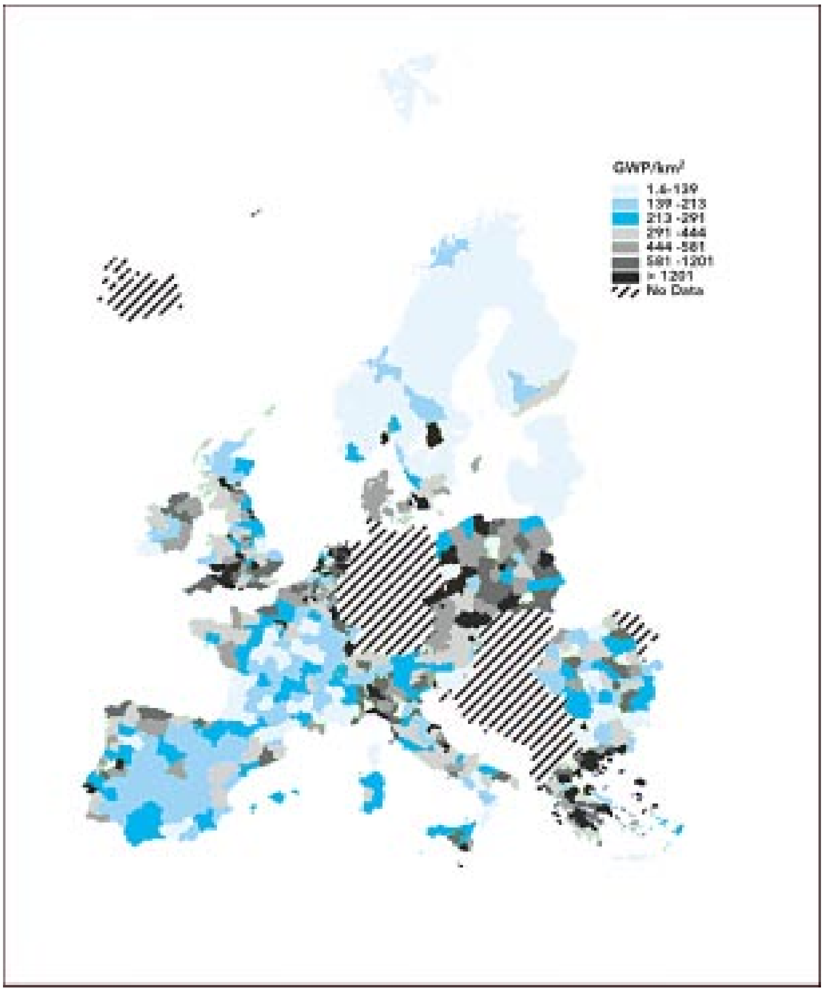


Figure 4: **Total greenhouse gas emission density in 1994/1995 in various countries by NUTS3 area (CO_2, CH4, N_2O in tonnes GWP per km^2)**

Figure 4 shows the emissions of total greenhouse gases (CO_2, CH_4 and N_2O, global warming potential weighted) from regions (NUTS3) within various countries in tonnes GWP per square kilometre. In general industrial areas show high emission densities.

2.2. Carbon dioxide (CO_2)

☹ Total EU carbon dioxide emissions in 1996 were in line with the target of stabilising emissions at 1990 levels by 2000. From 1990 to 1996, emissions decreased substantially only in Germany (economic restructuring in the new Länder and increased energy efficiency) and the UK (switch from coal to natural gas

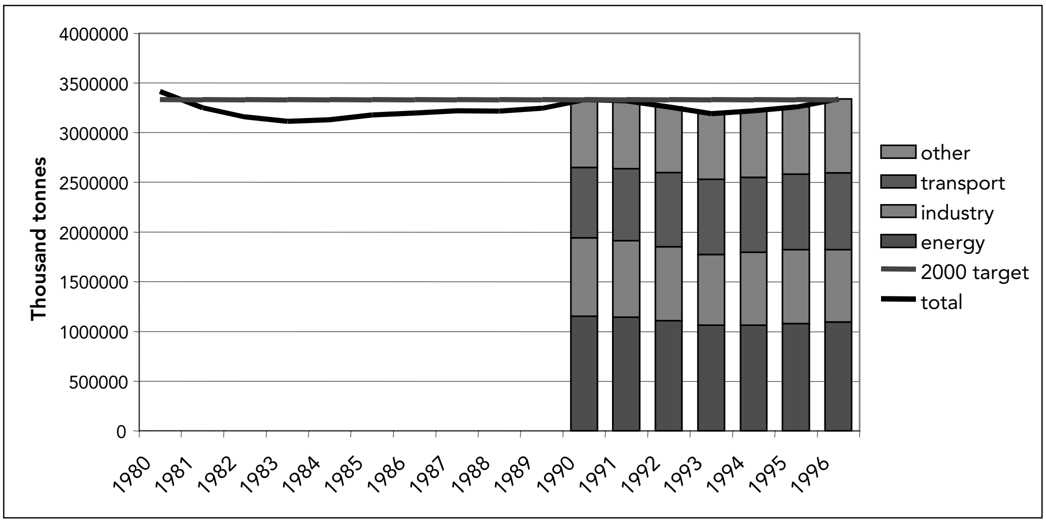
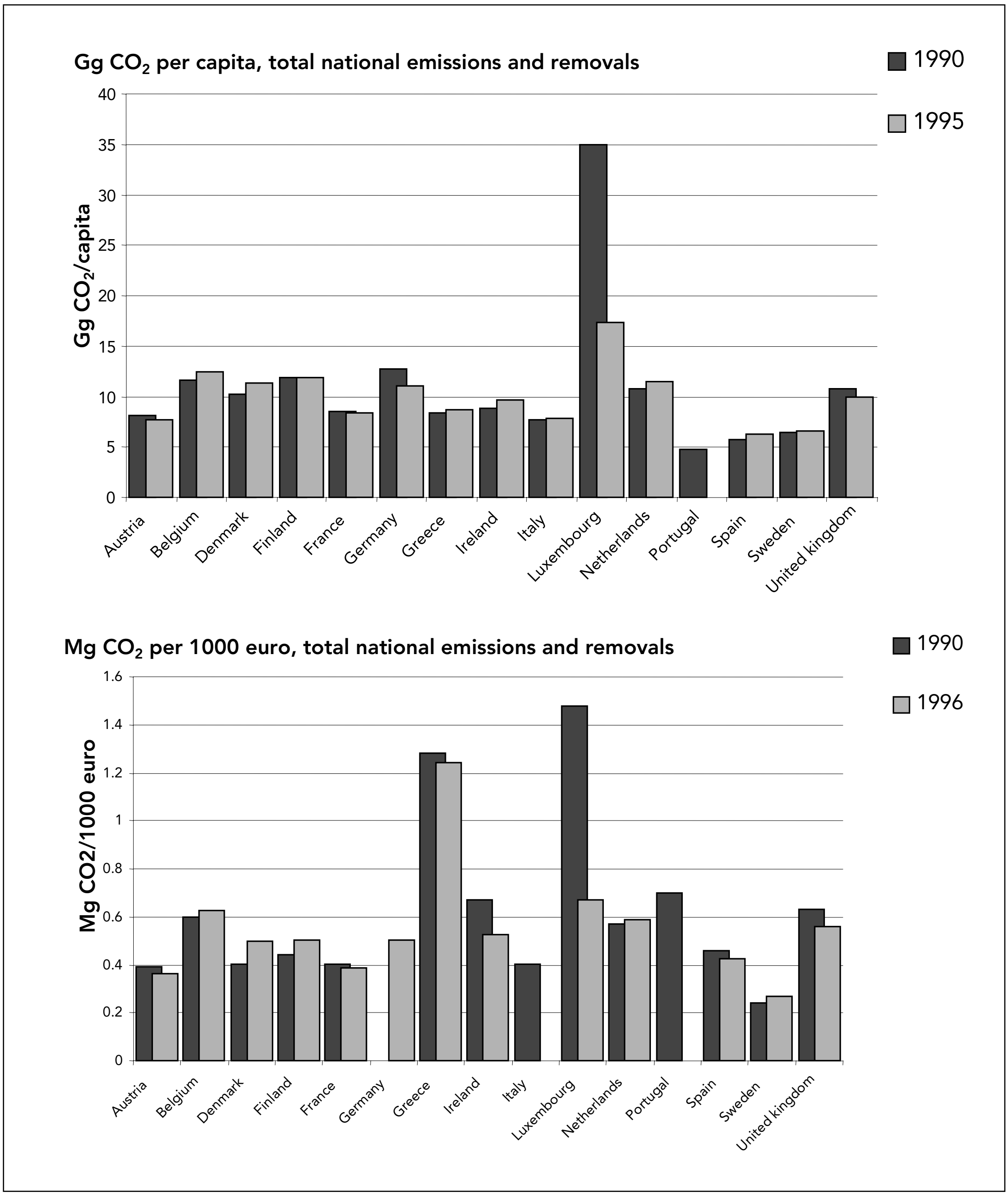


Figure 5: EU15 CO_2 emissions since 1980

In the fifth environmental action programme (5EAP), the EU set a target of stabilising carbon dioxide emissions at 1990 levels by 2000. Carbon dioxide emissions from EU Member States decreased initially in the early 1990s, but started to increase again in 1994 (Figure 5). The energy sector (mainly power and heat generation) is the main contributor to EU emissions (32 %), followed by transport (22 %) and industry (21 %). Emissions in 1996 were at almost the same level as 1990 due to decreases in Germany, Luxembourg and the UK. Emissions have increased significantly in all other Member States. The largest emission reduction took place in Germany, mainly due to economic restructuring in former East Germany (new Länder) and increased energy efficiency. The substantial UK reduction in emissions was primarily caused by a switch from coal to natural gas (natural gas produces lower emissions per unit of energy used).

Carbon dioxide emission trends can be compared with economic development during the same period. Between 1990 and 1996, GDP in the EU grew by about 9 % (almost 6 % between 1990 and 1995). Apart from the oil crisis in the early 1980s, the five-year average GDP growth in the period 1960 to 1990 was about 16 %. This suggests that the reduction in carbon dioxide emissions between 1990 and 1996 is partly due to the relatively low GDP growth in this period, partly to an increase in energy efficiency, and partly to the effects of policies and measures to reduce greenhouse gas emissions.



Source of GDP and Population data: Eurostat.

Figure 6: Per capita (top; Gg/capita) and per GDP (bottom; Mg/1000 euro) emissions of CO_2 in EU Member States (excluding those reported under land use change and forestry, IPCC sector 5)

To compare national emission between countries, Figure 6 presents per GDP (top) and per capita (bottom) emissions of CO_2. This shows emissions are roughly comparable between the EU Member States on the basis of economic production and of population size. Most countries are within a factor of two from each other, however with a few exceptions:

- emissions of CO_2 in Sweden and France are relatively low, mainly due to the large share of hydropower and nuclear power in both countries.
- emissions of CO_2 in Greece are quite high on the basis of the economic production.

- emissions of CO_2 in Luxembourg are quite high, both on a GDP and on a per capita basis. This is caused by the fact that Luxembourg is a small country with a comparatively large steel industry (this is confirmed by the high variability between years).

2.3. Methane (CH_4)

☺ Total EU methane emissions have fallen 12 % from 1990 to 1996, mainly in Germany (economic restructuring in the new Länder) and the UK (switch from coal to natural gas)

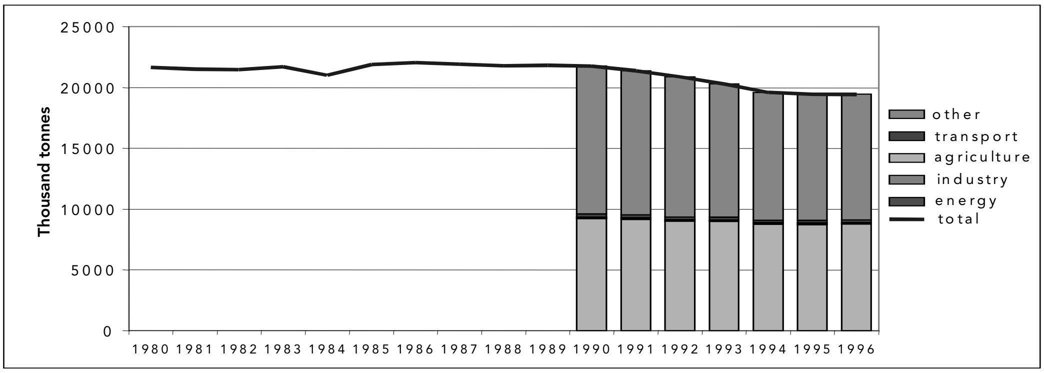
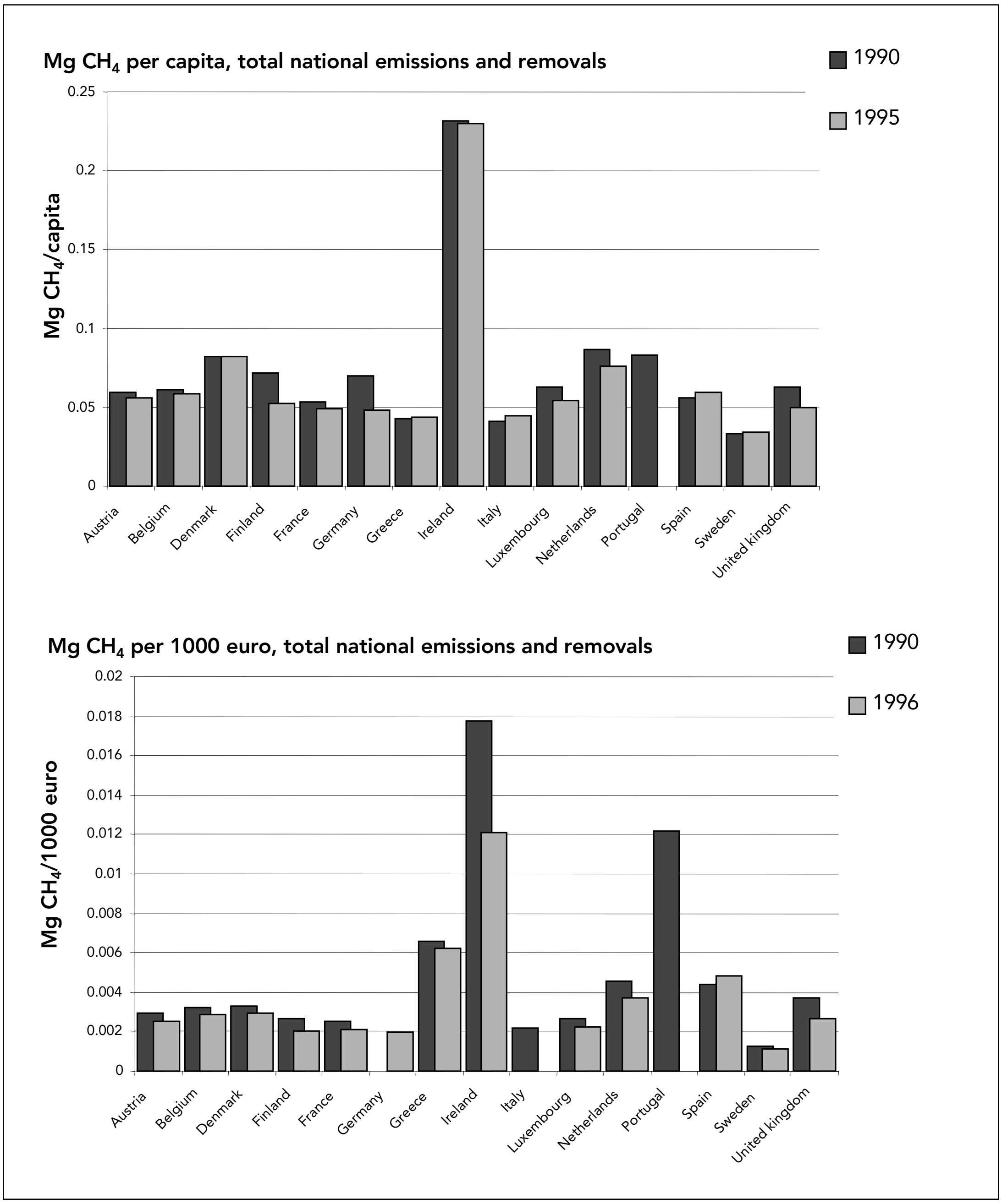


Figure 7: EU15 CH_4 emissions since 1980 (Other includes: extraction and distribution of fossil fuels, and landfill)

Total EU methane emissions fell by 12 % between 1990 and 1996 (Figure 7), but with considerable variation between Member States. Emissions from Germany and the UK fell by 36 % and 23 % respectively, but large increases occurred in Italy and Spain.

The main sources of methane emissions in the EU are: agriculture (45 %), particularly from ruminant animals (enteric fermentation and manure management) and 'other', which includes waste treatment and disposal, mainly landfilling (36 %) and coal mining and leakage from natural gas distribution networks. Estimates for methane emissions are much more uncertain than those for carbon dioxide emissions as the main sources (agriculture and waste treatment) are not well quantified.

The largest reduction in emissions appears to be due to the decline of deep mining in the UK – and to some extent in Germany – and the replacement of old gas-distribution pipework. Agricultural emissions also fell, mainly due to a reduction in the number of dairy cows (AEA, 1998).



Source of GDP and Population data: Eurostat.

Figure 8: Per capita (top; Mg/capita) and per GDP (bottom; Mg/1000 euro) emissions of CH_4 in EU Member States. (Excluding those reported under land use change and forestry, IPCC sector 5)

Figure 8 presents emissions of CH_4 on a per capita and a per GDP basis. Emissions of methane in Ireland and Portugal are relatively high. Ireland's agriculture industry provides a significant contribution to the Irish economy. Ireland's emissions per GDP have steadily decreased since 1990 demonstration improving environmental efficiency compared with GDP. Per capita emissions of methane in Denmark and the Netherlands are also relatively high, while the emission per GDP in these countries is closer to the EU average.

2.4. Nitrous oxide (N_2O)

☺ Total EU nitrous oxide emissions have fallen slightly (2 %) from 1990 to 1996

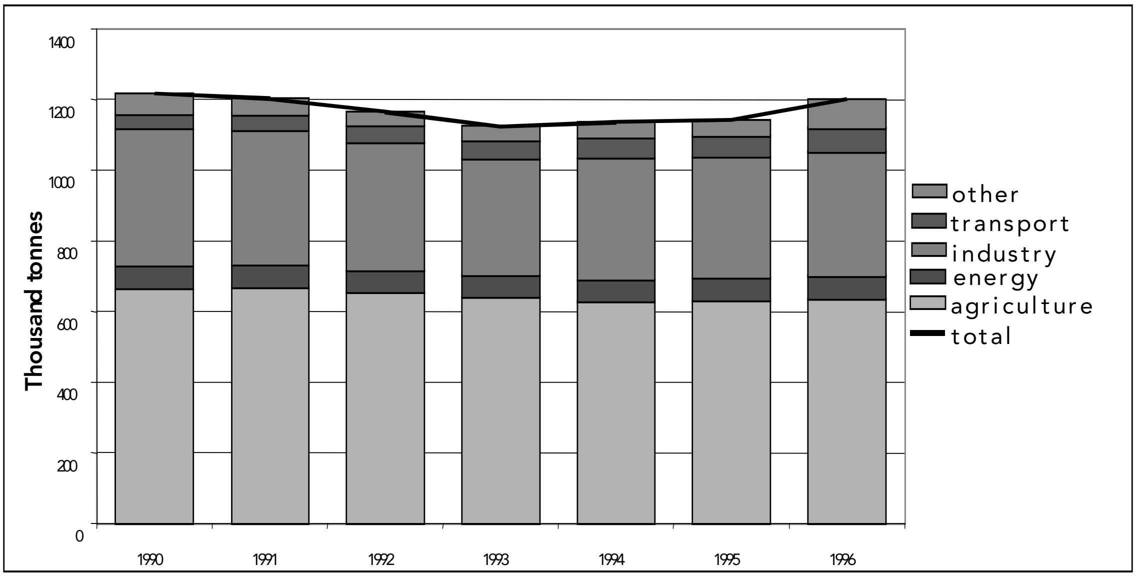
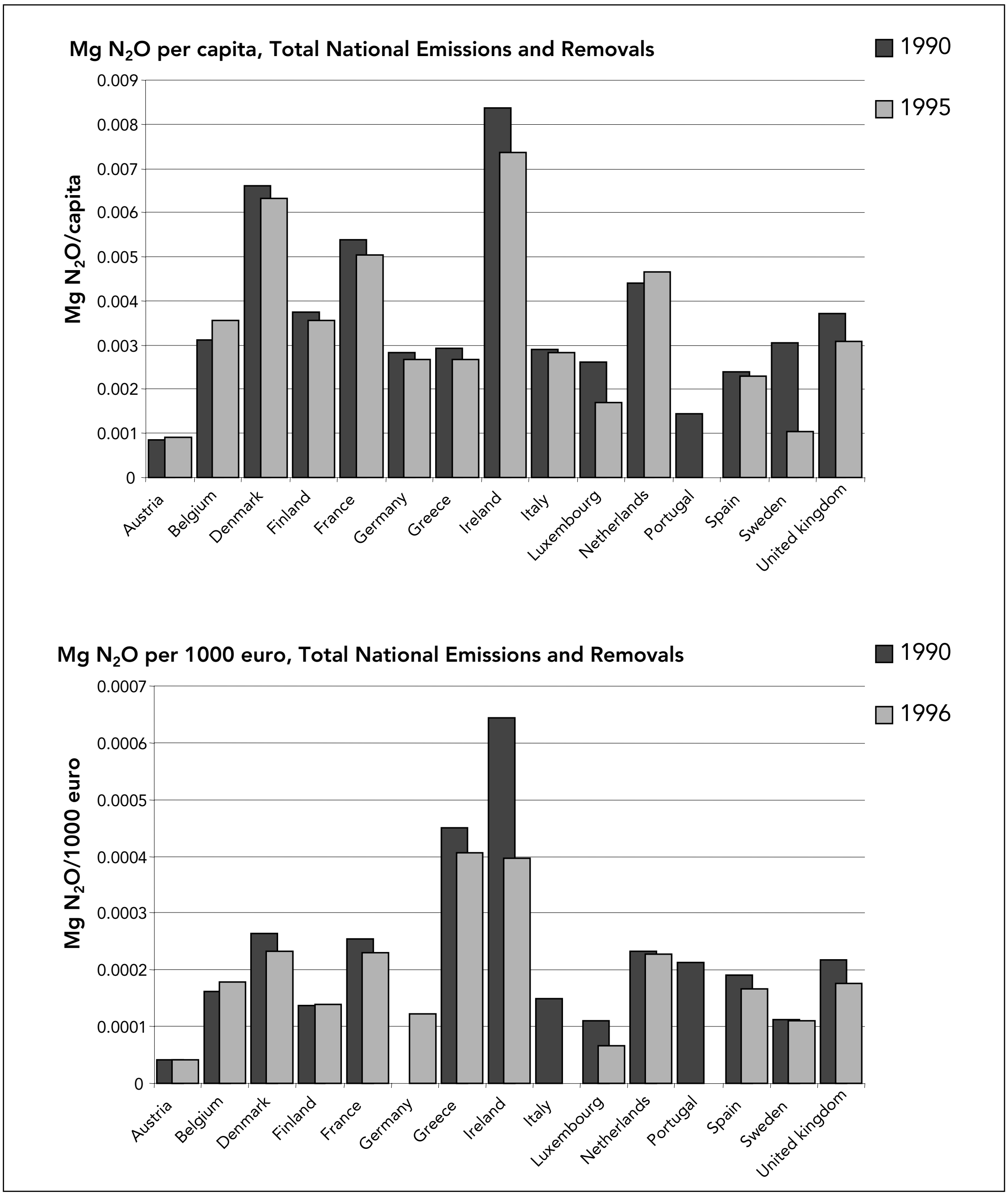


Figure 9: EU15 N_2O emissions since 1990

Total EU nitrous oxide emissions were 2 % lower in 1996 than in 1990 (Figure 9). However, this trend varies considerably between Member States. The main sources of nitrous oxide emissions in the EU are: fertilised agricultural land (46 %); industry (28 %), particularly adipic acid and nitric acid manufacture; transport (5 %); and energy (5 %). Emissions from the transport sector are due to three-way catalysts in passenger cars which reduce emissions of nitrogen oxides, carbon monoxide and hydrocarbons, but as a side effect, increase nitrous oxide emissions. Emissions data for nitrous oxide is much more uncertain than for carbon dioxide and methane primarily because the major source (agriculture) is not well quantified.

The agricultural sources (from soils and fertiliser use) are difficult to quantify and control, although reductions in agricultural production due to possible reforms of the common agricultural policy would lead to some falls in emissions. Industrial emissions, however, come from well-understood and defined sources and can be controlled. The largest reductions appear to be from reduced production levels for adipic and nitric acid in industry and less use of inorganic nitrogenous fertilisers in agriculture. These reductions were partly offset by an increase in transport emissions as the number of cars with catalytic converters increased (AEA, 1998).



Source of GDP and Population data: Eurostat.

Figure 10: Per capita (top; Mg/capita) and per GDP (bottom; Mg/euro) emissions of N_2O in EU Member States (excluding those reported under land use change and forestry, IPCC sector 5)

Figure 9 shows the N_2O emissions of EU Member States by capita and by GDP. A rather large variance is observed. The explanation of this is unclear, but the high uncertainties in the emission estimates might in part explain this variance.

2.5. Fluorocarbon gases (HFC, PFC, SF_6)

☺ Total fluorocarbon emissions in 1995 are 1 % of total EU greenhouse emissions. Trends are uncertain but emissions are most likely to have increased since 1990

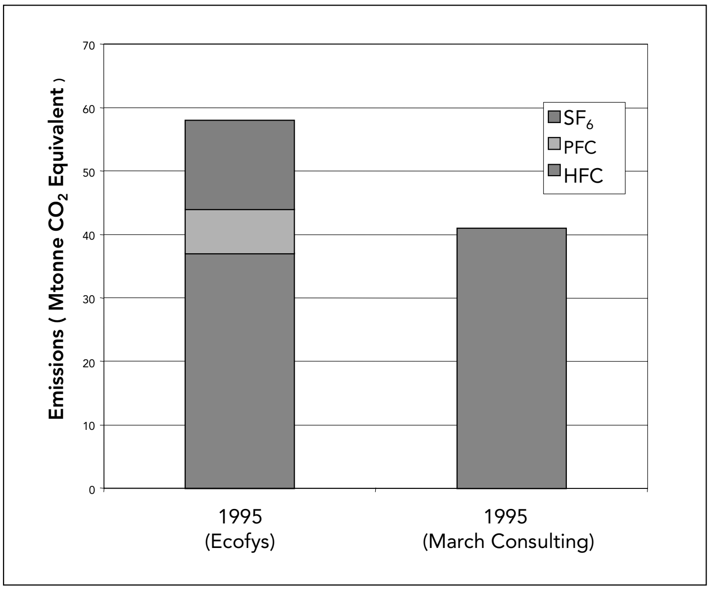


Figure 11: EU15 emissions of HFC, PFC and SF_6 (as CO_2 equivalents) for 1995

The remaining three 'Kyoto' direct greenhouse gases, which have high GWP values, the fluorocarbons HFC, PFC and SF_6 are shown in Figure 11. Under the Kyoto Protocol, countries can select either 1990 or 1995 as the base year for fluorocarbon emission reduction targets. Most EU Member States are expected to choose 1995. Total EU fluorocarbon emissions in 1995 are difficult to estimate as not all EU Member States provided data. Initial estimates shown here (from two separate studies for the Commission, 1998/1999) suggest that total EU emissions in 1995 of the three groups of Kyoto Protocol fluorocarbon gases (HFCs, PFCs and sulphur hexafluoride) are about 58 million tonnes of carbon dioxide equivalents (EEA, 1999). This is about 1.3 % of total EU emissions of total carbon dioxide, methane and nitrous oxide emissions in 1990 in terms of carbon dioxide equivalents (Ecofys, 1998).

The largest contribution comes from HFCs (64 %), followed by sulphur hexafluoride (25 %). At present, HFCs are mainly emitted as a by-product during the production of the hydrochlorofluorocarbon, HCFC-22. HCFCs are not controlled under the Kyoto Protocol, but under the Montreal Protocol for ozone-depleting substances (Chapter 9). The most important source of sulphur hexafluoride emissions is its use in switches in electricity distribution. PFC emissions arise mainly from production processes in the primary aluminium and the electronics industry.

Figure 12 shows the countries that have reported fluorocarbon emissions. Current trends are difficult to ascertain though the emissions are likely to have grown since 1990.

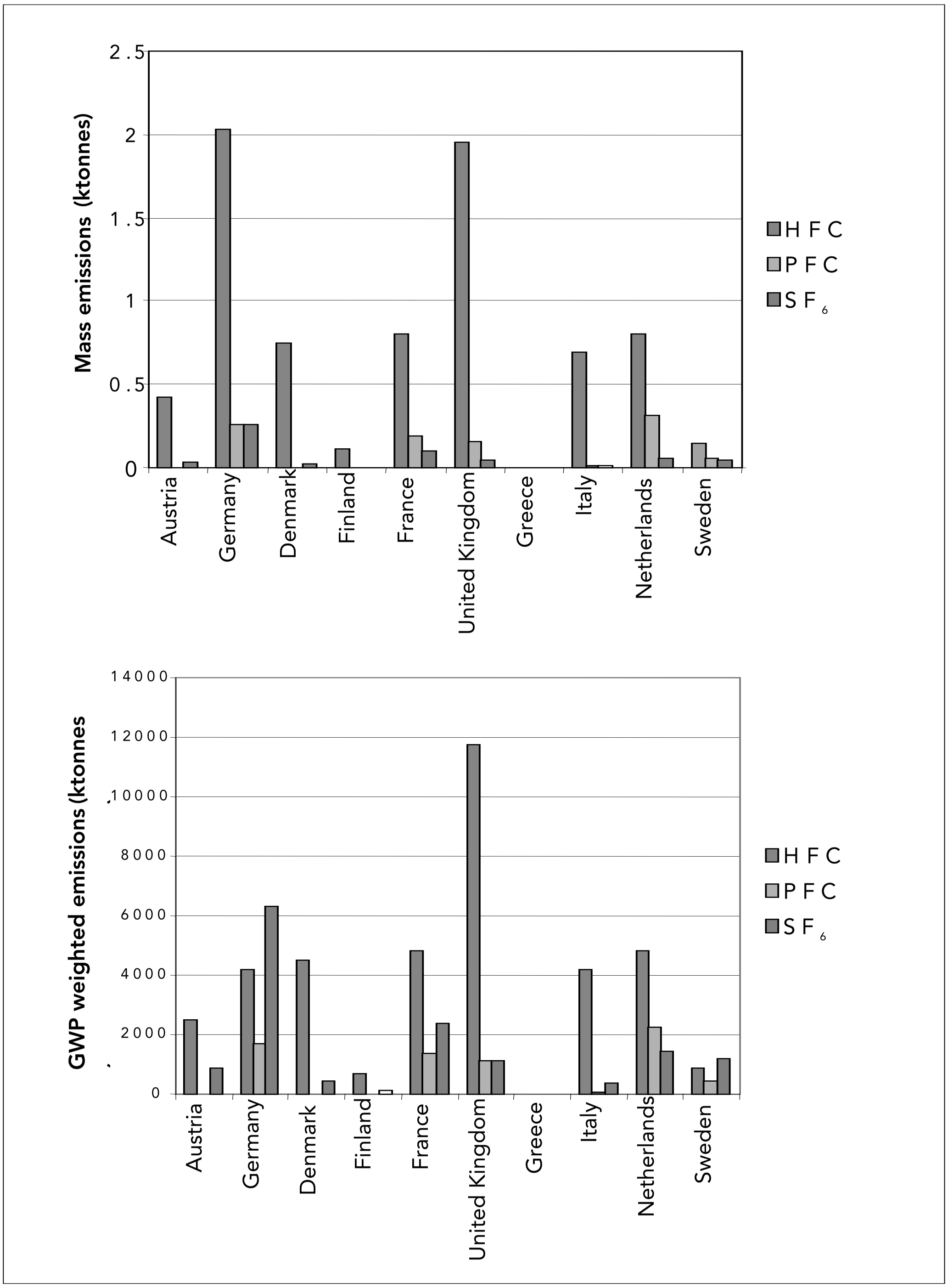


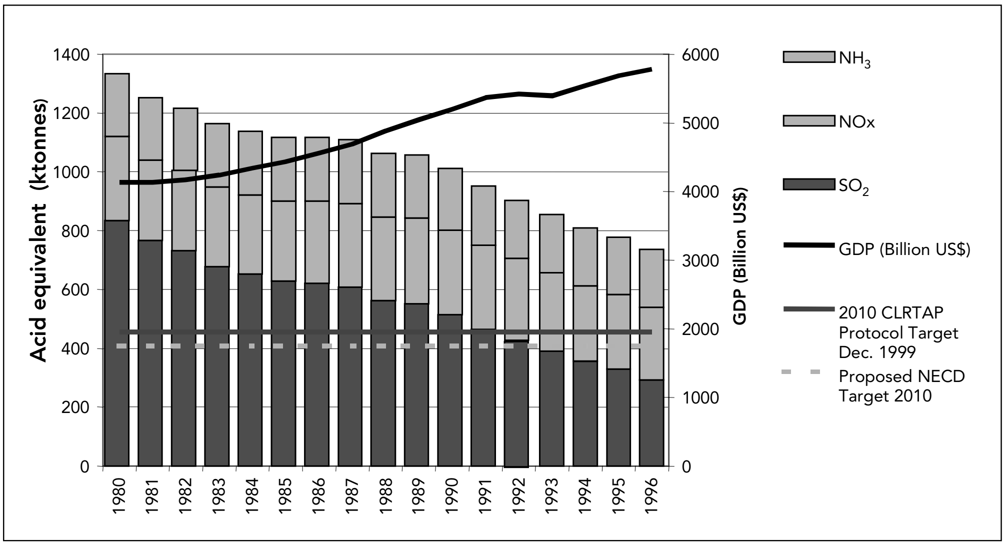
Figure 12: **Reported emissions of HFC, PFC and SF_6 (various EU Member States) for 1995**

3. Acidification – emissions of SO_2, NO_x and NH_3

3.1. Total acidifying gases

☺ Total EU emissions of acidifying gases have decreased significantly (45 % from 1980 to 1996), while GDP has risen showing a de-coupling from GDP growth. This reduction is mainly due to a significant decline in SO_2 emissions

😐 Further reductions in nitrogen oxide and ammonia emissions will be necessary to achieve the proposed NECD and agreed CLRTAP targets for 2010



Source of GDP: Eurostat.

Figure 13: EU15 emissions of acidifying gases (acid equivalents) and GDP since 1980 compared with targets

Notes: Emission reduction targets are for the EU and combined for the three gases using weighting factors. Acidifying equivalents per g used for weighting are: sulphur dioxide 1/32; nitrogen oxides 1/46; ammonia 1/17.

In the EU as a whole, total emissions of acidifying gases (SO_2, NO_x and NH_3) decreased by about 45 % between 1980 and 1996 and by 27 % between 1990 and 1996 (Figure 13) despite an increase in gross domestic product (GDP). This shows that economic development does not inevitably result in increased emissions and environmental pollution (de-coupling).

The substantial fall in acidifying gases is mainly due to a reduction of over 60 % in sulphur dioxide emissions from industry and the energy sector since 1980. However, nitrogen oxide emissions decreased much less and are unlikely to meet the fifth environment action programme (5EAP) target for 2000. Ammonia emissions, mainly from agriculture, are stabilising. Compared to the other two acidifying gases ammonia emissions are poorly quantified and are difficult to limit.

Substantial further reductions of emissions of acidifying pollutants are needed to achieve the proposed ambitious NECD targets or even the less strict CLRTAP targets for 2010 agreed on 1 December 1999.

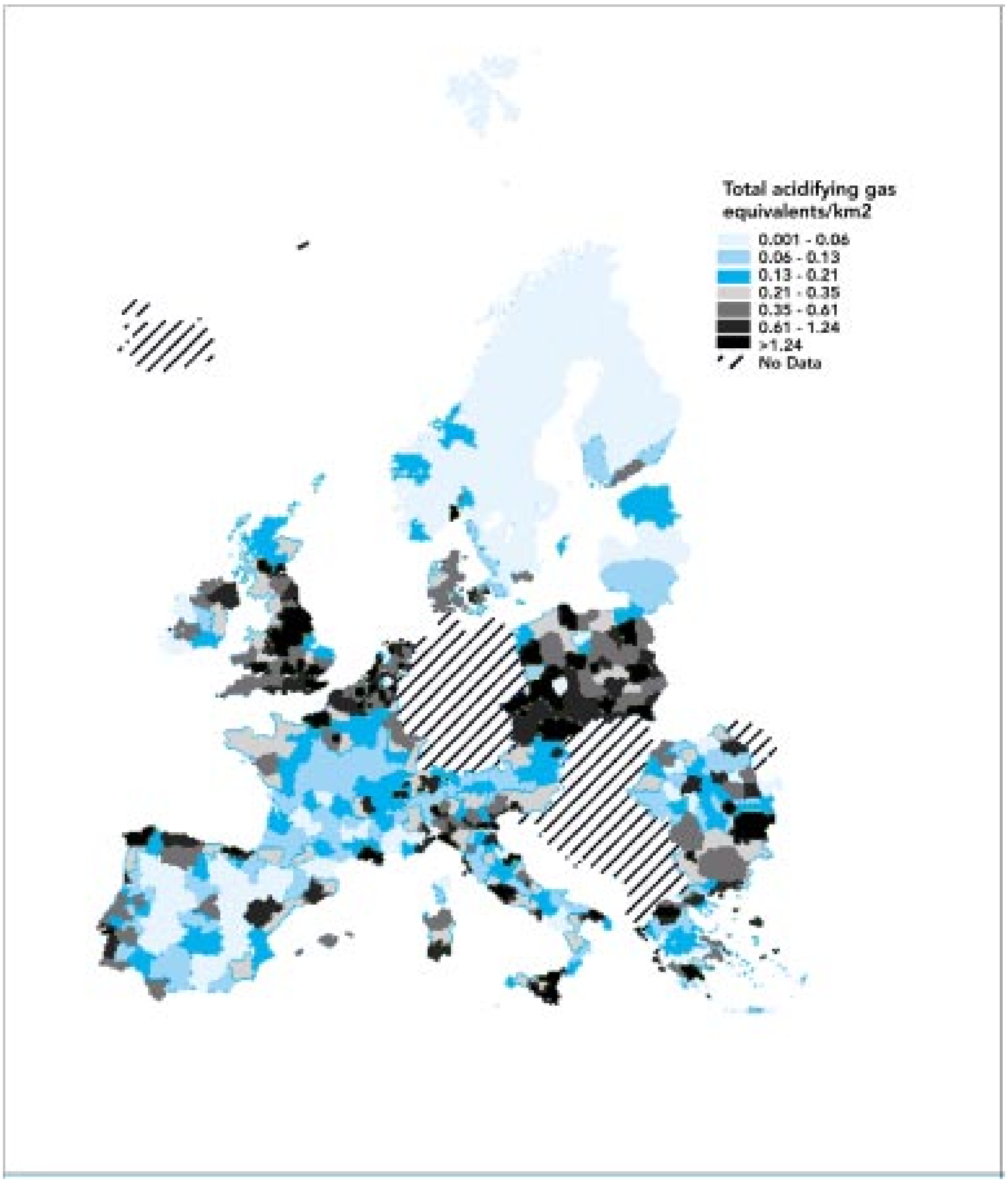


Figure 14: Total acidifying gas emissions in 1994/1995 in various countries by NUTS3 area (SO_2, NO_x, NH_3 in tonnes acid equivalent per km^2)

Figure 14 shows emission densities of total acidifying gases in regions (NUTS3) in various countries in 1994/1995. The areas of highest emission densities are in central Europe between Poland and the Czech and Slovak Republics. Areas of high emission density in the UK are dominated by emissions from power stations with emissions from high stacks rather than low-level local sources.

3.2. Sulphur dioxide (SO_2)

☺ Since 1980, EU Member States have reduced their sulphur dioxide emissions by over 60 %. Reduction targets for 2000 have already been achieved for the EU as a whole
😐 The proposed NECD and agreed CLRTAP targets for 2010 appear to be attainable for the EU, although additional measures will be required in some EU Member States
😐 For most PHARE Central and Eastern European countries, SO_2 emissions have decreased between 1990 and 1996 (up to 60 %), and emissions are below the 2010 CRLTAP targets. This is due to economic restructuring and measures. However, in some countries additional measures will still be required

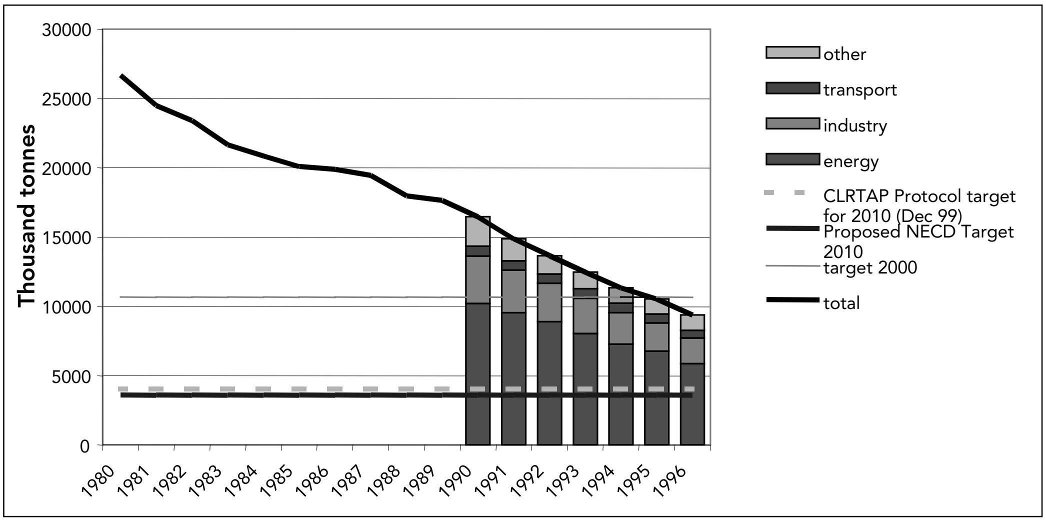


Figure 15: EU15 SO_2 emissions compared with targets

Note: Target 2000 refers to the EC's 5EAP target. The proposed NECD target requires a 78 % reduction below 1990 emissions by 2010 and the CLRTAP Protocol (1 December 1999) target a 75 % reduction below 1990 emissions by 2010.

The main sources of SO_2 are energy (60 %), industry (25 %), transport (6 %). Total EU SO_2 emissions decreased over 60 % from 1980 (over 40 % since 1990) (Figure 15). The largest reductions occurred in the energy and industry sectors, due to a switch from coal to natural gas, construction of new power plants, use of low-sulphur coal and more flue-gas desulphurisation.

The EU's 5EAP target (-35 % of 1985 emissions by 2000) was reached in 1992. By 1996, EU emissions had fallen to 55 % below 1985 levels. In 1996, the EU as a whole achieved the CLRTAP Second Sulphur Protocol target (-62 % from 1980 emissions by 2000). There are important differences between Member States in approaching the proposed NECD and agreed CLRTAP targets for 2010.

The UNECE's CLRTAP 1985 first Sulphur Protocol laid down a target of 30 % reduction from 1980 by 1993 for all countries. Greece, Iceland, Ireland, Portugal, Spain and the United Kingdom did not ratify this protocol but Spain and the United Kingdom did in fact meet the requirement. The Second Sulphur Protocol, with a target year of 2000, requires different reductions per country (see also section 1.3). Iceland, Portugal and Belgium have not ratified this protocol.

Most EEA member countries have reduced their emissions (Figure 16) by more than 50 % but Greece, Portugal and Iceland have increased their emissions. Germany's emissions did not fall until after reunification and the subsequent closure and replacement of inefficient generating plant and industry in the former East Germany.

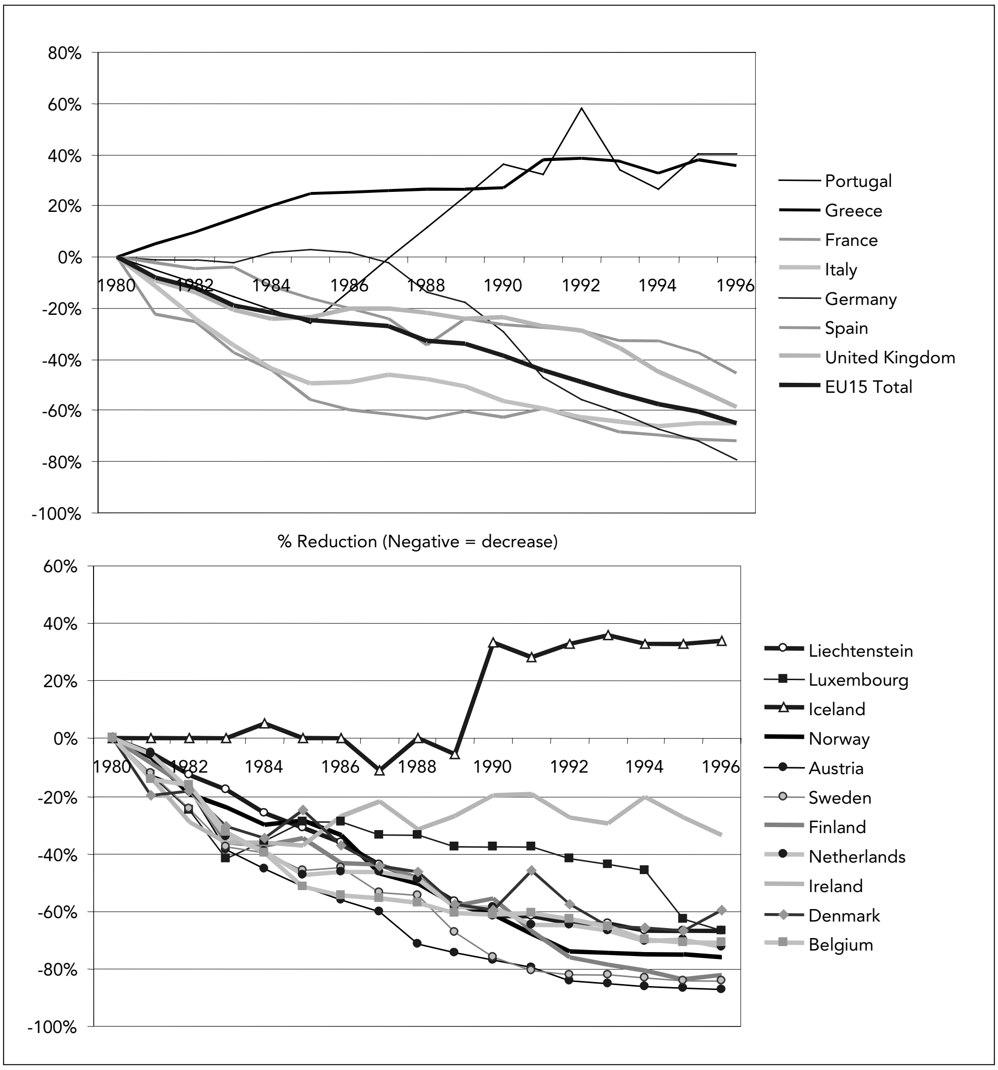


Figure 16: Trends in SO_2 emissions in EEA18 countries (1980 = 0 %)

Note: Percentage values against each country (e.g. 'Portugal 4 %') show their contribution to EEA18 SO2 in 1996.

In Figure 17 the percentage change in national SO_2 emissions (1990-1996) is compared with proposed NECD targets and agreed CLRTAP Protocol (Dec. 1999) targets to be achieved by 2010, for EEA member countries and PHARE countries.

Some EU countries have met, or nearly met, their target for 2010 (Germany, Finland, Austria), while others still need to achieve considerable additional reductions. Emissions from all PHARE countries have reduced between 28 % and 58 %, mainly due to a combination of the economic restructuring process and a switch from coal to natural gas. However, most of EU and Slovak Republic, Czech Republic, Slovenia, Bulgaria and Poland need substantial further reductions to meet the targets for 2010.

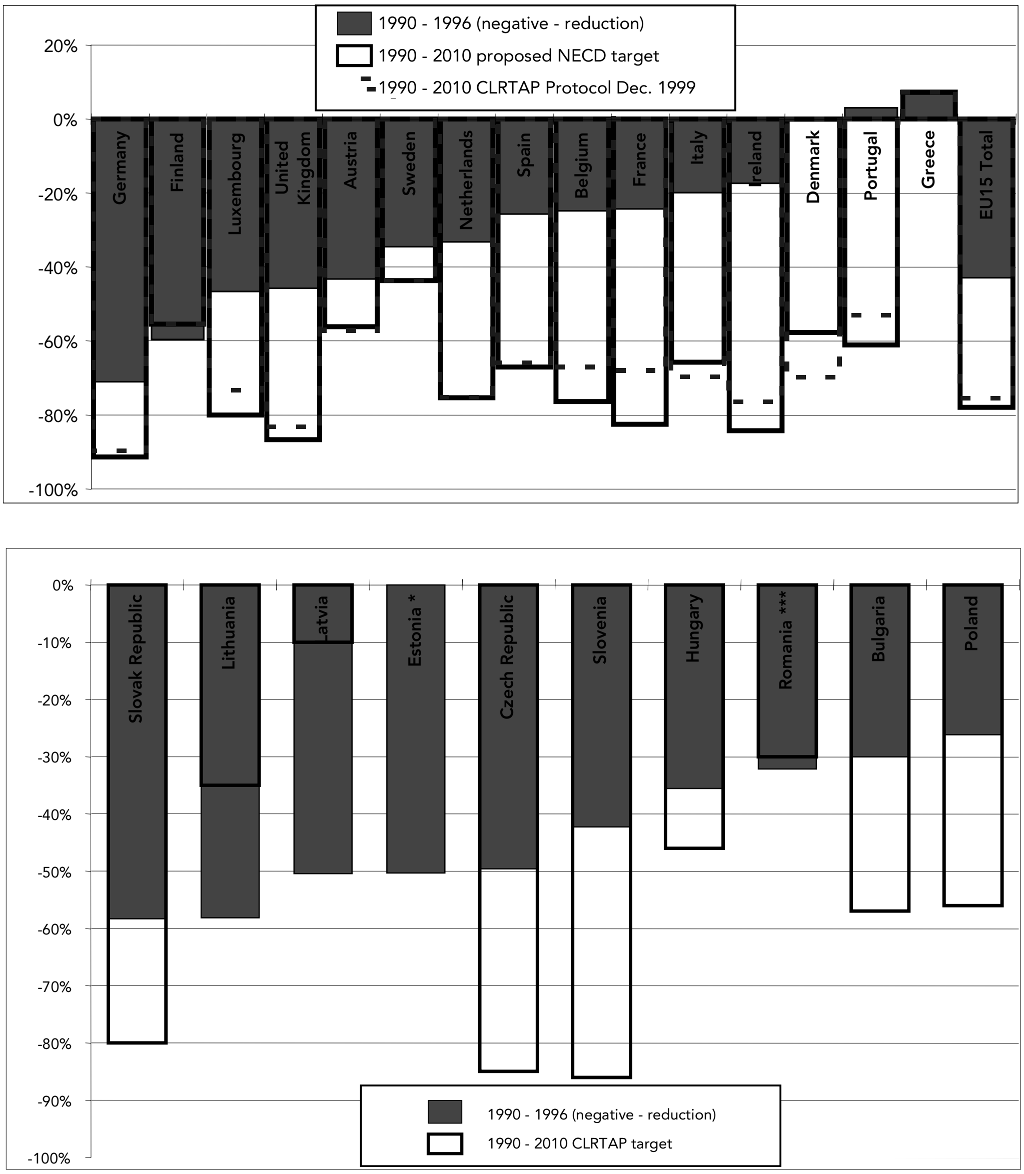
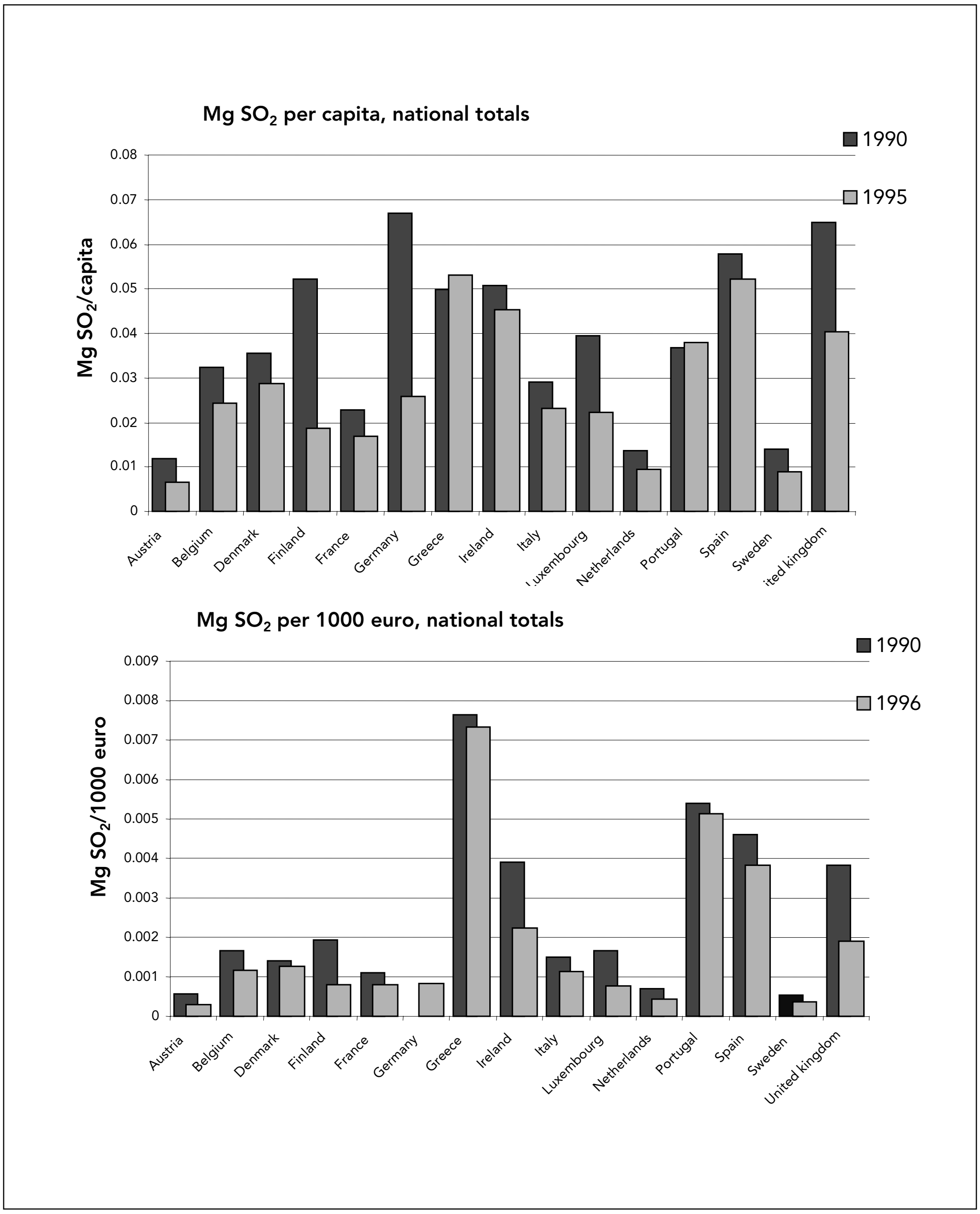


Figure 17: Percentage change in national SO_2 emissions (1990-1996) compared with proposed NECD targets and agreed CLRTAP Protocol (Dec. 1999) targets for EEA member countries and PHARE countries

Figure 18 presents national per capita and per GDP emissions of sulphur dioxide. The differences between countries reflect differences in fuel mix used. The emissions are low in the Netherlands (high share of sulphur free natural gas), Austria and Sweden (high share of hydropower). Italy, Spain, Ireland and United Kingdom show a relatively high emission of SO_2, both per capita and per GDP. Most EU member countries reduced the emissions of SO_2 considerably before 1990, as is also shown in Figure 16 and Figure 17. In the United Kingdom this reduction occurs later (see also Figure 16).



Source of GDP and Population data: Eurostat.

Figure 18: Per capita (top; Mg/capita) and per GDP (bottom; Mg/1000 euro) emissions of SO_2 in EU Member States

3.3. Nitrogen oxides (NO_x)

☺ The EU as a whole achieved the CLRTAP target of stabilizing nitrogen oxide emissions at 1987 levels. Emissions decreased by 14 % from 1990 to 1996

😐 The EU 5EAP target is unlikely to be reached by 2000. To achieve the proposed NECD and agreed CLRTAP targets for 2010 additional measures will be required in various EU Member States

😐 For most PHARE Central and Eastern European countries, NO_x emissions decreased between 1990 and 1996 (30 to 60 %). This is due to economic restructuring and measures. In various countries additional measures will be required to achieve the CRLTAP targets for 2010

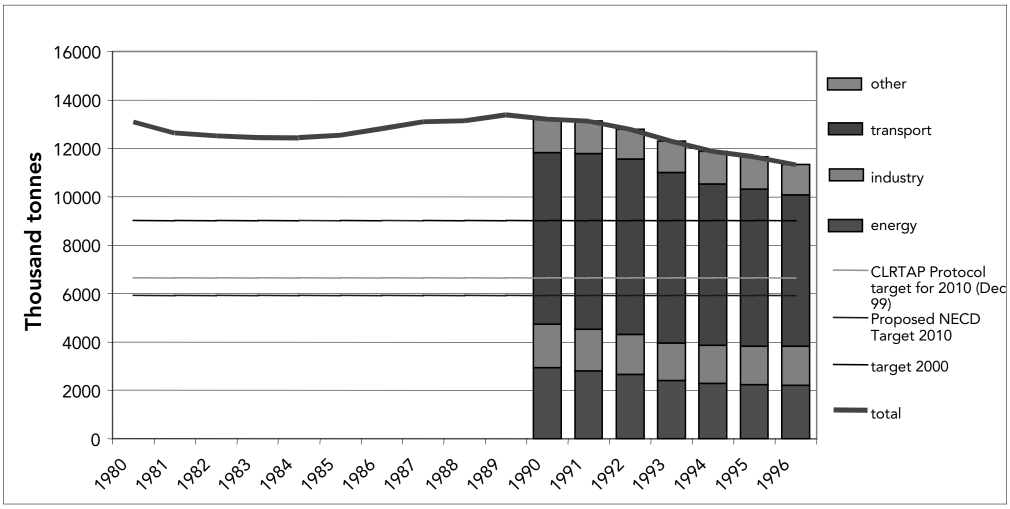


Figure 19: EU15 NO_x emissions compared with targets

Note: Target 2000 refers to the EC's 5EAP target of a 30 % reduction in emissions below 1990 levels by 2000. The proposed NECD target requires a 55 % reduction below 1990 emissions by 2010 and the CLRTAP Protocol target (1 December 1999) a 50 % reduction below 1990 emissions by 2010.

Total EU15 NO_x emissions decreased 14 % since 1990 in the EU, mainly due to the introduction of three-way catalysts to petrol-engined cars and improved abatement in the energy and industry sectors. Catalysts were first introduced in some countries, for example Germany and the Netherlands, and in 1993 became compulsory on all new petrol-engined cars sold in Europe. Increasing road travel has partly offset reductions achieved by emission abatement (Figure 19). Main sources are transport (55 %), energy (19 %) and industry (14 %).

The first CLRTAP Nitrogen Oxide Protocol target (stabilising to 1987 emissions by 1994) was achieved by the EU as a whole and by most Member States. However emissions in France, Greece, Ireland, Luxembourg, Portugal and Spain were, by 1996, not below their 1987 levels (Figure 20). Furthermore, the Fifth Environment Action Programme target, for the EU and all Member States, of a 30 % reduction by 2000 with respect to 1990 will not be achieved.

In Figure 20 the percentage change in national NO_x emissions (1990-1996) is compared with proposed NECD targets and agreed CLRTAP Protocol (Dec. 1999) targets to be achieved by 2010, for EEA member countries and PHARE countries.

Some EU Member States have reduced emissions substantially from 1990 (Germany, UK, Austria, Netherlands). For almost all PHARE Central and Eastern European countries, except Slovenia, NO_x emissions reduced substantially between 1990 and 1996 and are currently below the 2010 CRLTAP targets, with the exception of Slovenia, Czech Republic and Poland. This is due to a combination of the economic restructuring process, a switch from coal to natural gas, construction of new power plants.

Emission reduction for NO_x is generally more difficult than for SO_2 where a relatively small number of well-known large sources (power plants and some industries) are responsible for the majority of emissions. Switching to natural gas from oil only provides small NO_x emission reductions. The low-NO_x burners fitted to many large power plants are not as effective in reducing emissions as FGD is for

SO_2. Furthermore the large and increasing number of motor vehicles is more difficult to control.

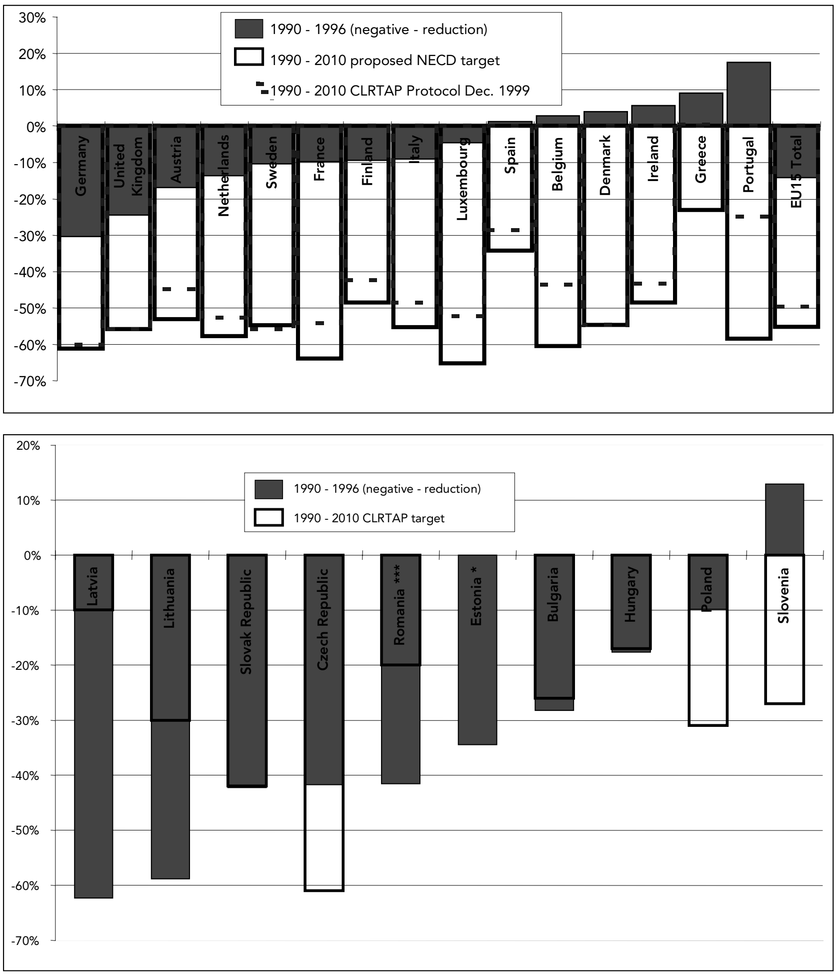
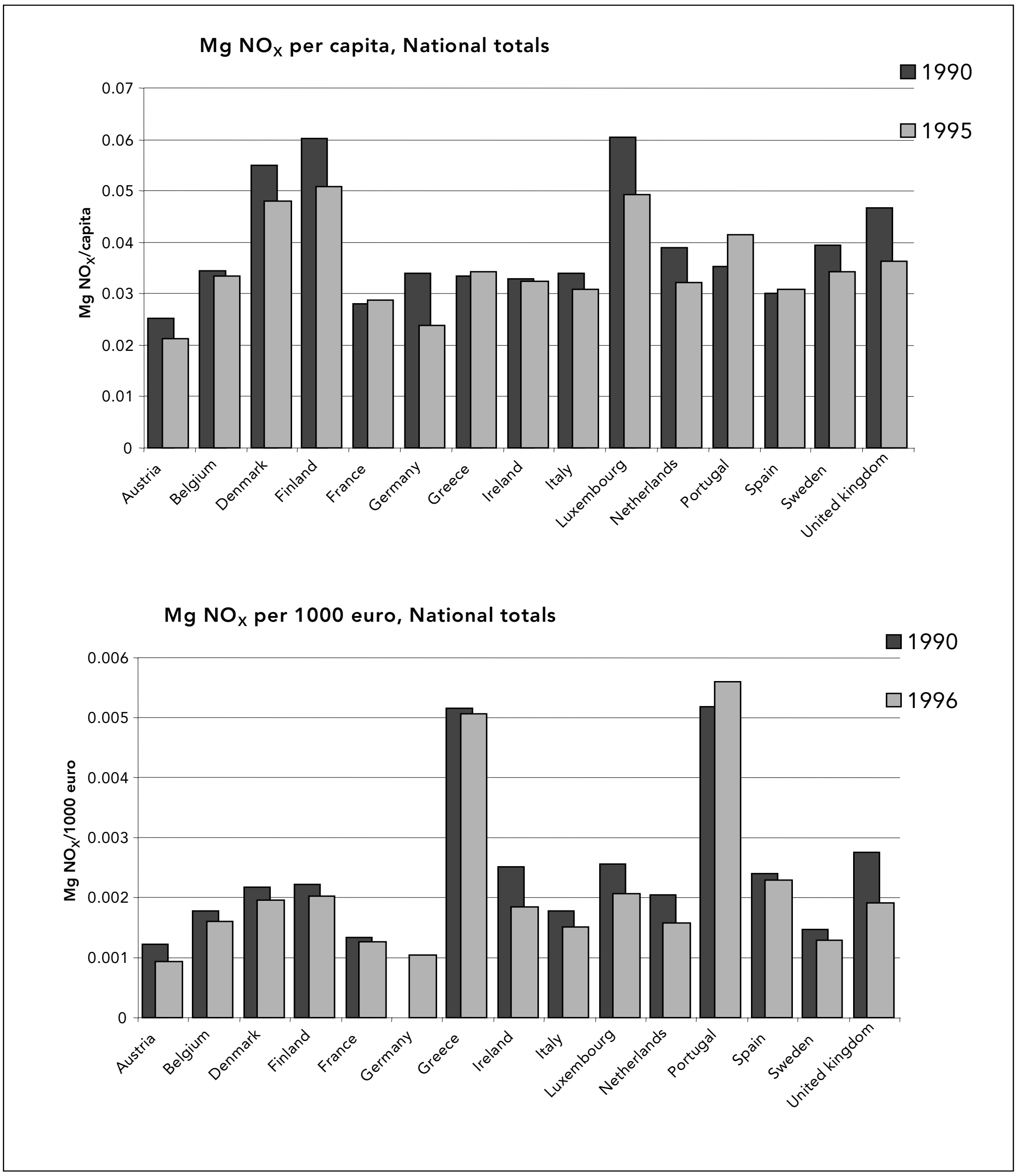


Figure 20: Percentage change in national NO_x emissions (1990-1996) compared with proposed NECD targets and agreed CLRTAP Protocol (Dec. 1999) targets for EEA member countries and PHARE countries

The per capita and per GDP national emissions of NO_x, as shown in Figure 21, vary over a factor of 2 to 3 between the EU Member States.

Contrary to the case of SO_2, the NO_x emissions of the Netherlands are comparable to other countries, showing that the energy intensity of the economy also is comparable. This confirms the observation that the relatively low SO_2 emission will be due to the specific fuel mix in the Netherlands. The per capita emissions in Denmark and Finland are high relative to countries like Belgium, Ireland, Italy, the Netherlands and the United Kingdom. This difference is not observed for the per GDP emissions in these countries. The emissions in France and Sweden are relatively low, both on a per capita and a per GDP basis. This is explained by a relatively high energy-intensity of the economies in Denmark and Finland and a high share of non-fossil fuel energy sources in France and Sweden respectively.



Source of GDP and Population data: Eurostat.

Figure 21: Per capita (top) and per GDP (bottom; Mg/1000 euro) emissions of NO_x in EU Member States

3.4. Ammonia (NH_3)

- ☺ The EU ammonia emissions have decreased slightly (7 %) from 1990 to 1996, with substantial decreases (15 to 35 %) in a few Member States
- 😐 Reduction targets have been defined for the first time for ammonia emissions. The proposed NECD and agreed CLRTAP targets for 2010 will be difficult to achieve for the EU and additional measures will be required in a number countries
- 😐 Emissions from all PHARE countries decreased (between 10 % and 80 %), probably due to the economic restructuring process. However a few PHARE countries need further reductions to meet the CLRTAP targets for 2010

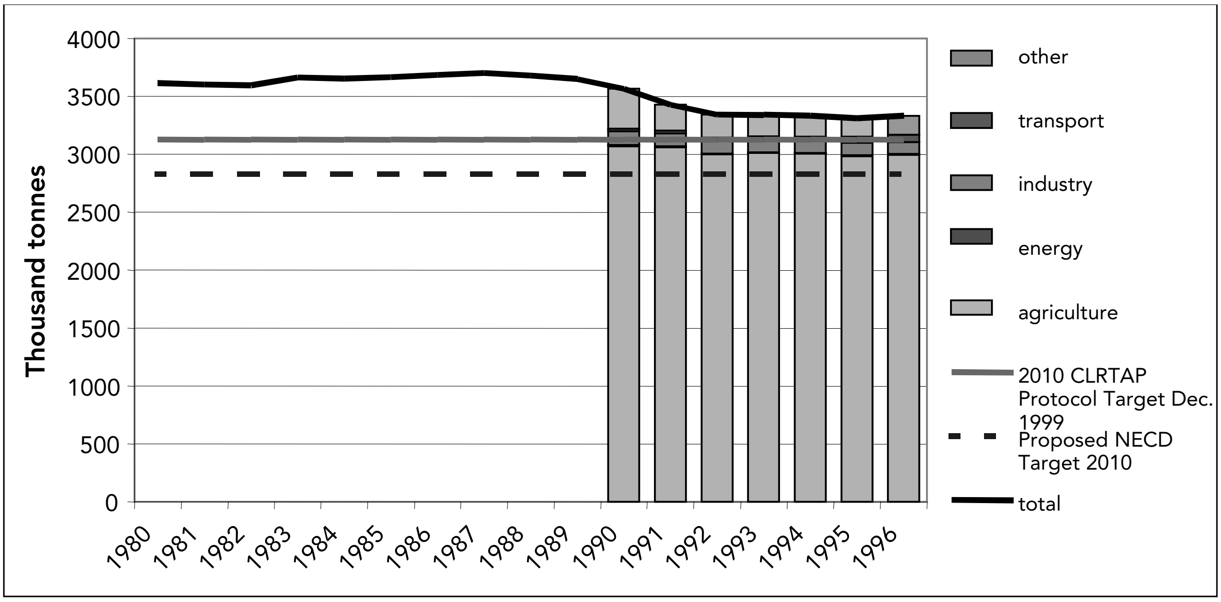


Figure 22: EU15 Ammonia emissions compared with targets

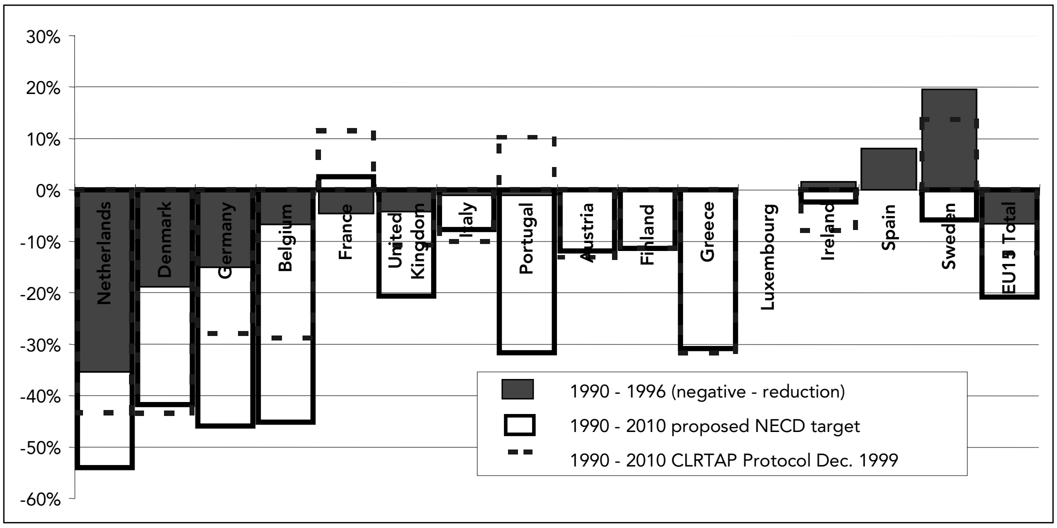
Note: The proposed NECD target requires a 21 % reduction and the agreed CLRTAP Protocol target (1 December 1999) a 12 % reduction below 1990 emissions by 2010.

Total EU15 emissions decreased by 7 % between 1990 and 1996, due to reduced agricultural activity and measures taken by a few Member States (Figure 22). The main source is agriculture (90 %), particularly livestock (pigs, cattle, sheep and poultry). Estimates of ammonia emissions are more uncertain than those for sulphur dioxide and nitrogen oxide.

Until recently no internationally agreed targets existed for ammonia. The proposed NECD target is a 21 % reduction and the agreed CLRTAP Protocol a 12 % reduction below 1990 emissions by 2010. These targets, in particular the proposed NECD, will be difficult to achieve for the EU, because it would need substantial additional measures.

In Figure 23 the percentage change in national NH_3 emissions (1990-1996) is compared with proposed NECD targets and agreed CLRTAP Protocol (Dec. 1999) targets to be achieved by 2010, for EEA member countries and PHARE countries.

A substantial emission reduction was achieved in Denmark (19 %), Germany (15 %) and the Netherlands (35 %) (Figure 23). Emissions from some Member States increased (Spain, Sweden). Emissions from all PHARE countries have reduced between 10 % and 80 %, due to the economic restructuring process. However most EU and a few PHARE countries (Romania, Slovenia) need further reductions to meet the targets for 2010 and additional measures will be required. If livestock rearing becomes less intensive, or livestock numbers fall with any reform of the Common Agricultural Policy then emissions may decrease.



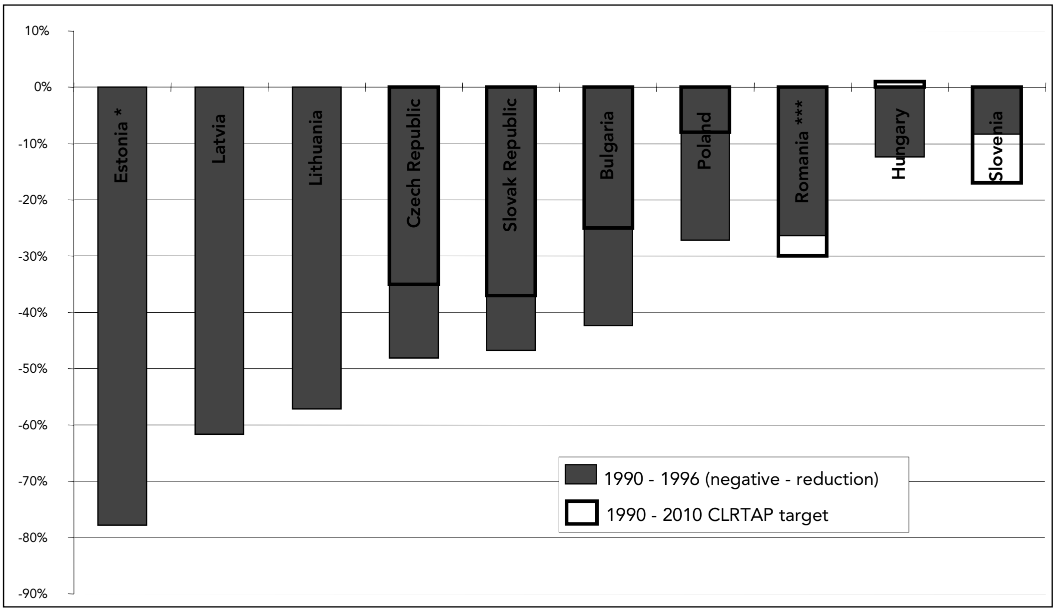
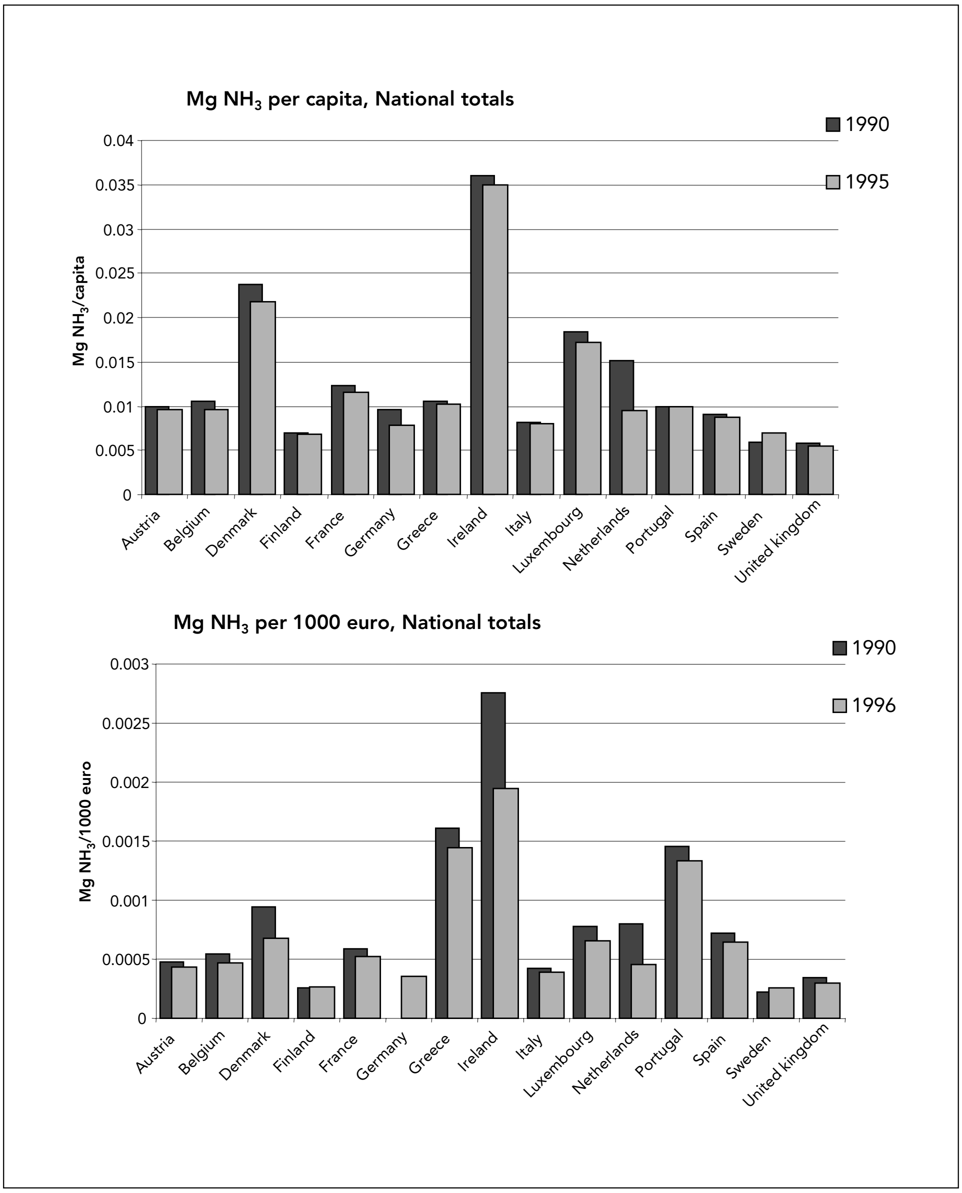


Figure 23: **Percentage change in national NH_3 emissions (1990-1996) compared with proposed NECD targets and agreed CLRTAP Protocol (Dec. 1999) targets for EEA member countries and PHARE countries**



Source of GDP and Population data: Eurostat.

Figure 24: Per capita (top; Mg/capita) and per GDP (bottom; Mg/1000 euro) emissions of NH_3 in EU Member States

The per capita and per GDP emissions of ammonia (Figure 24) show considerable variance amongst the EU Member States. The per capita emissions in Ireland, Denmark and Luxembourg are relatively high, whereas those in the Netherlands are decreasing towards the average level from a relatively high level in 1990/1991 due to implementation of various measures in the agriculture sector (intensive livestock keeping). The emissions in Sweden (except 1994) and Austria are relatively low.

The importance of agriculture in the Portuguese economy is reflected in a relatively high per GDP emission of ammonia, while this is not reflected in the per capita emission of this country. On a per GDP basis, the emissions of Ireland are decreasing, showing the decrease in the relative importance of agriculture to the Irish economy. The decrease in emissions in the Netherlands is also evident on a per GDP basis.

4. Tropospheric ozone – emissions of NO_x, NMVOC, CO and CH_4

4.1. Total ozone precursor gases

☺ The EU emissions of ozone precursors have decreased 15 % from 1990 to 1996, while GDP has risen, showing a de-coupling from GDP

☹ Additional measures will be necessary to achieve sufficient reductions in EU emissions to meet the proposed NECD and agreed CLRTAP targets for 2010

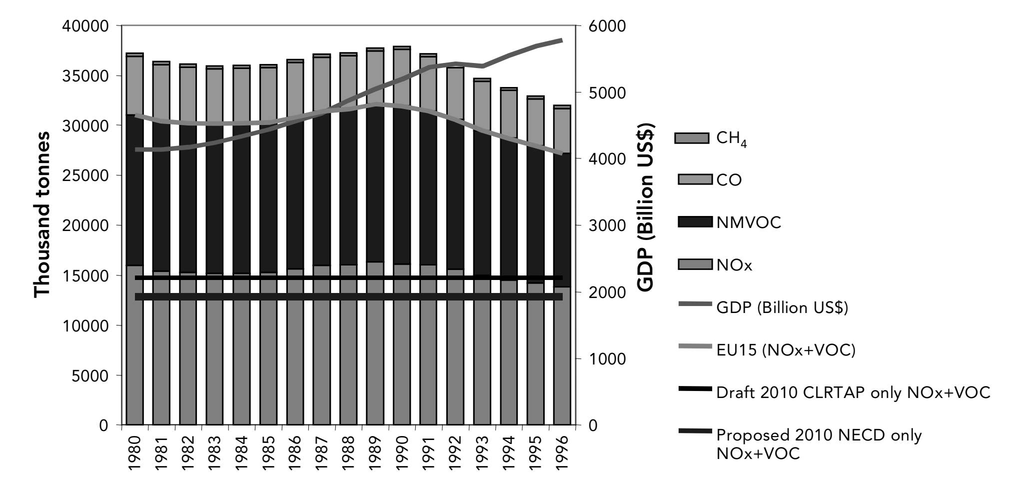


Figure 25: EU15 emissions of ozone precursor gases (as tropospheric ozone formation potential, TOFP, equivalents) and GDP since 1980 compared with targets

Notes: This indicator is a first attempt at weighting total EU ozone precursor emissions, but it is an oversimplification. Emissions are combined for four ozone precursors, but reduction targets exist only for the two main precursors (nitrogen oxides and non-methane volatile organic compounds). Weighting factors (tropospheric ozone precursor potentials) used: nitrogen oxides 1.22; non-methane VOCs 1.00; carbon monoxide 0.11, methane 0.014.

Four pollutants (CH_4, CO, NMVOC and NO_x) contribute to the formation of tropospheric ozone (‘ozone precurors’) (Figure 25). Emissions of ozone precursor gases fell in most EU Member States and by 15 % in the EU as a whole between 1990 and 1996. This is mainly due to reductions in NMVOC emissions (Figure 27), which fell in the EU as a whole by 13 % between 1990 and 1996, due to limits on industrial sources and controls on road transport emissions (catalysts on cars and further emission limits). These results were achieved despite an increase in gross domestic product (de-coupling).

However further emission reductions are needed to meet the 5EAP target (30 % reduction from 1990 level) by 2000 and the even more demanding proposed NECD targets and agreed CLRTAP targets for 2010.

Figure 26 shows emission densities of total ozone precursor gases in regions (NUTS3) in various countries in 1994/1995. Areas of highest emission densities are mainly a result of a high traffic density and/or industrial sources.

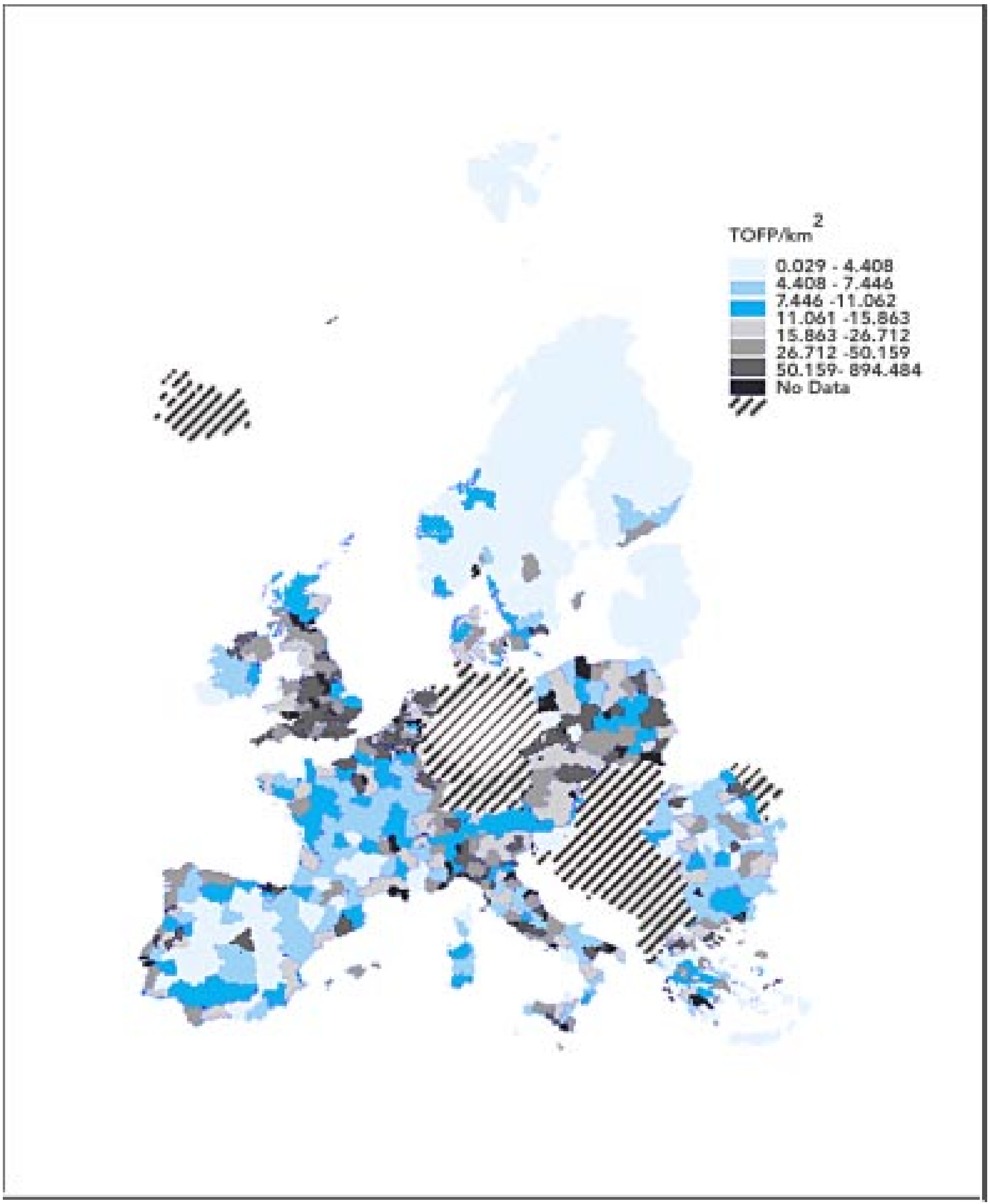


Figure 26: **Total ozone precursor emissions in 1994/1995 in various countries by NUTS3 area (NO_x, NMVOC, CO, CH_4 in tonnes TOFP equivalent per km^2)**

4.2. Non methane volatile organic compounds (NMVOC)

☺ Total EU emissions of NMVOCs fell by 13 % between 1990 and 1996, with substantial decreases (30 to 40 %) in a few Member States, while emissions from some other Member States increased

☹ Further reductions in EU emissions will be necessary to achieve the EU 5EAP target for 2000 and the proposed NECD and agreed CLRTAP targets for 2010

☹ Emissions from most PHARE countries decreased from 1990 to 1996 (10 % to 70 %,) probably due to the economic restructuring process. A few PHARE countries need further reductions to meet the CLRTAP targets for 2010 and additional measures will be required

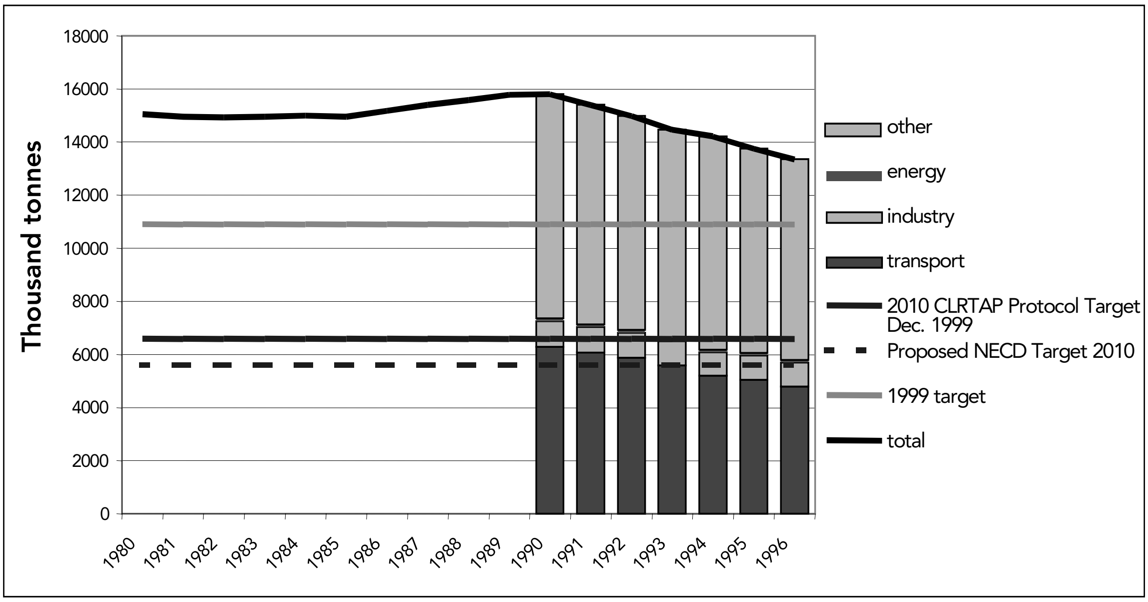


Figure 27: EU15 emissions of NMVOC (Other includes: solvent use, and extraction and distribution of fossil fuels)

Note: Target 1999 refers to the EC's 5EAP target of a 30 % reduction in emissions below 1990 levels by 2000. The proposed NECD target requires a 62 % reduction and the agreed CLRTAP Protocol target (1 December 1999) a 59 % reduction below 1990 emissions by 2010.

Total EU emissions decreased by 13 % between 1990 and 1996 (Figure 27). Main sources are transport (35 %) and emissions from industrial and household solvent use (including paints and glues) and the storage and distribution of fossil fuels (all in category 'other' in Figure 27). Reductions were mainly due to the introduction of catalytic converters in vehicle exhausts and measures in industry. Increasing road travel has partly offset reductions achieved by emission abatement. VOC emissions from solvent use and manufacturing processes have been reduced through best practice, substitution by water-based products and pollutant-abatement technology. These efforts are expected to increase with the implementation of the Solvents Directive. Emission reductions so far have not lead to fewer exceedances of critical ozone levels or ozone concentration thresholds.

The CLRTAP NMVOC Protocol target (-30 % below 1988 emissions by 1999 for EU Member States) has not been achieved. The Fifth Environmental Action Programme target (-30 % below 1990 emissions by 2000) appears unlikely to be achieved. To achieve the proposed NECD and agreed CLRTAP targets for EU substantial additional emission reductions are required.

In Figure 28 the percentage change in national NMVOC emissions (1990-1996) is compared with proposed NECD targets and agreed CLRTAP Protocol (Dec. 1999) targets to be achieved by 2010, for EEA member countries and PHARE countries. A substantial emission reduction was achieved in Ireland Denmark (43 %), Germany (42 %), Netherlands (28 %), Austria (28 %). Emissions from some Member States increased (Italy, Portugal, Greece). Emissions from all PHARE countries, except Slovenia, have reduced between 10 % and 70 %, probably due to the economic restructuring process. However most EU and a few PHARE countries (Czech Republic, Slovenia) need substantial further reductions to meet the targets for 2010 and additional measures will be required.

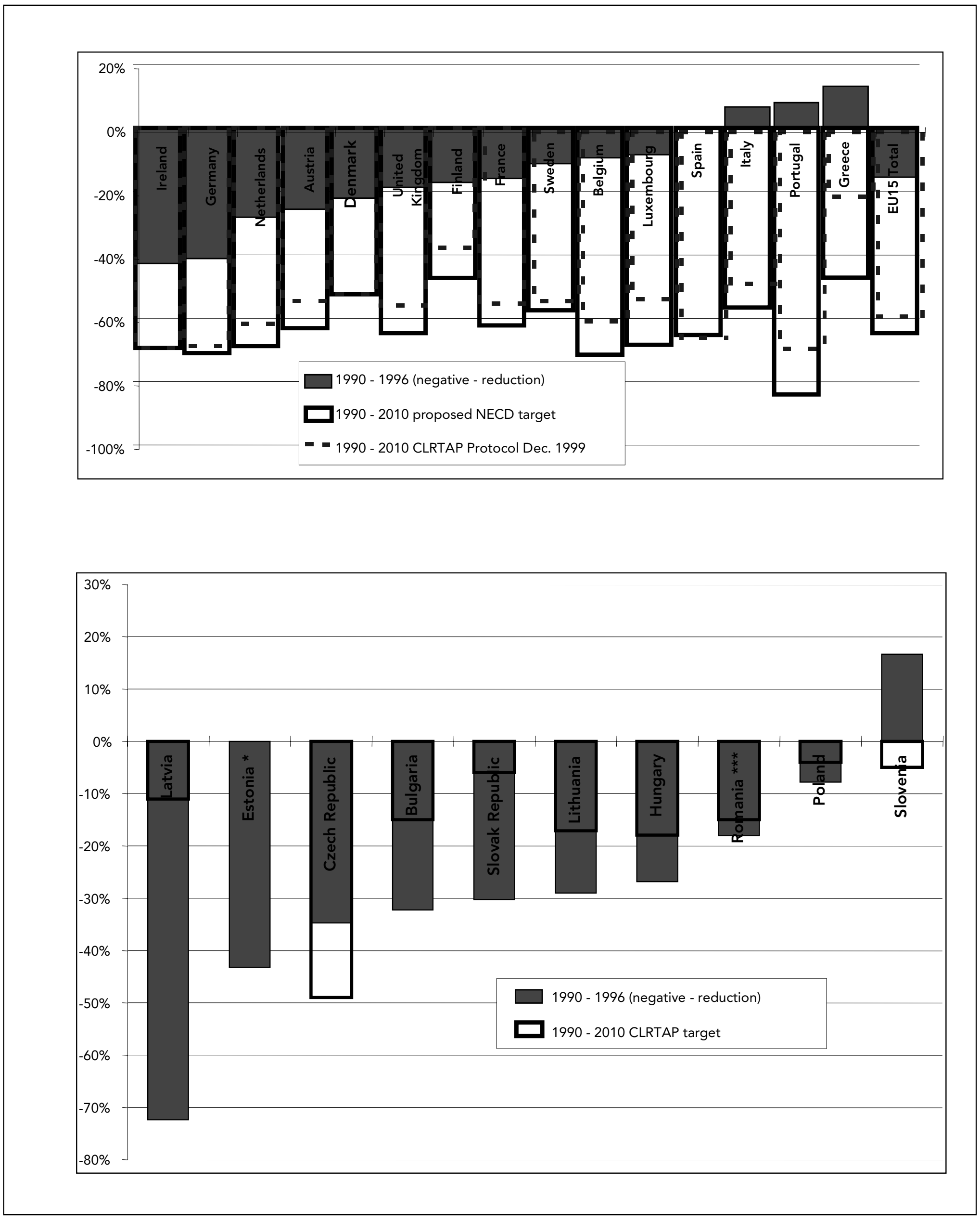
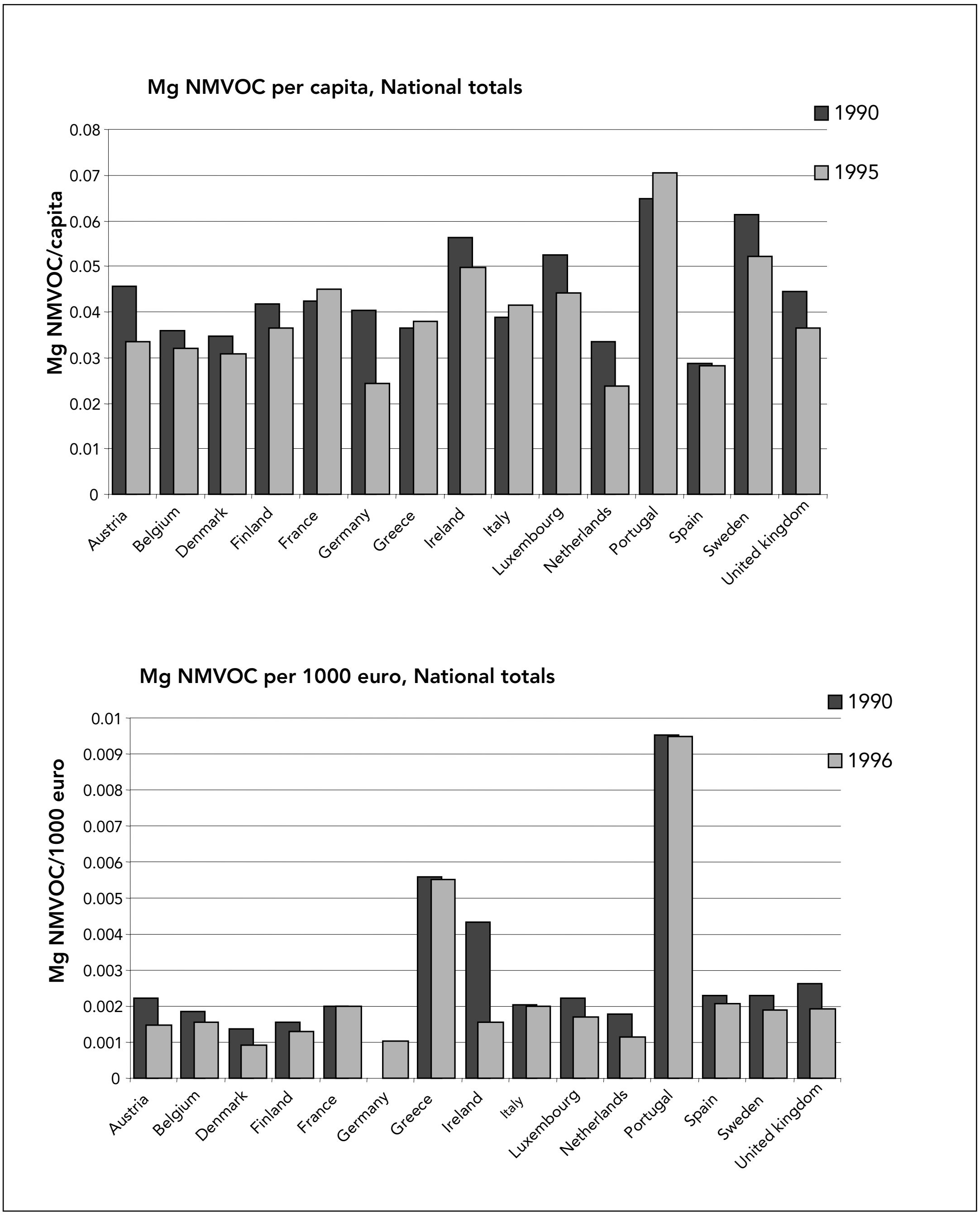


Figure 28: Change in NMVOC emissions since 1990 compared with targets in the NECD



Source of GDP and Population data: Eurostat.

Figure 29: Per capita (top; Mg/capita) and per GDP (bottom; Mg/1000 euro) emissions of NMVOC in EU Member States

Emissions of NMVOC per capita are high across most of the EU Member States. Emissions per capita for the Netherlands and Germany are noticeably lower where controls on emissions from vehicles and industrial processes are strict. Emissions by GDP are high for Portugal and Greece where the GDP is relatively low.

4.3. Nitrogen oxides (NO_x) and methane (CH_4)

Nitrogen oxides (NO_x) and methane (CH_4) are dealt with in other sections of this report, respectively under acidifying emissions (3.3) and methane (2.3).

4.4. Carbon monoxide (CO)

☹ Total EU emissions of CO fell by 20 % between 1990 and 1996

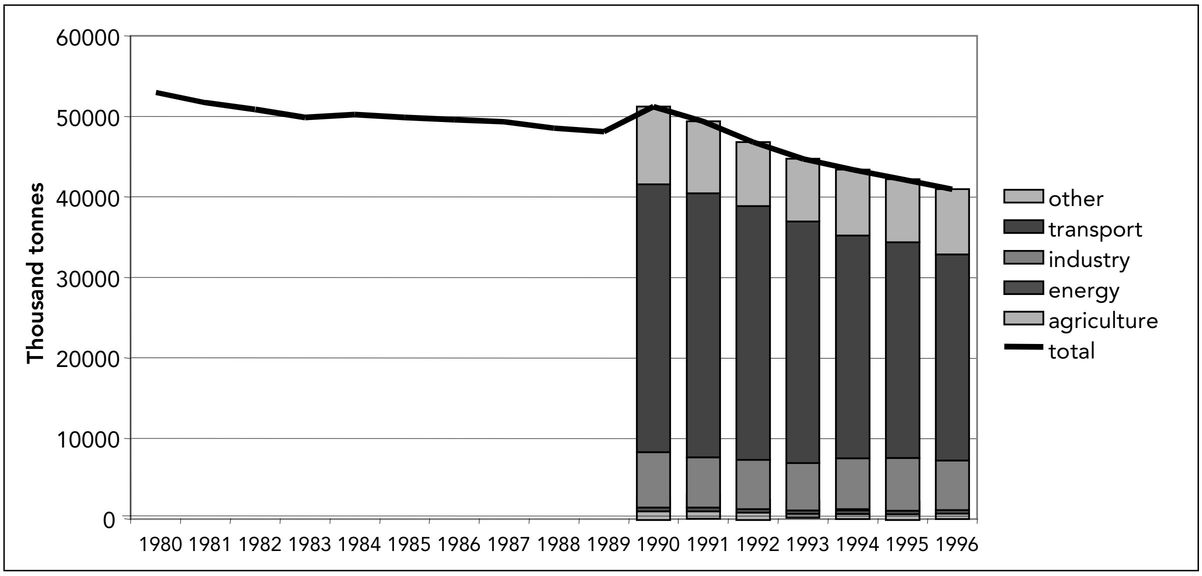


Figure 30: EU15 Emissions of CO

Figure 30 shows EU15 total carbon monoxide (CO) emissions falling from 1990 to 1996 by 20 %, mainly through the introduction of catalysts on petrol-engined motorcars.

Carbon monoxide is mainly emitted from transport (63 %) (petrol-engined cars) with smaller emissions from the domestic use of fossil fuels and some industrial processes (15 %).

There are no internationally agreed emission reduction targets or emission ceilings for CO. However, CO contributes to ozone formation, which is subject to control under the EU Ozone strategy.

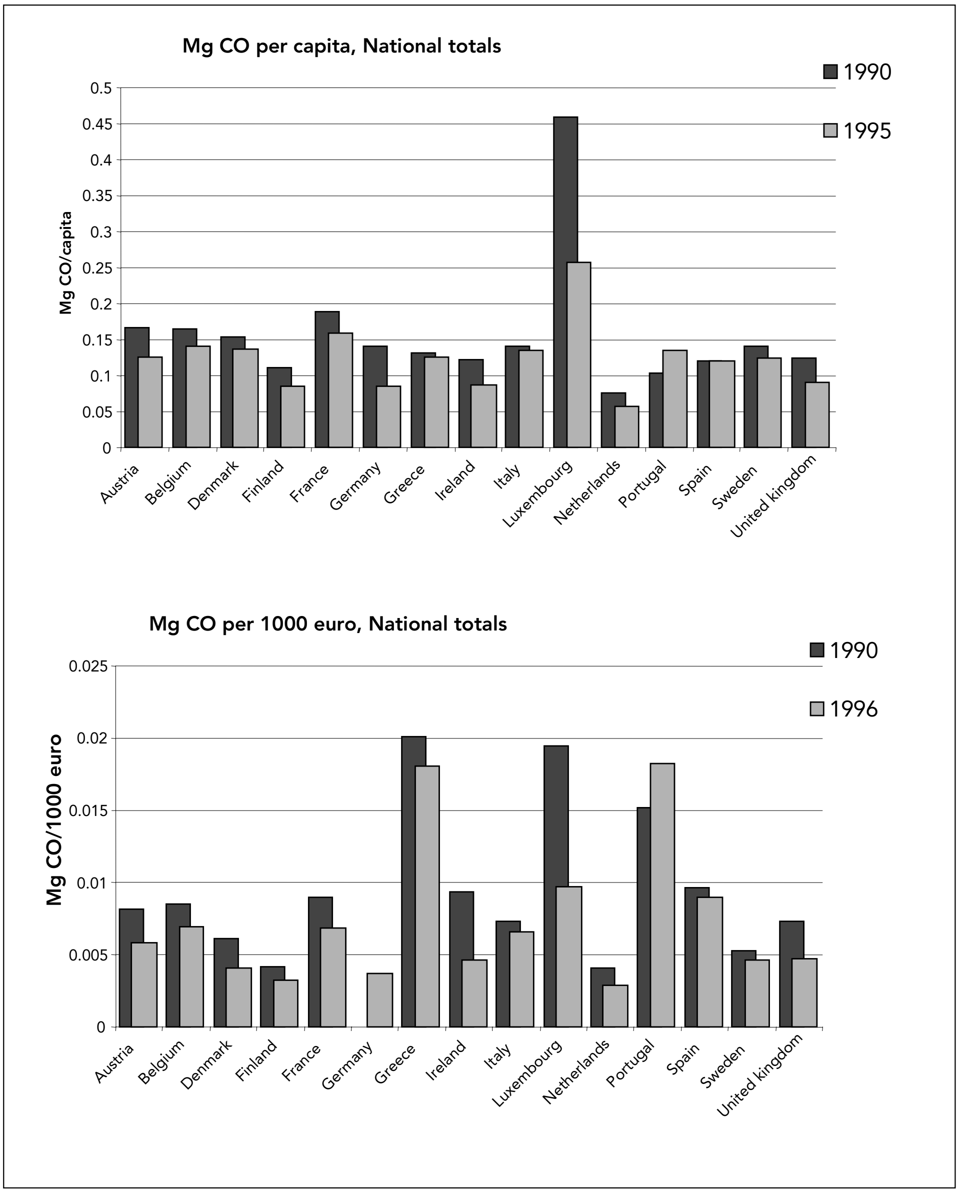


Figure 31: Per capita (top; Mg/capita) and per GDP (bottom; Mg/1000 euro) emissions of CO in EU Member States

Figure 31 shows the per capita and per GDP emissions of CO for EU Member States. Emissions from Luxembourg are high on a per Capita basis reflecting the relatively small population and large steel industry.

5. Emissions of toxic air pollutants

5.1. Background

Toxic pollutants have damaging effects on human health and ecosystems. In addition to local impacts many of these substances can accumulate in the environment and transported over long distances.

This chapter presents some data on emissions of toxic substances in Europe: particulate matter (PM_{10}), some selected heavy metals (HM) and persistent organic pollutants (POPs). HM and POP data have to be submitted by Parties to CLRTAP, but are far from complete. Submission of PM_{10} emission data is currently not required, although the importance of emission data is recognised both within CLRTAP and within the framework of the recently adopted Air Quality Daughter Directive (on PM).

The emissions data presented in this chapter have been estimated by partner organisations within ETC/AE (TNO) in the past years, in close collaboration with national experts in countries, within the framework of CLRTAP, work for the EEA report 'Environment in the EU at the turn of the century' and a study for the Commission (Berdowski et. al, 1997; Visschedijk, et.al., 1998 and European Commission, 2000). Data on HM and POPs have been prepared by TNO in 1997 and are partly based on country submissions of official data. The inventory has been completed with TNO default emission estimates where country data was lacking. Hence the emissions of HM and POPs are partly validated by countries. The emissions of PM_{10} as presented in this chapter entirely consist of TNO estimates, as prepared in 1997. Due to the uncertainties in the emission estimates, it is not feasible at this stage to present reliable time series and trendsThis situation is expected to improve the coming years, when countries will report higher quality HM/POP emission trends data to UNECE/CLRTAP. The chapter therefore concentrates on identifying the major sources of these pollutants.

5.2. Particulate matter

☹ Uncontrolled combustion of coal in stationary sources and diesel in transportation contribute significantly to PM_{10} emissions in Europe

☹ EU15 urban area PM_{10} emissions are dominated by road transport

☹ PHARE countries' urban area PM_{10} emissions are influenced by high emissions from industry and energy production within the urban area

5.2.1. National total emissions

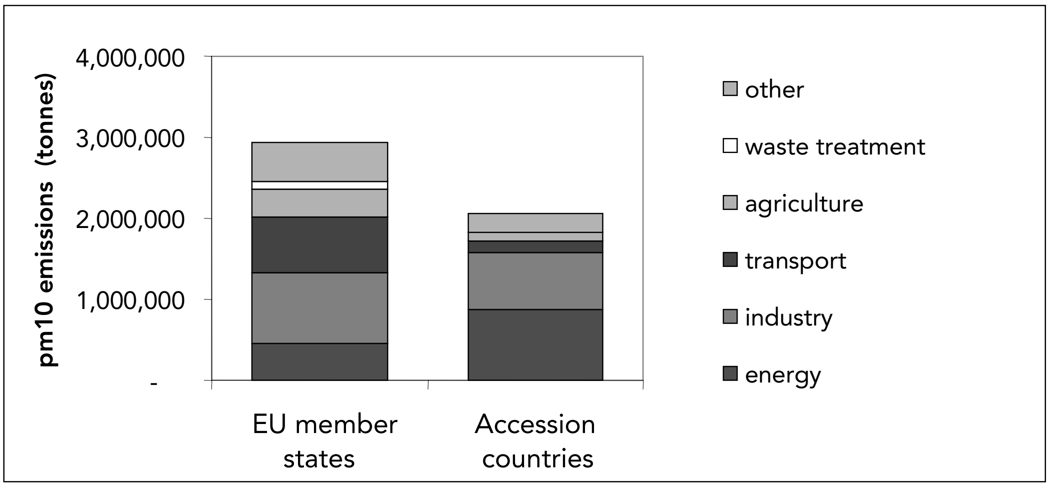


Figure 32: PM_{10} emissions in 1990 in EU15 and PHARE accession countries [source: Berdowski et al. 1997a]

Figure 32 shows 1990 national total emissions of PM_{10} for the 15 EU Member States and the 10 PHARE PHARE accession countries by main source sector. Emissions in the PHARE accession countries are dominated by the energy and industry sectors. In the early 1990s the PHARE accession countries of Eastern European burned large quantities of coal with limited use of efficient flue gas cleaning equipment, which is a significant source of PM_{10} emissions. In more recent years the situation in these countries has improved with the development of new plant and abatement technologies and due to the economic restructuring process. In EU countries, where gaseous fuels and flue gas cleaning in solid fuel combustion and process industries are more common the contributions from the energy and industrial sectors is less important. However, the intensive use of road transport in the EU has a significant contribution to PM_{10} emissions.

Figure 33 shows per capita emissions of PM_{10} in EU Member States. Emissions vary between 4 and 17 kg/capita/annum. Germany showed the highest per capita emission in 1990, mainly due to the extensive use of solid fuels and less effective particulate emission control in the new Länder's energy and production sector. Portugal has the lowest per capita emission. Energy sector differences between Member States are mainly the result of different fuel mixes, since gaseous fuels, nuclear and hydro power do not result in significant particulate emissions. Road transport emissions are comparable in all Member States. Luxembourg, Germany and Belgium show high industrial emissions from iron and steel industries. Finland's relatively high emissions in industry are due to combustion of solid fuels.

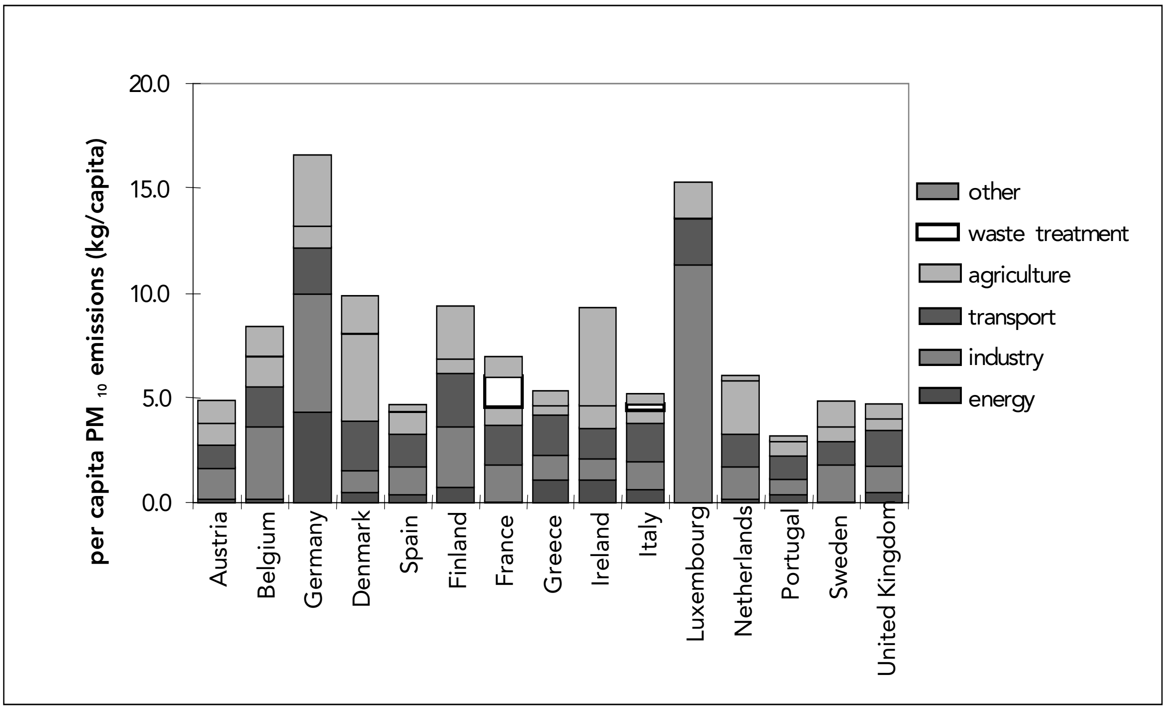


Figure 33: Per capita PM_{10} emissions by sector in the EU Member States, in 1990. [source: Berdowski et al. 1997a]

5.2.2. Urban emissions

Figure 34 shows the sector contribution to total PM_{10} emissions and PM_{10} emissions from the urban area for the EU15 and Central and Eastern European countries. Although definitions of urban areas are in some cases uncertain, some clear conclusions can be drawn. For both the EU and PHARE countries road transport and non-industrial stationary combustion are a more significant source in urban areas (EU15 urban: 66 %) than in the regions as a whole (EU15 total: 39 %). Road transport emissions are the primary source of PM10 pollution (34 %) in EU countries' urban areas. Road transport emissions in PHARE countries are less significant, partly due to less intensive use of road transport but also due to the location of more heavy industries within urban areas. In the EU15, where legislation and public awareness resulted in removing heavy industry from urban areas, these emissions are considerably less important.

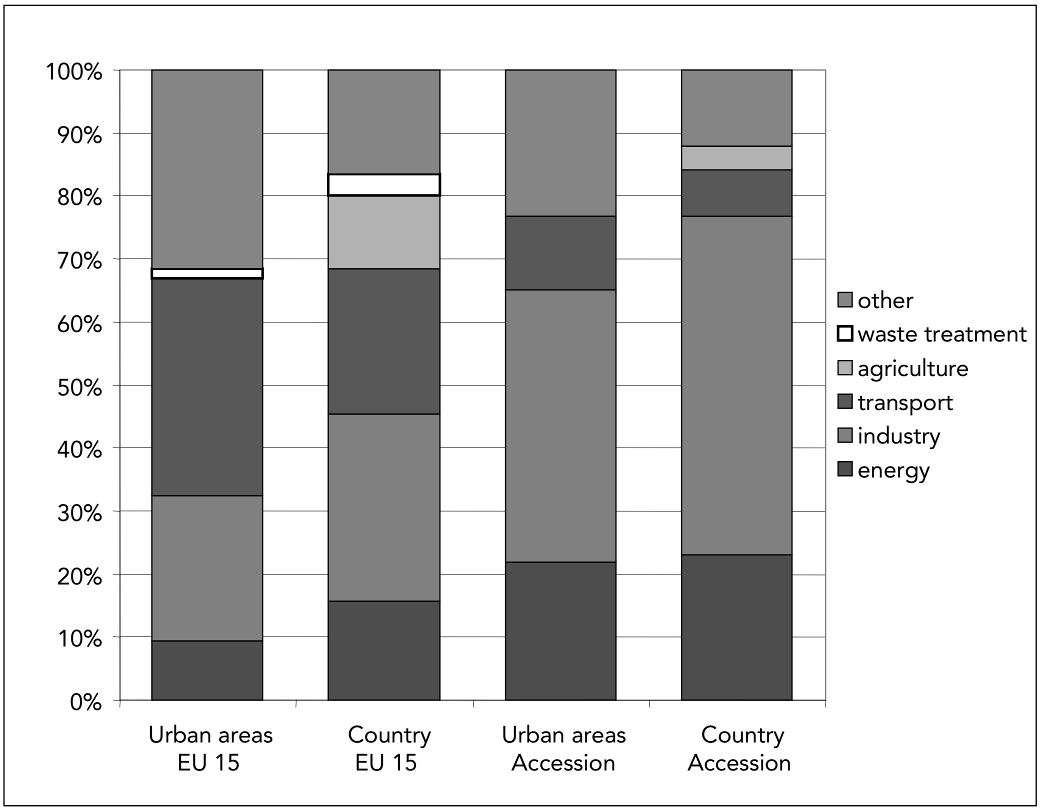


Figure 34: Comparison of sector contribution to urban and to total PM_{10} emissions, for EU15 and PHARE accession countries

5.3. Selected heavy metals

☺ The phase out of leaded petrol has reduced emissions dramatically over recent years

☺ The use of leaded petrol contributed to about 75 % of lead emissions across the EU in 1990

☹ Significant EU emissions of cadmium and mercury originate from industrial processes

5.3.1. National total emissions

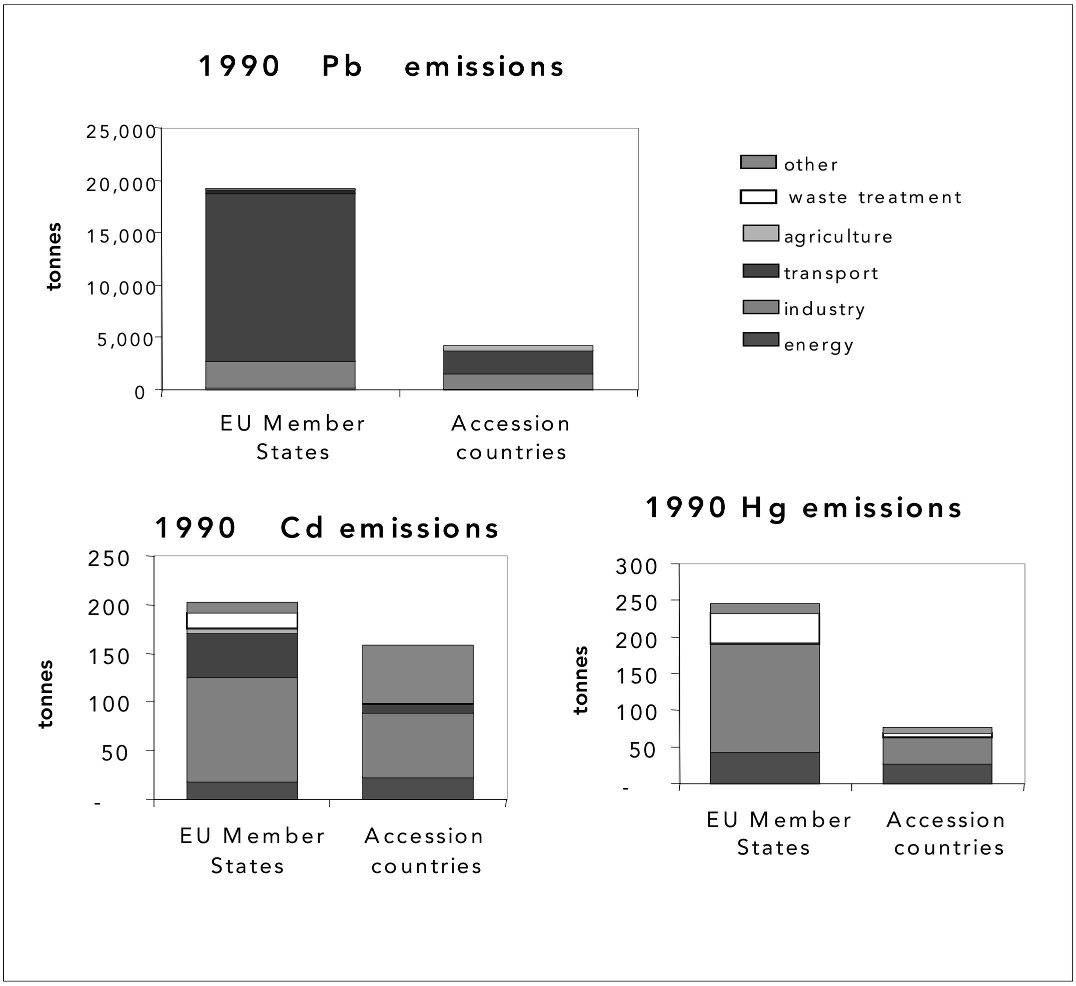
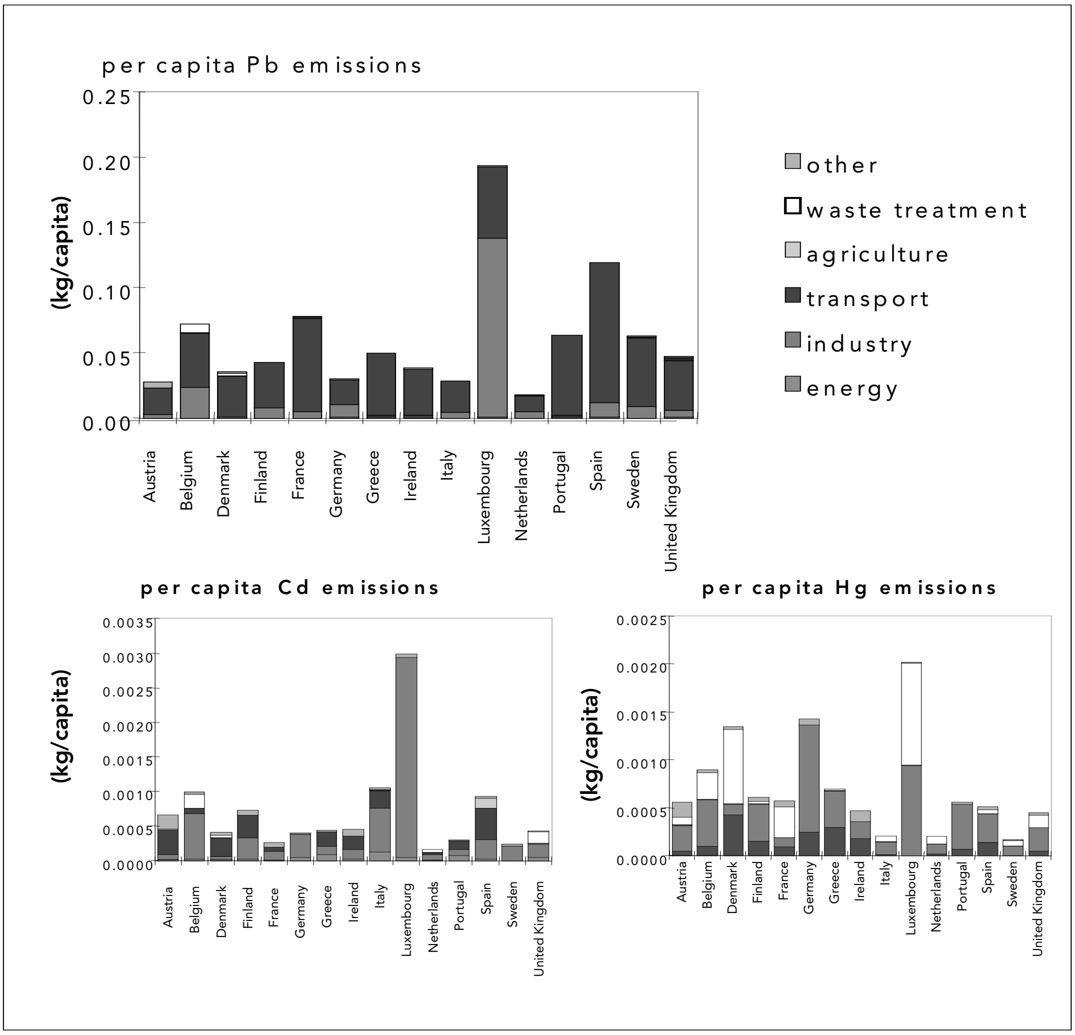


Figure 35: Heavy metal emissions by source sector in EU Member States and PHARE accession countries in 1990 [source: Berdowski et al. 1997b]

Figure 35 shows emissions for 1990 of lead, cadmium and mercury by source sector. Lead emissions in both the EU and PHARE accession countries are dominated by road transport from lead added to petrol. In more recent years these emissions have been dramatically decreased by the introduction of unleaded gasoline in many of the EU Member States (see also Visschedijk et al., 1998). Major sources of cadmium in both EU Member States and PHARE accession countries are the iron and steel and non-ferrous metals industry. Coal combustion for energy production and for domestic heating in the PHARE accession countries were also a major source of cadmium in 1990. Waste incineration is a considerable cadmium source in the EU but insignificant in the PHARE accession countries where comparatively little waste is incinerated.

EU emissions of mercury are dominated by the non-ferrous, chlorine and cement industries. Also combustion of coal results in emissions. Waste incineration in EU countries is an additional important source of mercury emissions.



Source of GDP and Population data: Eurostat.

Figure 36: Per capita emissions of selected heavy metals in EU Member States in 1990. [Source: Berdowski et al. 1997b]

Figure 36 shows the emissions per capita of lead, cadmium and mercury. Emissions per capita differ by up to a factor of ten between EU Member States.

Much of the lead emission depends on the consumption of leaded gasoline within the country. In Belgium and Luxembourg, there is also significant lead emission from the metals industry.

Sources of cadmium and mercury vary significantly between Member States. About half of the countries show a considerable emission of cadmium from road transport. This variation might be due to differing cadmium content of gasoline. Belgium, Germany, Italy, Luxembourg and Sweden show substantial cadmium contributions from zinc, secondary steel and other metals industry. Belgium and The United Kingdom show a significant contribution from waste incineration. Cadmium and mercury are present in various waste streams (in the form of batteries and electrical or medical equipment). Waste disposal is also a major source of mercury emission (Luxembourg, Denmark). The largest source of mercury emission in the EU is from cement production and the mercury based chloro-alkali industry. In 1990 end-of-pipe technology for removing mercury not well established in the EU. The combustion of solid fuels also contributes to mercury emissions.

In general, the variation in source contributions between Member States is due to the unique composition of industries and different technologies used. However, emission estimates from various sources can be improved.

5.3.2. Urban emissions

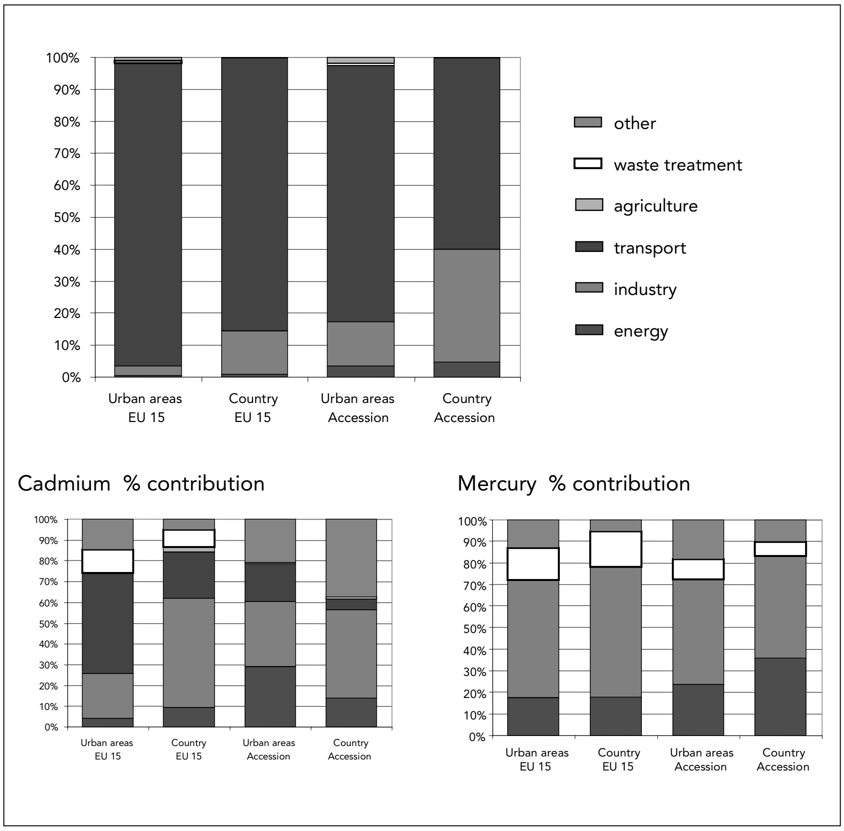


Figure 37: Comparison of sector contribution to urban and to total lead, cadmium and mercury emissions, for EU15 and PHARE accession countries in 1990

Figure 37 shows the source contributions to the urban lead, cadmium and mercury emissions for large cities in Europe and for Europe as a whole. The significance of road transport for lead is clear particularly in EU countries where traffic intensity is higher and urban emissions from industrial processes are better controlled. Cadmium emissions from transport show a two to three fold increase in percentage contribution for EU and PHARE accession urban areas compared with the totals. Industrial contributions are higher for the EU countries than PHARE accession countries for both cadmium and mercury, probably due to higher intensity of cadmium and mercury involving industries and due to reduced emissions from solid and liquid fossil fuel combustion in the EU.

5.4. Selected persistent organic pollutants

☹ Waste treatment and industry are primary sources of dioxins and furans in the EU

☹ PAH emissions from wood treatment and wood combustion contribute significantly to EU and PHARE accession countries’ emissions

5.4.1. National emissions

This section presents emissions of two categories of persistent organic pollutants (POPs): dioxins/furans and polycyclic aromatic hydrocarbons (PAH) (Borneff 6: fluoranthene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene, indeno(1,2,3,-cd)pyrene).

In Figure 38 regional emissions of dioxins/furans and PAH are presented by source sector. There are some fundamental differences between EU Member States and the PHARE accession Countries. Waste incineration in EU Member States in the early 1990's contributes to a large proportion of the emissions and is far less important in the PHARE accession countries. Industrial process emissions in the PHARE accession countries are comparable to those of the EU. Abatement of dioxins and furans is complex and was not yet implemented successfully in 1990 in the EU or in the PHARE accession Countries. Some upgrading of incinerators in the EU and regulations on fuel quality has helped to reduce emissions in more recent years.

Significant sources of PAH in the EU Member States are small combustion plants (residential combustion of fuel wood); application of oils and tars for wood preservation and road transport. Production of carbon anodes and coke in the metals industry also contribute to PAH emissions in the EU and PHARE accession countries.

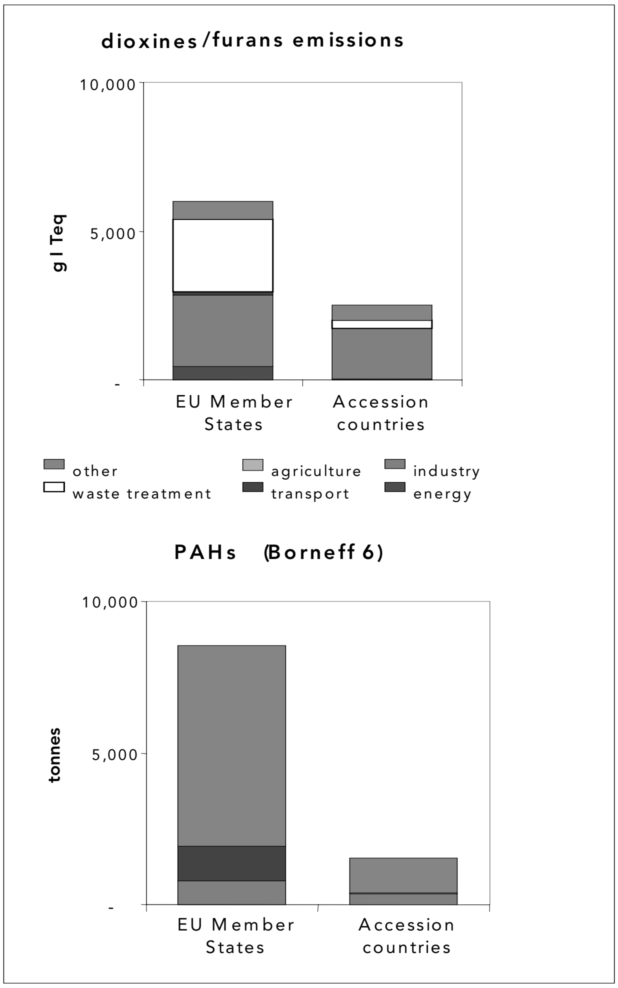
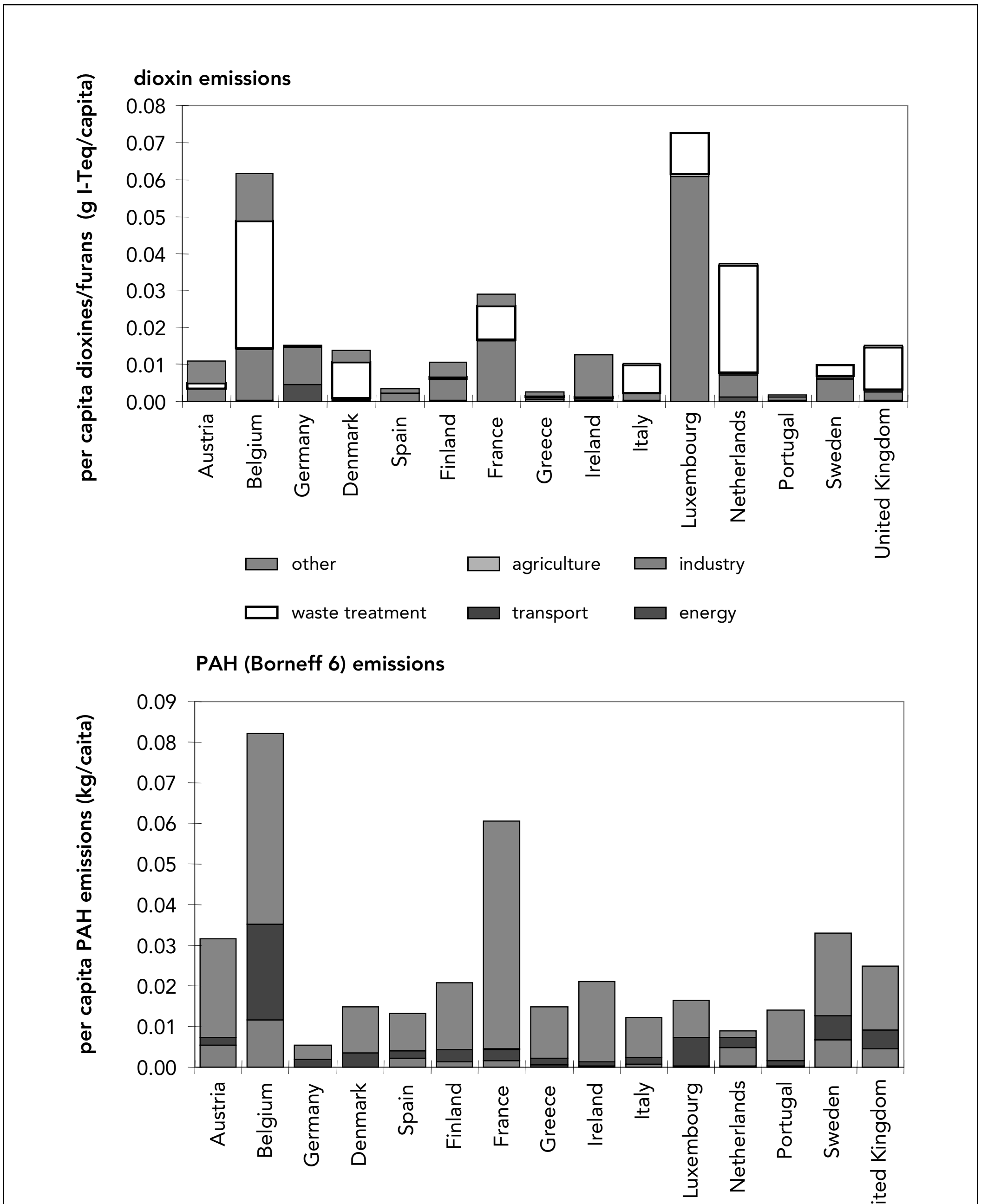


Figure 38: POP emissions by source sector in EU Member States and PHARE accession countries in 1990 [source: Berdowski et al. 1997b]

Figure 39 shows a considerable variation of per capita emissions of dioxin/furan and PAH between Member States. Luxembourg, Belgium and Germany show a high contribution of dioxins/furans from the ferrous and non-ferrous metals industry (especially ore sintering processes). The high emission from industry in France is from combustion. In Belgium, The Netherlands, Denmark and The United Kingdom waste incineration is the dominating source. Small, non-industrial combustion is a relative important source in Ireland, Belgium and Austria. For PAH emissions, the two largest sources are wood preservation and fuel wood combustion reported here under 'Other'. These sources dominate the emissions for all countries. France and Belgium have the highest per capita emission. Belgium also shows a relatively high emission from road transport and road paving with asphalt.



Source of GDP and Population data: Eurostat.

Figure 39: Per capita emissions of selected POPs in EU Member States in 1990. [Source: Berdowski et al. 1997b]

6. Emissions by sector

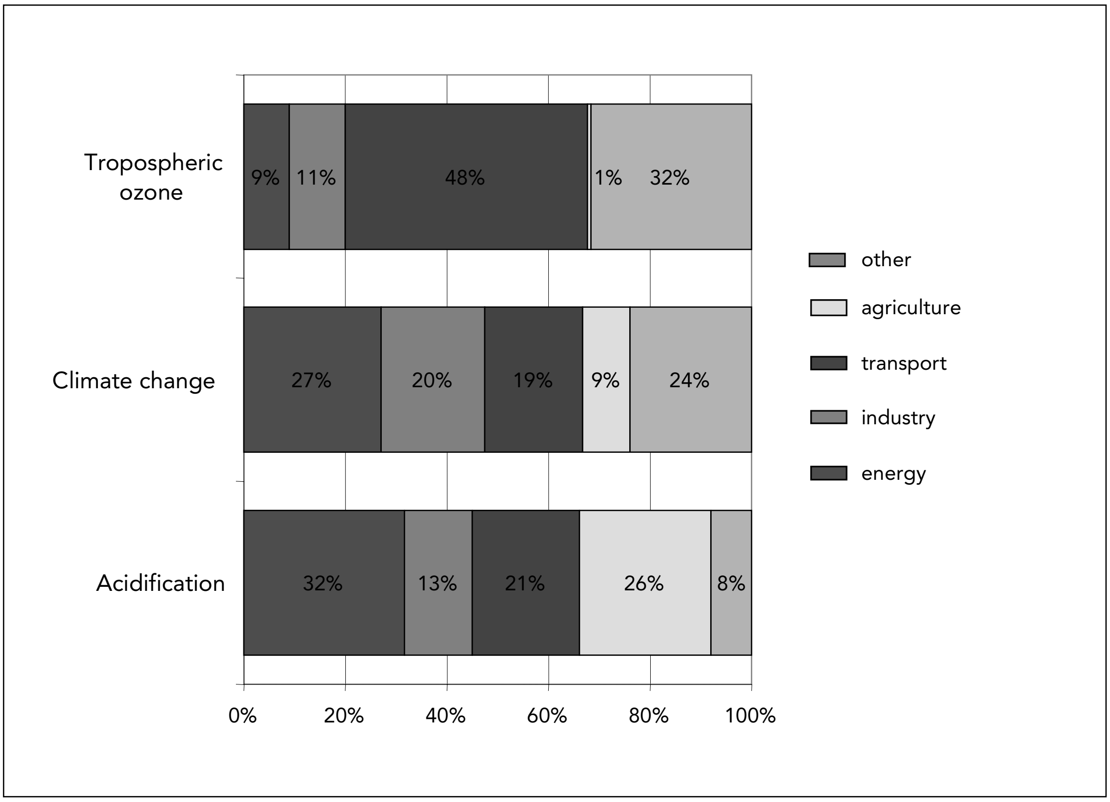


Figure 40: Sector contributions in the EU to climate change and air pollution issues in 1996

This chapter present environmental 'profiles' by main sector, as defined in this report and various other EEA reports (see the introduction, 1.5). It shows the emissions by sector for the pollutants contributing to climate change, acidification and tropospheric ozone.

Figure 40 shows that greenhouse gas emissions mainly result from energy (27 %), industry (20 %), transport (19 %), agriculture (9 %) and waste (included in other). Acidifying pollutant emissions are mainly from energy (32 %), agriculture (26 %), transport (21 %). Emissions of ozone precursors are mainly due to transport (48 %), industry (11 %), energy (9 %) and solvents use (included in other).

6.1. Energy

☺ Emissions of acidifying gases, tropospheric ozone precurors and carbon dioxide from the energy sector decreased between 1990 and 1996 by 26 %, 15 % and 5 % respectively, while primary energy demand increased by 7 %. Reductions are due to implementation of end-of-pipe abatement measures, increased efficiency in power generation strategies and the increased share of natural gas

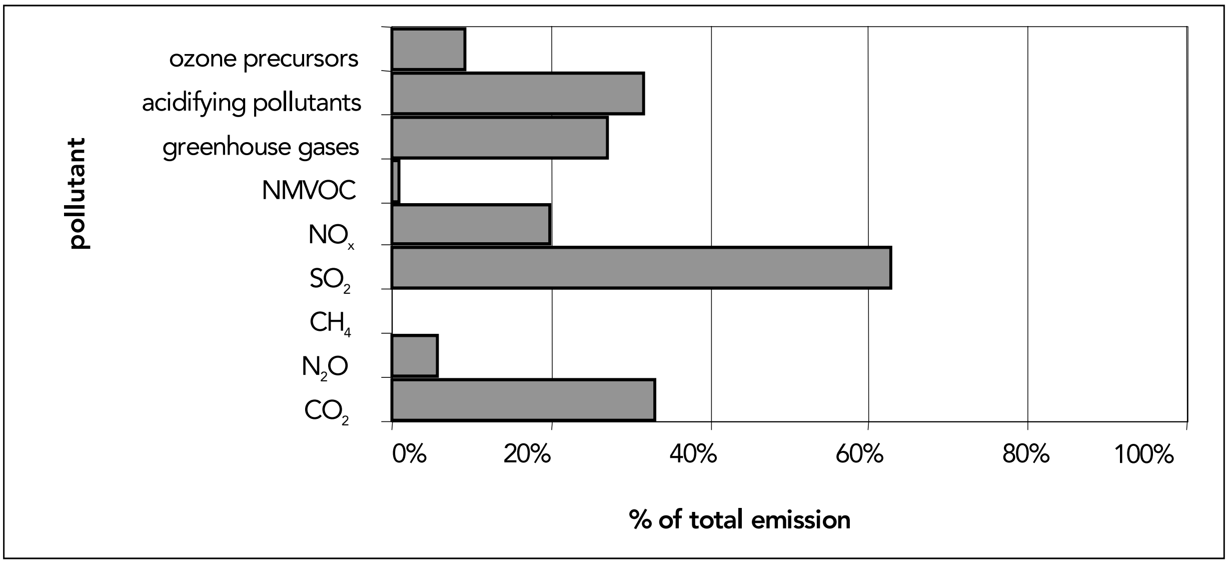
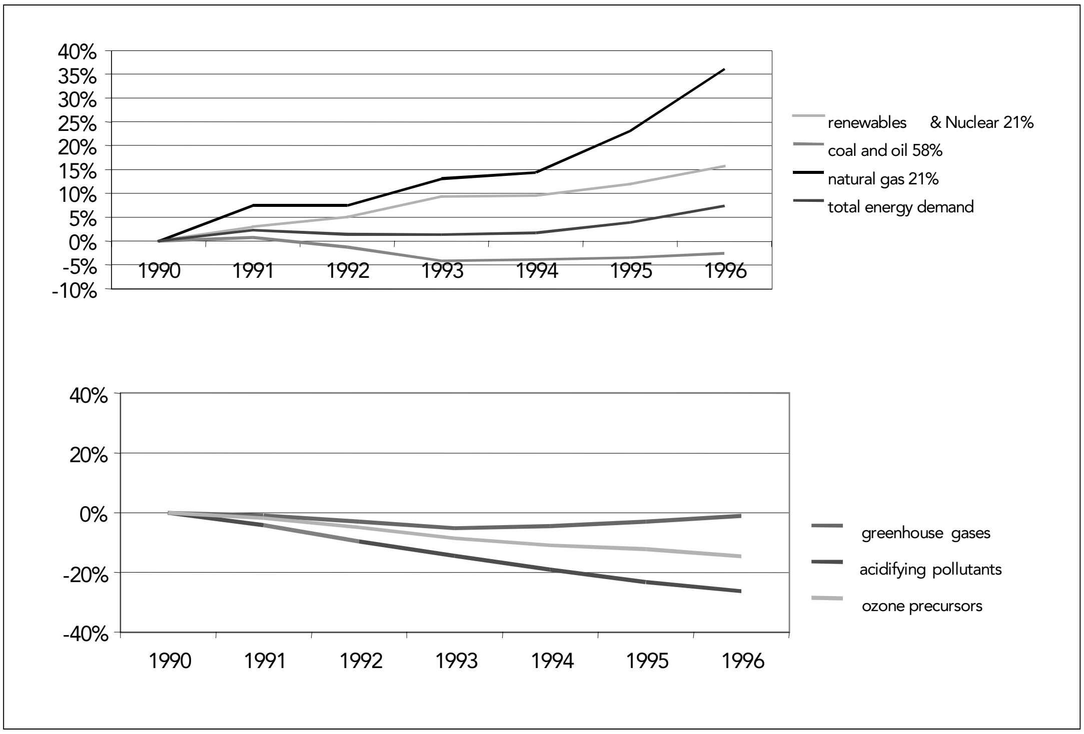


Figure 41: Energy sector share of total EU emissions of air pollutants

The energy sector as defined in the introduction of this report (section 1.5) consists mainly of power plants, producing electricity and heat. Energy use in industry and for transport (passenger and freight) is not dealt with in this chapter (for industry see chapter 6.2 and for transport chapter 6.3).

Despite reductions in the SO_2 between 1990 and 1996 of 42 %, the energy sector, is still the most important sector contributing to SO_2 emissions (62 % of EU total emissions). SO_2 is emitted from combustion of coal and heavy fuel oils, which have a high sulphur content. Greenhouse gas and in particular CO_2 emissions are high from the energy sector as the demand for energy use in the households, industry and in transportation continues to increase. NMVOC and CO emissions contribute very little to EU total emissions as a result of high combustion efficiencies in the energy sector.



Source energy data: Eurostat.
Note: Figures for energy data represent the EU15 % of total energy demand in 1996.

Figure 42: Energy sector's emissions, energy input (use) and share of fuel type for EU15. (% Change since 1990: Negative = Reduction)

Emissions of acidifying gases (SO_2 and NO_x combined) from the energy sector decreased by 26 % between 1990 and 1996, while tropospheric ozone precursers (mainly NO_x) emissions decreased less, but still by 15 %. These reductions are the result of controls (end-of-pipe technology) on emissions from coal combustion and a trend from solid and liquid fuel to natural gas. Abatements measures in the energy production and refining industries have helped to reduced SO_2 emissions by 42 % of 1990 values. The energy sector continues to have difficulties with reduction of greenhouse gas emissions (mainly CO_2). Increased efficiency of power plants and some switching from the carbon rich fuels of coal and oil to renewables or natural gas, which has less carbon per unit energy, has resulted in a 5 % reduction on CO_2 emissions between 1990 and 1996. This reduction appeared despite an increase in energy demand in the energy sector of 7 % between 1990 and 1996.

6.2. Industry

☺ Emissions of acidifying gases, tropospheric ozone precursers and greenhouse gases from the industry sector decreased between 1990 and 1996 by 36 %, 10 % and 8 % respectively, while industrial production and energy use in 1996 were on 1990 levels. This suggests a positive development of eco-efficiency in industry

☺ Emission reductions are due to a range of abatement measures and end-of-pipe technology, increased energy efficiency and a trend from solid and liquid fuel to natural gas. The Large Combustion Plant (LCP) Directive, the Integrated Pollution Prevention and Control (IPPC) Directive and the 'Solvents' Directive are expected to contribute to further emission reductions

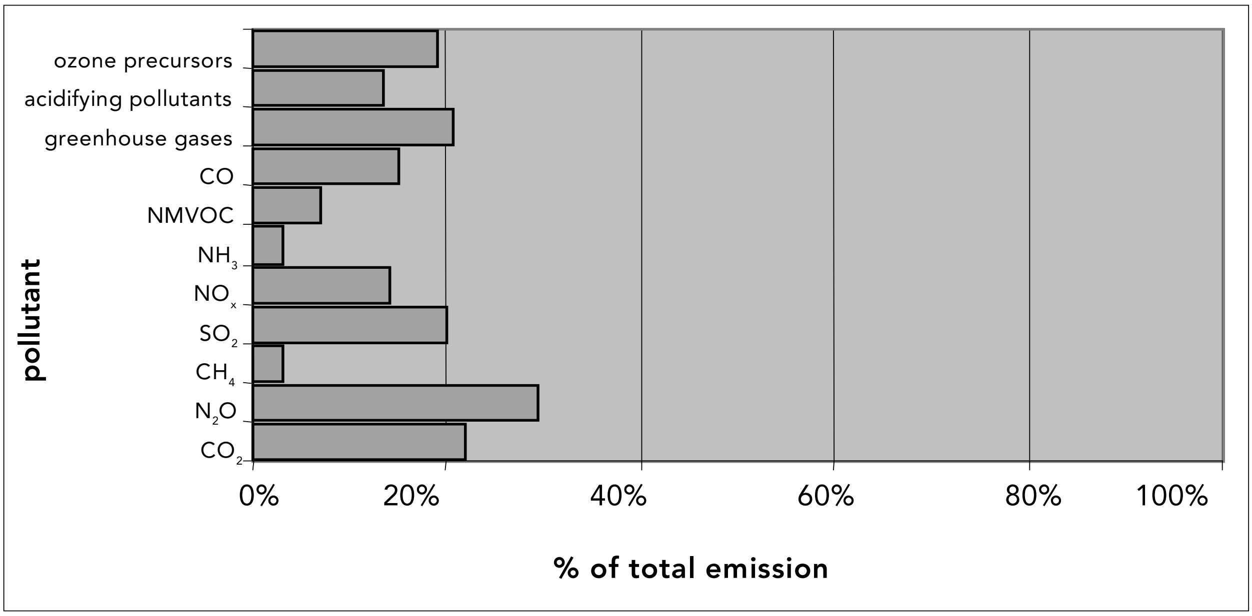
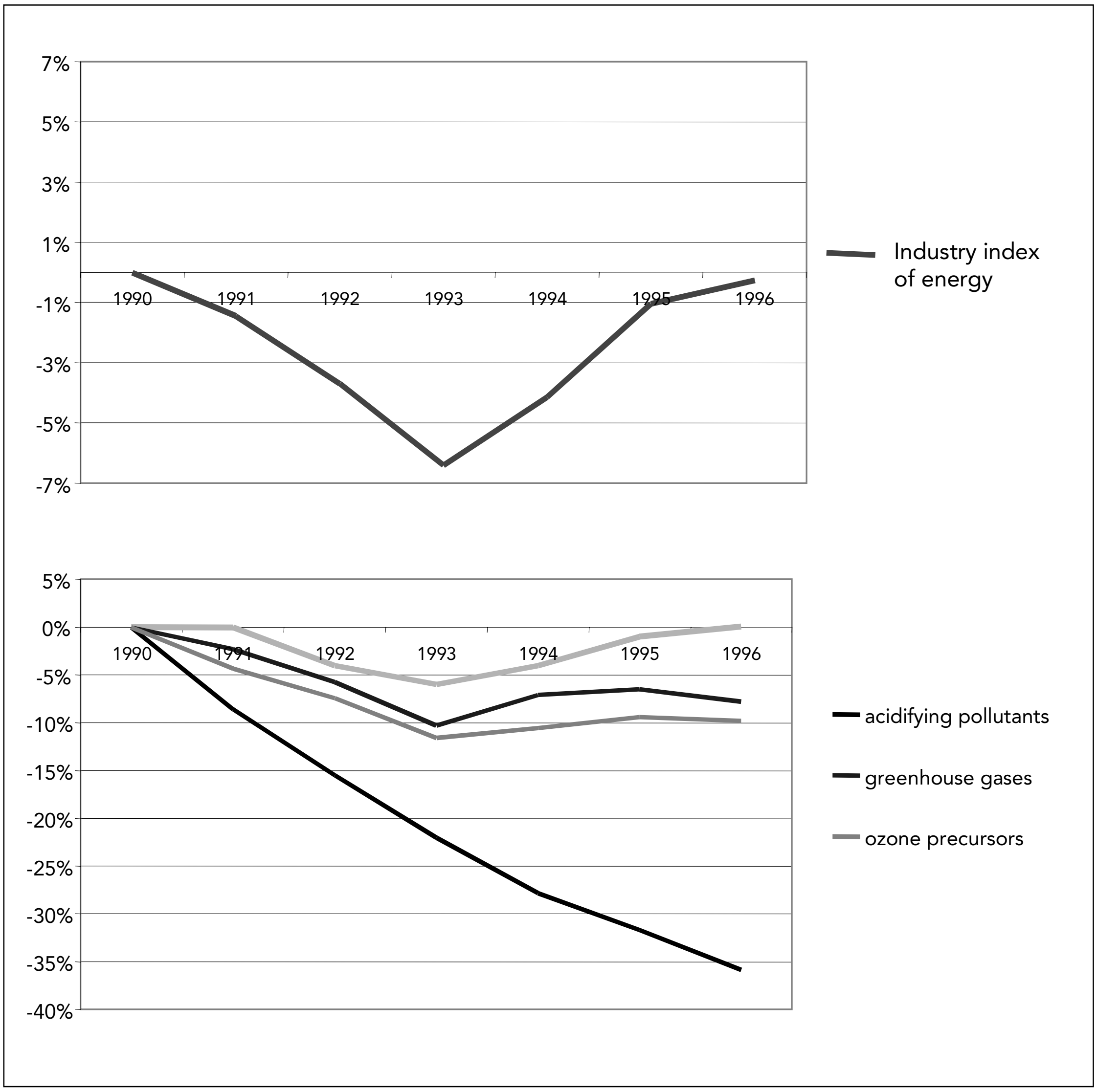


Figure 43: Industry sector share of total EU emissions of air pollutants

This chapter deals with emissions in industry, as defined in the introduction of this report (section 1.5), which includes emissions from energy use in industry as well as other emissions from processes.

Figure 43 shows the share of EU emissions from industrial sources in 1996. The highest contribution to any pollutant or issue area covered here is that of N_2O at approximately 30 %. These N_2O emissions occur from the production of nylon and nitric acid. Emissions for other pollutants range from 3-20 %. However it should be noted that NMVOC emissions to a large extent fall within 'other' emissions, as defined in section 1.5. This includes all emissions from SNAP sector 6 (Solvent and other product use), which is a combination of emissions from various industries and processes and from households. Therefore the share of NMVOC emissions from industry would in total be substantially higher than given in Figure 43. NMVOC emissions from industrial activities are quite diverse. Most industrial NMVOC emissions result from solvent use, which is associated with production activities like automobile and ship production, textile manufacture, paper coating and chemical product manufacture. However, domestic solvent use and road transport (see section 6.3) are another important sources of NMVOC.



Source of industry index: Eurostat.

Figure 44: Industry sector's emissions, energy use and index of industrial production for EU15. (% Change since 1990: Negative = Reduction)

Figure 44 shows industrial EU15 emissions of acidifying substances, greenhouse gases and ozone precursors compared with industrial economic developments (energy use and index of production).

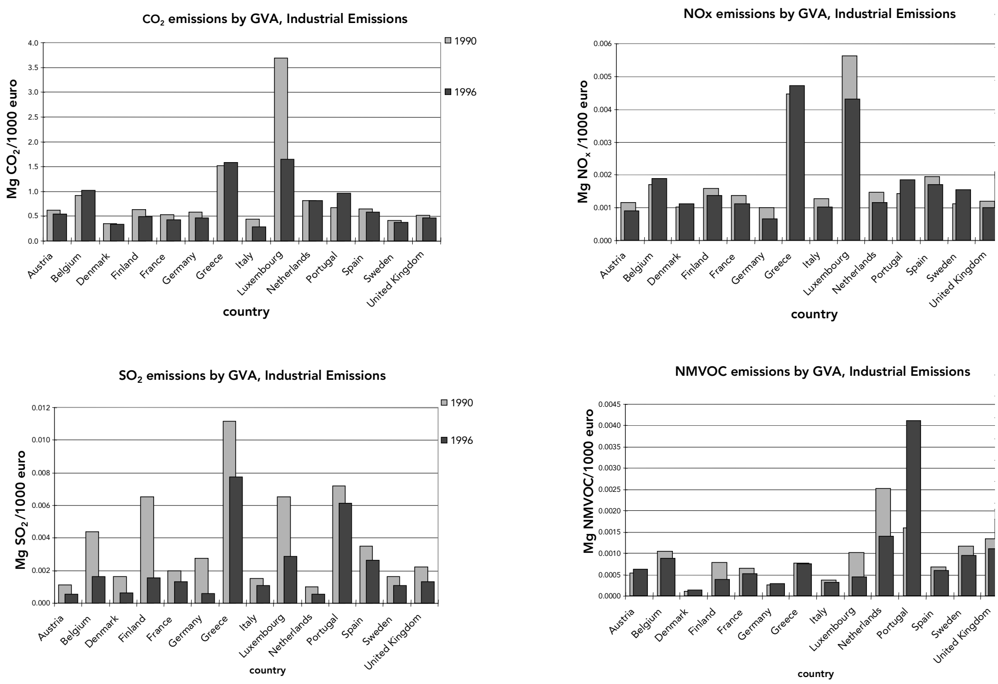
Emissions of acidifying gases (SO_2, NO_x and NH_3 combined) from the industry sector decreased by 36 % between 1990 and 1996, while tropospheric ozone precursers (NO_x, NMVOC) emissions decreased less, but still by 10 %. Greenhouse gas emissions (CO_2 with the largest share, also CH_4 and N_2O) decreased by 8 %. Figure 44 shows emissions of some pollutants (CO_2, NO_x, NMVOC) following a similar trend as industrial production and energy use, although there is a more pronounced downward trend in the emissions. In the same period industrial production and energy use initially dropped, until 1993, but changed back to 1990 level by 1996. This suggests a positive development of eco-efficiency, defined as emissions per unit of industrial activity (production index and/or energy use). However there are different trends between Member States and it should be noted that emissions from small and medium sized enterprises (SMEs) are not well known and therefore trends in their emissions are uncertain.

The most striking emissions reductions are for SO_2, by 46 % over the period 1990 to 1996. For the other gases the emission reductions over the same period are in the order of 10 %. The SO_2 and NO_x emission reductions are the result of reduced emissions from energy use, by means of abatement measures and end-of-pipe technology (flue gas desulphurisation, de-Nox installations), increased energy efficiency and a trend from solid and liquid fuel to natural gas. SO_2 emissions from industrial manufacturing processes have also been reduced by measures in specific industries such as copper melting and fertiliser industries.
Emission reduction for NMVOC to date have been difficult but achieved to some extent through 'clean production' measures such as better production control and substance substitution and also by means of end of pipe abatement measures such as incineration and other technologies.

Reduction of CO_2 emissions by 8 % over the period 1990 to 1996 has been achieved, despite an energy consumption by industry in 1996 at the same level as in 1990, due to increased energy efficiency and a trend from solid and liquid fuel to natural gas.

The main Community level measures focused on industry are the Large Combustion Plant (LCP) Directive, the Integrated Pollution Prevention and Control (IPPC) Directive and the 'Solvents' Directive (Directive on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations). These measures have contributed to the emission reductions and are expected to help in further future reductions. Reductions of CO_2 emissions could also be achieved through other measures, such as negotiated and/or voluntary agreements with industry. This approach currently exists in some Member States.

To analyse in more detail whether the emission reductions can be attributed to emission reduction measures or are the consequence of economic developments and to compare national emission levels, the per country emission levels per unit of gross value added (GVA) are presented in Figure 45. There is little change in historical industrial CO_2 emissions per gross value added, although the differences between countries to the contrary are rather large. Countries with high CO_2 emissions per gross value added are Greece and Luxembourg. Most countries have managed to cut the SO_2 emissions per GVA considerably, but in some countries (e.g. Portugal and Greece) there has been little or no reduction. The SO_2 emissions per GVA are low in Sweden and Denmark. NO_x emissions per GVA some countries decreased over the period 1990 to 1996 (Germany, the Netherlands, Austria and Portugal), remained stable in most countries and increased in a few countries (Finland and Greece). In most countries the NMVOC emissions per unit of industrial economic activity has remained stable. Other countries (the Netherlands, Sweden, the United Kingdom and Finland) show decreases in recent years.



Source of GVA data: Eurostat.

Figure 45: Per GVA (Gross Value Added) emissions from industry of CO_2, SO_2, NO_x and NMVOC in EU Member States

6.3. Transport

☺ Emissions of acidifying gases and ozone precursors from transport decreased by 11 % and 18 % respectively between 1990 and 1996, while in the same period transport activity increased (passenger road transport by 12 %). The emission reductions are mainly due to an increasing share (30 % in 1996) of petrol driven passenger cars fitted with catalytic converters.

☹ Greenhouse gas emissions resulting from transport have increased by 10 % from 1990 to 1996

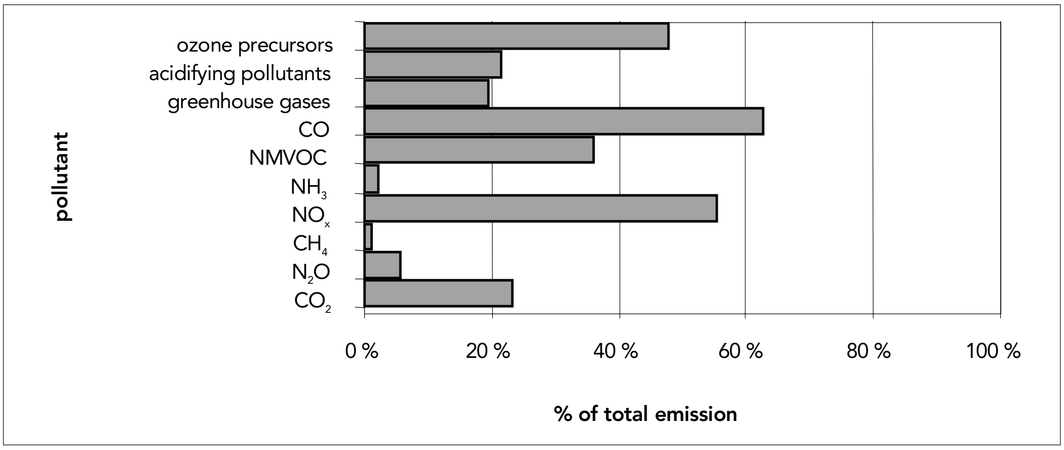
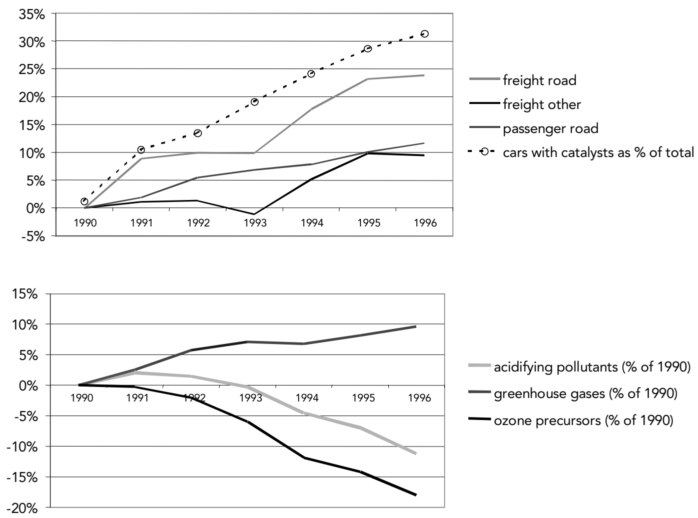


Figure 46: Transport sector share of total EU emissions of air pollutants

This chapter deals with emissions from transport, as defined in the introduction of this report (section 1.5), which includes emissions from passenger and freight transport. Figure 46 shows the share of EU emissions from all means of transport. The transport sector is a major source of emissions of ozone precursors and to a lesser extent, but still substantial, of acidifying pollutants and greenhouse gases. The shares are the highest for nitrogen oxides (NO_x) (55 %) and carbon monoxide (CO) (63 %), followed by non-methane volatile organic compounds (NMVOC) (35 %) and carbon dioxide (CO_2) (22 %).



Source of vehicle data: Eurostat.

Note: Catalyst cars are represented as % of all cars.

Figure 47: Transport: emissions, freight and passenger activity and cars with catalysts percentage for EU15. (% Change since 1990: Negative = Reduction)

Figure 47 shows trends in emission from transport compared with trends in transport activity (passenger kilometres and freight tonne kilometres) and passenger cars with catalysts (as a percentage of the total number of passenger cars).

From 1990 to 1996 transport emissions of greenhouse gases (mainly CO_2) increased by 10 %, while emissions of acidifying gases from transport decreased by 11 % and tropospheric ozone precursers by 18 %. In the same period transport activity increased substantially, by passenger road transport by 12 % and freight road transport by 24 %. The percentage of passenger cars with catalysts increased to over 30 % by 1996.

The increase in CO_2 emissions from transport to a large extent offsets the decrease in CO_2 emissions from other sectors resulting in the 1 % overall emission decrease (see chapter 2.2).

Road transport is the largest sub-sector of transport accounting for 76 % to 89 % of all transport related CO_2, NO_x and NMVOC emissions. Therefore, road transport trends clearly dominate the emissions of the whole transport sector for both freight and passenger transportation.

Transport related CO, NMVOC and NO_x emissions have decreased by 23 %, 24 % and 12 % respectively mainly due to the use of catalytic converters, despite a substantial increase in road transport passenger kilometres.

The implementation of the various Directives for emission limits on new cars and on fuel specifications, resulting from the first Auto Oil programme is expected to further reduce emissions of CO, NMVOC and NO_x. The second Auto Oil programme is expected to result in new proposals in 2000 for emission limit values on new cars, other technical measures as well as non-technical measures such as a move towards more environmentally friendly modes of transport.

The trends in Figure 47 show that CO_2 emissions are increasing at a similar rate as transport activity, which means there has been little or no improvement in CO_2 (and therefore also energy) efficiency of transport in the past years (CO_2 emissions per unit passenger and freight transport). The increasing use of heavier and more powerful vehicles, as well as decreasing occupancy rates (passengers) and load factors (freight), have more or less outweighed increases in vehicle energy (technological) efficiency.

In future the implementation of the negotiated agreement (1998) between the European Commission and the car industry is expected to reduce CO2 transport emissions. This is aimed at reducing carbon dioxide emissions from new passenger cars by 25 % (to 140 g/km) between 1995 and 2008.

A comparison by transport mode of CO_2 emissions per passenger or tonne kilometre shows that passenger cars cause about twice as much CO_2 emissions (per passenger kilometre), compared to rail and about three times as much as buses (Table 7). Air traffic shows the highest CO_2 emissions per passenger. Road freight emits about six times as much carbon (per tonne kilometre) as rail or inland navigation.

This analysis shows that a shift from road transport, of passengers and freight, to other transport modes would result in CO_2 emission reductions. Also enhancing the average occupancy rate of passenger cars would reduce emissions. However in the past decades there has been a dramatic shift from other transport modes to road transport. The promotion of public transportation and inland waterways, main goals of transport policies of the EU and the Member States, does not yet show positive results on air emissions. While in EU15 the total length of motorways nearly tripled between 1970 and 1996, the total length of railway lines decreased by 8 % (European Commission, 1999).

Therefore demand-side measures seem to be required, aimed at reducing further growth of transport volumes, in addition to technical measures.

Table 7: Specific emissions of CO_2 by mode of transport, EU average 1995

Passenger transport	**Grams per passenger.km**
Passenger car (1)	125
Bus	45
Railway (2)	65
Air	175
Freight transport	**Grams/tonne km**
Road freight	190
Railway (2)	30
Inland navigation	30
Sea (intra EU)	20
Pipeline	7

(1) Average occupancy of 1.7 passengers/car

(2) Rail lines, which are electrified, represent approximately 75 % of train kilometres. More than 50 % of electrical energy for railways are produced by non-fossil fuels (nuclear, hydro, etc.).

Source: European Commission (1999)

6.4. Agriculture

☺ Emissions of ammonia, nitrous oxide and methane from agriculture have decreased by 1-2 %, 4 % and 5 % respectively between 1990 and 1996, mainly due to reduction in livestock numbers.
☹ Changes in agricultural practices will be necessary to reduce EU emissions further.

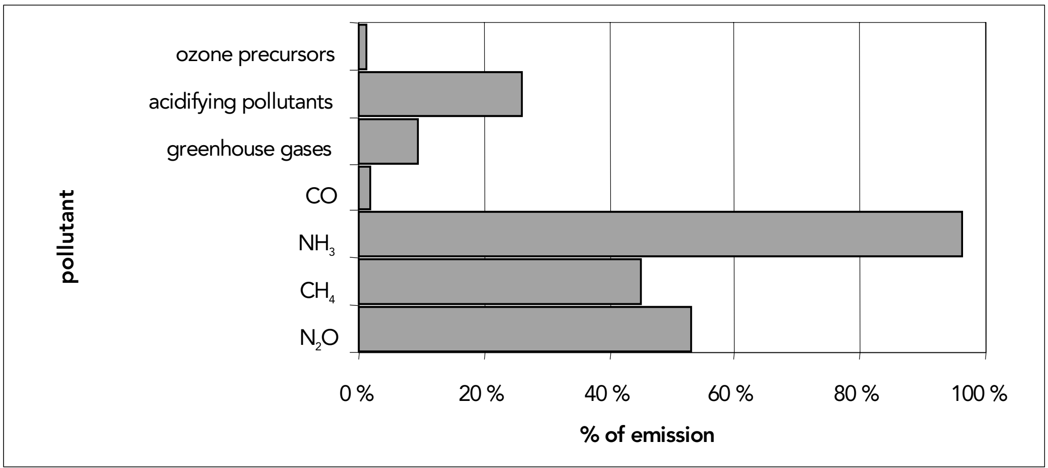
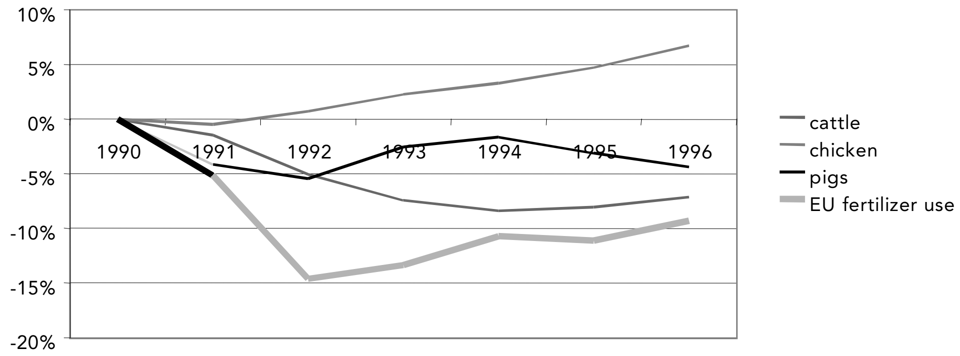
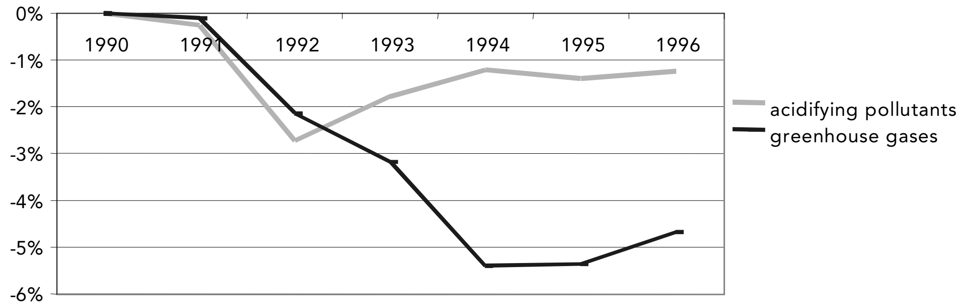


Figure 48: Agriculture sector share of total EU emissions of air pollutants

This chapter deals with emissions from agriculture, as defined in the introduction of this report (section 1.5), which includes emissions from energy use in industry as well as other emissions from processes.

Figure 48 Agricultural methane and ammonia emissions (45 % and 96 % of EU emissions respectively) occur from manure and enteric fermentation in livestock. Some ammonia is also produced from agricultural soils through manure spreading and field burning. Agricultural soils are the largest emission source of nitrous oxide emissions (51 % of EU emissions) mainly through fertiliser use. Nitrous oxide emissions result from soils treated with nitrogen fertilisers both organic and mineral where part of the added nitrogen is converted into nitrous oxide and released into the atmosphere.





Source agriculture statistics: Eurostat.

Figure 49: Live stock and fertilizer use variation and resulting emissions index of greenhouse gases and acidifying pollutants in the EU 15. (% change since 1990: Negative = Reduction)

Emissions of methane and ammonia from agriculture have marginally decreased through reducing livestock numbers. From 1990 to 1996 the number of cattle decreased by about 6 %. Similarly agricultural methane emissions have decreased by about 5 %. However, ammonia emissions have only decreased by between 1 and 1.5 % over the period 1990 – 1996. Ammonia emissions from intensive farming of chickens are significant. The ammonia emission reduction due to a decline in cattle and pig (4 % from 1990 to 1996) numbers is partly offset by an increase due to increase in chicken numbers (of more than 5 % from 1990 to 1996).

Between 1990 and 1996 the EU has seen a 9 % decrease in mineral fertiliser consumption. N_2O emissions have decreased by 4 % over the same period and do not exactly match the trend of reduced consumption of mineral fertilisers. This can be explained by the fact that emissions also occur due to use of organic fertilisers, which are not included in the data on use of (mineral) fertilisers (as presented above).

7. Quality of data in this report

7.1. Introduction to inventory quality

The main quality aspects relevant for air emission inventories and indicators are: timeliness, transparency (ensuring that the estimates are 'verifiable'), comparability, consistency and completeness. Annex 3 provides background information on these aspects.

In this section the main data, as used in this report (national emission inventories submitted to UNFCCC and UNECE/CRLTAP) are characterised against the quality aspects/criteria of 'completeness' and 'comparability'. The results presented here are not meant to be exhaustive, but merely summarise the data quality on these two aspects. Finally the aspects of 'consistency' are also elaborated by means a comparison between emissions reported to UNFCCC and to CRLTAP is presented.

7.2 Greenhouse gases (UNFCCC/IPCC format)

The tables and figures below show the number of EU Member States, reporting emissions by pollutant in each of the seven main IPCC sectors, as available by end of 1999, for use in this report. Since emission estimates for 1997 should have been reported to UNFCCC by 15 April 1999 (and also to the EU Monitoring Mechanism, by early 1999), data for the year 1997 should have been available for inclusion in this report.

It can be seen that only for the years 1990 and 1994 all EU Member States reported emissions of the original three greenhouse gases as national totals. For the other years, for one or more countries data are missing. Roughly half of the countries reported emissions of the new gases, while the number of countries reporting these seems to be increasing. It should be noted that under the EU Monitoring Mechanism various actions take place in 1999 and beyond to improve the reporting of GHG inventories by EU Member States, which is expected to lead to an improved situation in 2000.

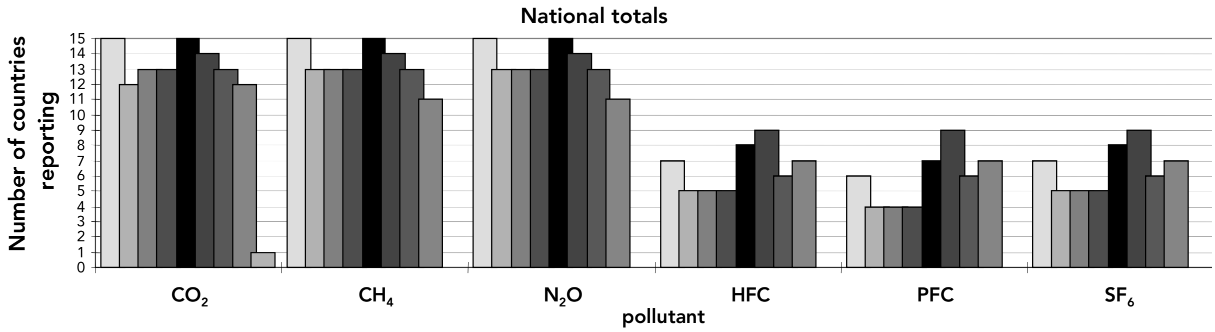


Figure 50: Completeness of reporting of national total GHG emissions by EU Member States by gas (UNFCCC, IPCC format) in 1999

Table 8 presents for each EU Member State the latest year for which emissions and removals for each of the greenhouse gases have been reported.

Table 8: Overview of latest year with GHG data availability (by gas and by country)

Country	CO_2	CH_4	N_2O	HFC	PFC	SF_6	CO_2-Removals
Austria	1997	1997	1997	1995	1995	1995	1997
Belgium	1997	1997	1997				1997
Denmark	1997	1997	1997	1997	1997	1997	1996
Finland	1997	1997	1997	1997	1997	1997	1995
France	1997	1997	1997	1997	1997	1997	1997
Germany	1998	1997	1997	1997	1997	1997	1998
Greece	1997	1997	1997				1997
Ireland	1997	1996	1996				1996
Italy	1995	1995	1995	1995	1995	1995	1995
Luxembourg	1997	1997	1997				1997
Netherlands	1997	1997	1997	1997	1997	1997	1997
Portugal	1994	1994	1994				1994
Spain	1996	1996	1996				1996
Sweden	1997	1997	1997	1997	1997	1997	1997
United Kingdom	1997	1997	1997	1997	1997	1997	1997

At the level of the main IPCC sectors the picture is less clear (Figure 51). Most countries are reporting emissions of the original three greenhouse gases in the Energy and Industrial Processes sectors. The majority of countries also report emissions of methane and nitrous oxide from agriculture and methane emissions from 'Waste'. For other sectors and gases roughly half of the countries report emissions.

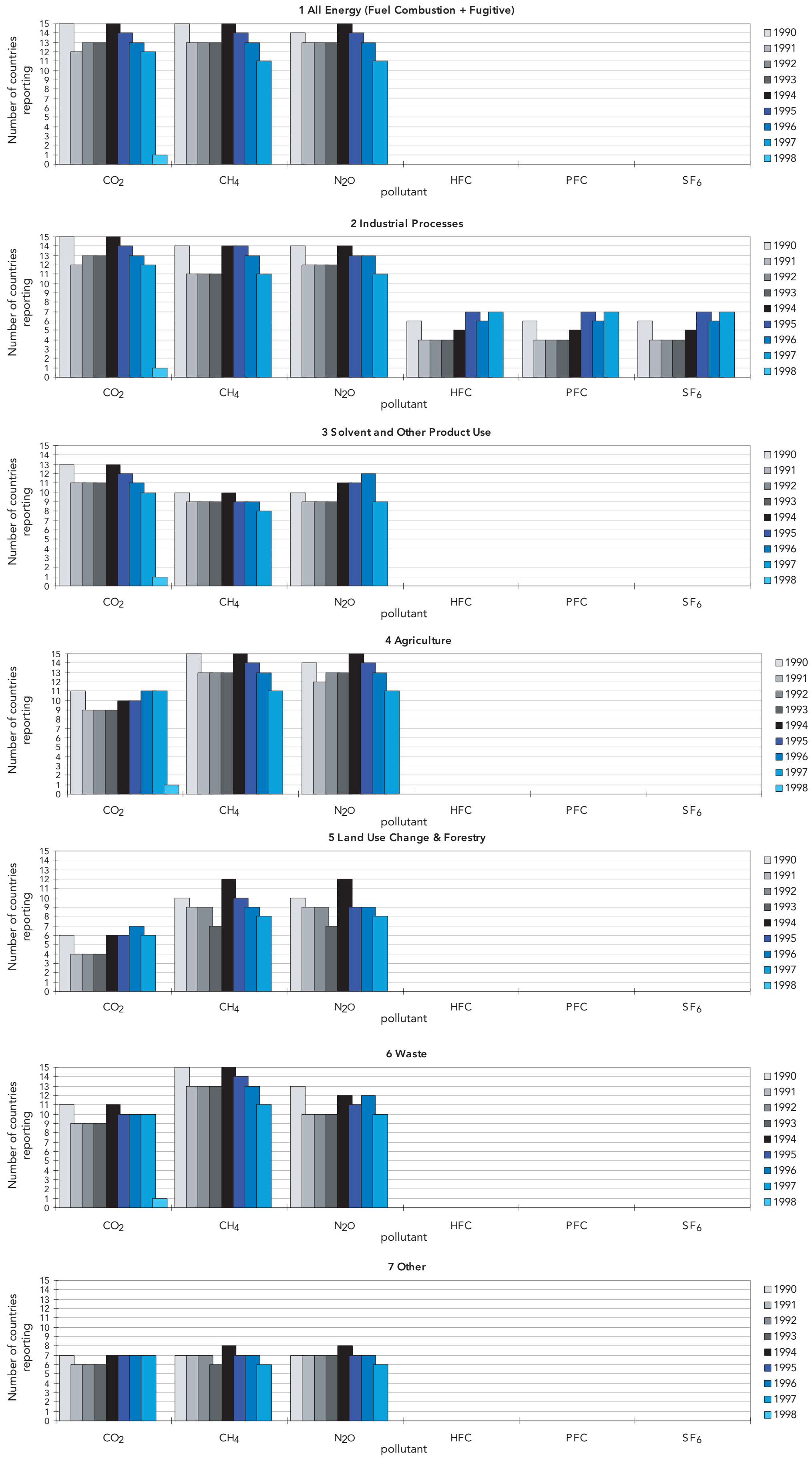


Figure 51: Completeness of reporting of sectoral GHG emissions by EU Member States by gas (UNFCCC, IPCC format) in 1999

7.3 Acidifying gases, ozone precursors (CLRTAP/EMEP/CORINAIR format)

The status report on EMEP emission data (UNECE/EMEP, 1999) presents a comprehensive overview on the data as delivered by parties to the Convention on Long Range Transport of Air Pollutants (CRLTAP). This chapter summarises these results on the aspects of timeliness and completeness, for the EU Member States. All EU Member States have delivered data in 1998/1999 (up to May 1999). However, for pollutants other than SO_2 and NO_x data deficiencies and gaps are still substantial.

Data deliveries on emissions of the classical CRLTAP pollutants for EU 15 are characterized in the table below (based on UNECE/EMEP, 1999). From this table it can be seen, that Italy and Spain by May 1999 delivered data for 1995, France, Germany, Greece and Luxembourg for 1996 and all other EU Member States for 1997. Data for the new pollutants (heavy metals and POPs) are much less well delivered. However, since the 1997 data (national total and at least SNAP level 1 for sectors) were due by December 1998, not all EU Member States comply with this deadline.

Table 9: Completeness of reporting of sectoral emissions by EU Member States by gas (acidifying pollutants and ozone precursors (EMEP/CORINAIR SNAP level 1) in 1999

	Latest year reported in 11 category split (SNAP level 1)					
Country	SO_2	NO_x	NH_3	NMVOC	CO	CH_4
Austria	1997	1997	1997	1997	1997	1997
Belgium	1997	1997	1997	1997	1997	1997
Denmark	1997	1997	1997	1997	1997	1997
Finland	1997	1997	1997	1997	1997	1997
France	1996	1996	1996	1996	1996	1996
Germany	1996	1996	1996	1996	1996	1996
Greece	1996	1996	-	1996	1996	1996
Ireland	1997	1997	1997	1997	1997	1997
Italy	1995	1995	1995	1995	1995	1995
Luxembourg	1996	1996	1996	1996	1996	1996
Netherlands	1997	1997	1997	1997	1997	1997
Portugal	1997	1997	1997	1997	1997	1997
Spain	1995	1995	1995	1995	1995	1995
Sweden	1997	1997	1997	1997	1997	1997
United Kingdom	1997	1997	1997	1997	1997	1997

7.4 Heavy metals and persistent organic pollutants

The European CORINAIR (ETC/AE) database contains data on heavy metals and POPs, provided by Member States directly to EEA. The tables below show the data availability for these substances at the national level. Only France and Finland have reported emissions of heavy metals for the full time series, whereas for the Netherlands, Luxembourg, Sweden and Denmark data for one or two years are available. Data for the emissions of POPs are even less complete. Again Finland and France have provided some data for the full time series for some POPs, but no data for others. Emission estimates for POPs are less consistent than other pollutants presented in this report. For dioxins for instance, emission factors used by countries can sometimes vary by more than a factor of 10 for comparable sources. Also there is less information available from national emission inventories.

Table 10: Completeness of reporting of national total heavy metal emissions by EU Member States in 1999

Country	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Austria									
Belgium									
Germany									
Denmark	1997	1997	1997	1997	1997	1997	1997	1997	1997
Spain									
Finland	1997	1997	1997	1997	1997	1997	1997	1997	1997
France	1996	1996	1996	1996	1996	1996	1996	1996	1996
United Kingdom									
Greece									
Ireland									
Italy									
Luxembourg	1997	1997	1997	1997	1997	1997	1997	1997	1997
Netherlands	1997	1997	1997	1997	1997	1997	1997	1997	1997
Portugal									
Sweden	1995	1995	1995	1995	1995	1995	1995	1995	1995

Table 11: Completeness of reporting of national total POP emissions by EU Member States in 1999

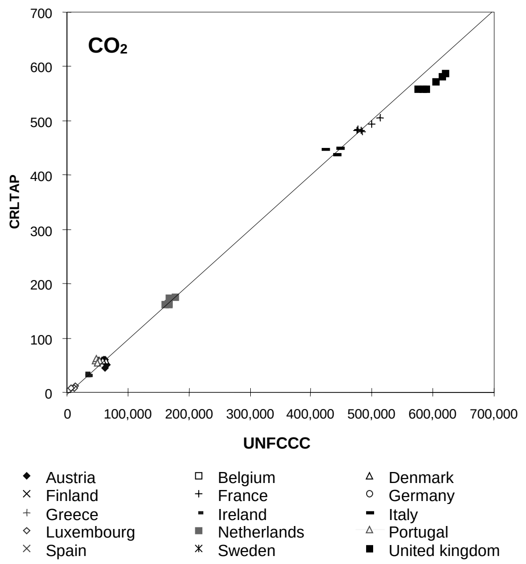
Country	DIOX	HCB	HCH	PAH	PCP	PER	TCB	TCE	TCM	TRI
Austria										
Belgium										
Germany										
Denmark										
Spain										
Finland	1997			1997	1997					
France	1996	1996	1996	1996	1996	1996	1996	1996	1996	1996
United Kingdom										
Greece										
Ireland										
Italy										
Luxembourg	1997	1997	1997	1997	1997	1997	1997	1997	1997	1997
Netherlands	1997	1997	1997	1997	1997	1997	1997	1997	1997	1997
Portugal										
Sweden	1995	1995	1995	1995	1995	1995	1995	1995	1995	1995

7.5 Consistency of data reported to UNFCCC and CLRTAP

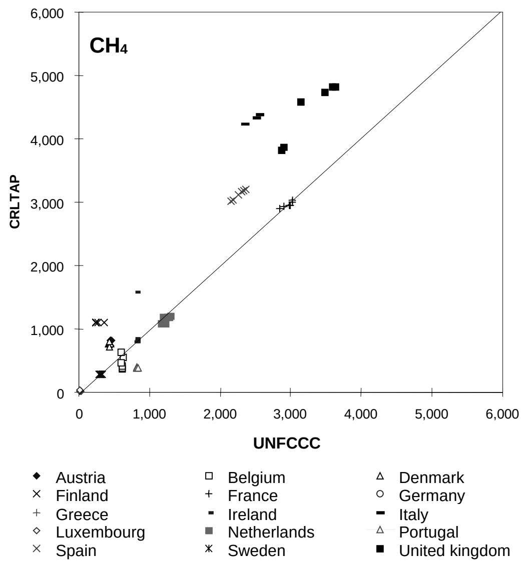
For those countries, that submitted emissions estimates for the same pollutants to both UNFCCC and CRLTAP, these reported national totals by pollutant can be compared to give some insight into the consistency and completeness of the reported inventory data. Some caution is required since in some cases differences actually should occur due to differences in reporting guidelines between these conventions, e.g. differently defined geographical scope of the Party (see also Annex 1). However for most countries and pollutants these differences will be rather small. Data reported to UNFCCC and CRLTAP are plotted against each other for the years 1990 through 1995 in the graphs below. Some observations are given directly adjacent to the graphs. Although the term 'report to CRLTAP' is used here, the data actually contain in various cases estimates, produced by EMEP MSC-West (UNECE/EMEP, 1999) to fill the gaps in national data deliveries. Furthermore it should be noted that the comparisons could only be made for countries that delivered data to both protocols in sufficient detail. Data reported to CRLTAP by Germany and Greece was not available for this report.

The emissions estimates available, reported by countries to CRLTAP and UNFCCC, show a number of inconsistencies. Further analyses are needed to identify the reasons for these inconsistencies. In such analyses care must be taken for a correct translation from SNAP source sectors, as used in CRLTAP and the IPCC main sectors as used in UNFCCC reporting.

Countries are encouraged to increase cooperation and coordination between all national organisations (statistical institutes, environmental protection agencies, scientific community, stakeholders/sectors, etc.) involved with compiling and reporting emissions estimates to various international reporting obligations to further reduce remaining inconsistencies.



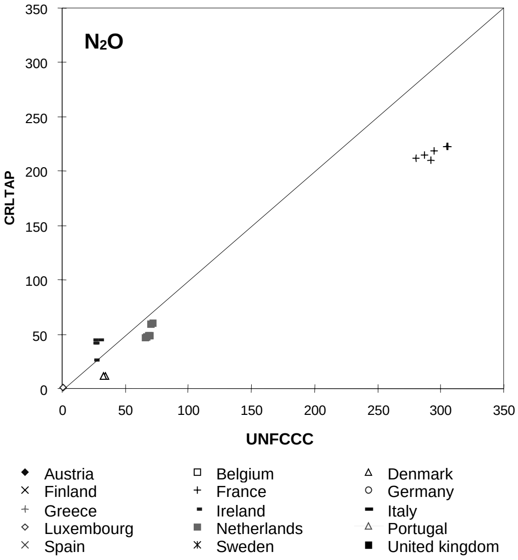
The consistency of the CO_2 emissions estimates between UNFCCC and CRLTAP reports by country seems to be quite good. The UK emissions are slightly lower as reported to CRLTAP compared to the UNFCCC report. Since the reporting format for CO_2 for both protocols has recently been made equal, this should no longer occur.

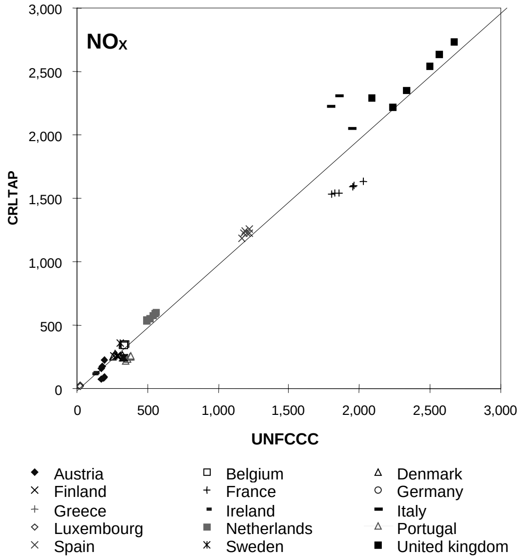


Methane emissions reported to both conventions show less consistency. This may be partly caused by the higher uncertainties for this pollutant.

Waste: (IPCC 6 vs. SNAP9) For the UK and Italy, about twice as high emissions for 'Waste' are reported to CRLTAP compared to the report to UNFCCC. Portugal does not report methane from waste to CRLTAP, but includes these emissions in the UNFCCC report.

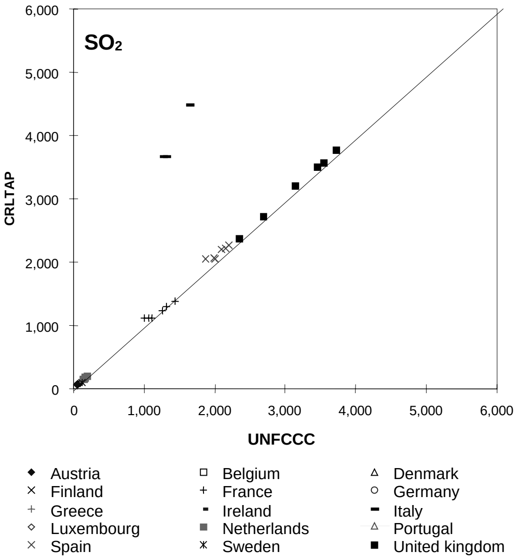
Agriculture (IPCC 4 vs. SNAP10) The emissions reported by UK and Italy to CRLTAP are higher than those reported to UNFCCC for this sector. All other countries report very similar values.

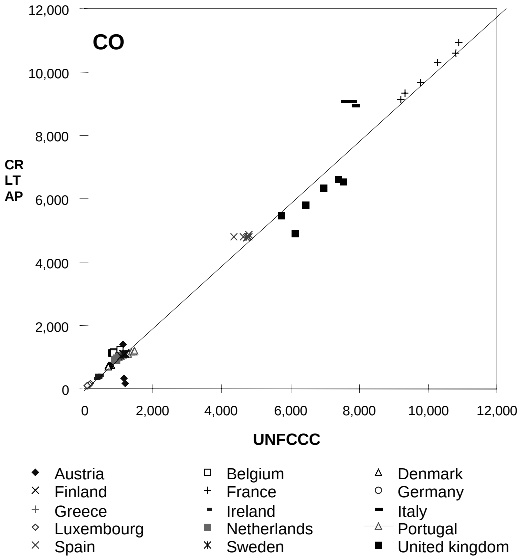




Some inconsistencies in N_2O emission estimates occur. France reports lower emissions from agriculture to CRLTAP compared to UNFCCC. The same is true for Denmark and to a lesser extent for the Netherlands, whereas in the case of Ireland the opposite occurs.

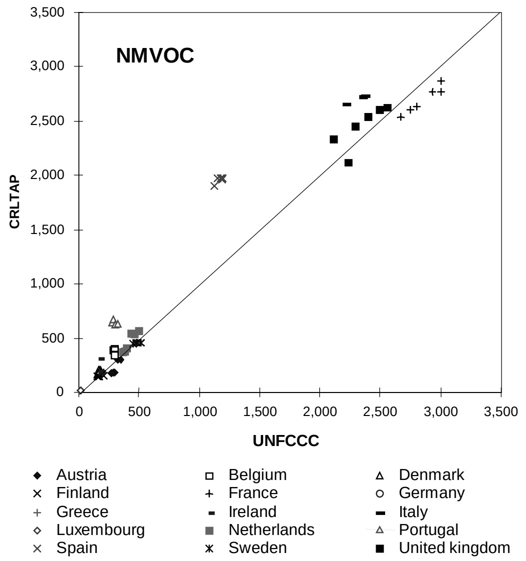
Some inconsistencies are evident for NO_x emissions reported by several countries for all base years (Italy, France, Portugal). Data for Austria and UK show inconsistencies for some years only.





Consistency for SO_2 emissions is generally good. The only exception is Italy, which reports (correctly) emissions from Nature (SNAP 11, volcanoes) to CRLTAP, but not to UNFCCC.

CO emissions reported to both conventions appear to be quite consistent. Austria reports low emissions to CRLTAP for some years. Minor differences occur for UK and Italy, and Sweden appears to report the same values to CRLTAP annually, whereas the UNFCCC data show changes over time.



Emissions of NMVOCs reported by Spain and Portugal to CRLTAP are significantly higher than the ones reported to UNFCCC. For other countries smaller differences occur.

8. References:

Relevant data and information available on the Internet:

All final EEA reports are available on the Internet, EEA website: http://www.eea.eu.int/ . Detailed emission data, compiled by ETC/AE is available on http://service.eea.eu.int/

Some additional information is available on the ETC/AE website: http://etc-ae.eionet.eu.int/etc-ae/index.htm

The following websites contain some of the reports mentioned in this reference list or other data/information:

- UNFCCC: http://www.unfccc.de/
- UNECE/CLRTAP: http://www.unece.org/env/lrtap/
- EMEP: http://www.emep.int/index.html
- IPCC (greenhouse gas inventory programme): http://www.ipcc-nggip.iges.or.jp/
- European Commission, DG Environment: http://europa.eu.int/comm/environment/
- Eurostat: http://europa.eu.int/en/comm/eurostat/eurostat.html

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Annex 1: Emission inventory guidelines and guidebooks

1. CLRTAP and EMEP/CORINAIR

Parties to CLRTAP should use the draft reporting procedures (EB.AIR/GE.1/1997/5) and are required to submit annual national emissions of SO_2, NO_x, NMVOC, CH_4, CO and NH_3 and various heavy metals and POPs using the 11 main source categories (level 1 of SNAP, Selected Nomenclature for sources of Air Pollution) by the 31 December following each year. For the inventories due on 31 December 1999, Parties are expected to also report emissions of more detailed sub-sectors (SNAP level 2). Parties are also required to provide EMEP periodically with emission data within grid elements of 50km x 50km, as defined by EMEP and known as the EMEP grid. Parties should use the EMEP/CORINAIR Atmospheric Emission Inventory Guidebook both as a reference book on good emission estimation practice and as a checklist to ensure that all relevant activities are considered and their emissions quantified. Parties should indicate where the Guidebook methodology has been used and where not. If another methodology has been used Parties are requested to provide additional explanatory information.

The Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP) formed by a Protocol under the Convention on Long Range Transboundary Air Pollution (CLRTAP) has formed a Task Force on Emission Inventories and Projections (TFEIP), led by the United Kingdom with support from the European Community (including the European Environment Agency) and various countries. The objectives of the Task Force are to:

- Provide a technical forum to discuss, exchange information and harmonise emission inventories including emission factors, methodologies and guidelines
- Conduct in-depth evaluation of emission factors and methodologies in current operation
- Cooperate with other international organisations working on emission inventories with the aim of harmonising methodologies and avoiding duplication of work.

The first meeting of the Task Force was held in 1992. The Task Force operates five expert panels to cover all main source categories as well as the issues of projections and verification. The first edition of the Guidebook was completed in 1996 and published by the EEA (on paper, CDROM and the EEA website). In December 1999 the second edition of this Guidebook was made available on the Internet, EEA website: http://themes.eea.eu.int/theme.php/state/air. A printed version was made available early 2000.

The European Topic Centre on Air Emissions (ETC/AE) has from the start in 1995 of its activities worked closely with EMEP and TFEIP. In 1995 ETC/AE, with EMEP and TFEIP, developed the CORINAIR SNAP source nomenclature (Selected Nomenclature for sources of Air Pollution) further, resulting in SNAP94, which was used and presented in the first edition of the Guidebook.

In 1998 ETC/AE, with EMEP and the TFEIP, developed the nomenclature still further, resulting in SNAP97 as used and presented in this second edition of the Guidebook. SNAP97 covers additional activities that are sources of the heavy metals and persistent organics and is fully consistent with the IPCC nomenclature *(1996 Revised IPCC Guidelines for National Greenhouse Gas Inventories, IPCC/OECD/IEA/WMO, 1997)* developed for reporting under the UN Framework Climate Change Convention (see also below). Various detailed correspondence tables between SNAP97 and IPCC1996 source categories are provided in the second edition of the Guidebook. SNAP97 consists of a hierarchical system with:

- Level 1: 11 main sectors
- Level 2: 75 sub-sectors
- Level 3: 414 activities

SNAP97 level 1 sectors are:

1. Combustion in energy and transformation industries
2. Non-industrial combustion plants
3. Combustion in manufacturing industry
4. Production processes
5. Extraction and distribution of fossil fuels and geothermal energy
6. Solvent and other product use
7. Road transport
8. Other mobile sources and machinery
9. Waste treatment and disposal
10. Agriculture
11. Other sources and sinks

2. UNFCCC, IPCC and EU Monitoring Mechanism

2.1. UNFCCC/IPCC

Parties are required to report emissions and sink estimates by 15 April for the last year but one of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6). For example data for 1997 should be reported by 15 April 1999 to the UNFCCC Secretariat. Parties should also provide information on emissions of carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOCs) and are encouraged to provide information of emissions of sulphur oxides (SO_2).

UNFCCC requires Parties to use the UNFCCC reporting guidelines for reporting and review (including guidelines for annual inventories), UNFCCC/CP/1999/7, available from the UNFCCC website under: http://www.unfccc.de/resource/docs/cop5/07.pdf. These UNFCCC guidelines refer also to the use by Parties of the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (‘IPCC Guidelines’). Parties may use different methods (‘tiers’), giving priority to those methods which are believed to produce the most accurate estimates, and Parties can also use national methodologies which they consider better able to reflect their national situation provided that these methodologies are compatible with the IPCC Guidelines and are well documented.

Within the framework of UNFCCC continuing efforts are aimed at improving transparency, consistency, comparability, accuracy and completeness of inventories, resulting in proposals for a new detailed ‘common reporting format’ (CRF) and for preparing and providing access to, an annual updated, detailed and complete national inventory report for all years. These proposals were adopted at COP5 in Bonn (25 October – 5 November 1999). Parties should use the CRF for reporting inventories due by 15 April every year beginning in the year 2000.

The IPCC Guidelines specify six main sectors for reporting emissions and removals:

1. All Energy (Combustion + Fugitive)
2. Industrial Processes
3. Solvent and other Product Use
4. Agriculture
5. Land Use Change and Forestry
6. Waste

2.2. EU Monitoring Mechanism

In 1999 Council Decision 99/296/EC (26 April 1999) amending Decision 93/389/EEC for a monitoring mechanism on CO_2 and other greenhouse gas emissions was adopted. The original Decision of 1993 was amended to allow for the updating of the monitoring process, in particular regarding the application to all six Kyoto Protocol greenhouse gases (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6), and to monitor greenhouse gas (GHG) emission limitations and reductions also after 2000, taking into account the requirements of the Kyoto Protocol to the UNFCCC for the EU and its Member States.

Under the amended Monitoring Mechanism, the EU Member States are requested to send greenhouse gas inventory data to the Commission by 31 December 1999. The Monitoring Mechanism (Article 3) requires Member States to report emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, as specified in Article 2(2) (which refers to the six greenhouse gases listed in the Kyoto Protocol), in accordance with the methodologies accepted by the IPCC and agreed upon by the Conference of Parties (COP).

According to Article 3.3 ‘The Commission shall establish inventories of emission/removal in the Community and circulate them by 1 March’. The Commission shall also take furthers steps to promote the comparability and transparency of national inventories and reporting *(Art.3.2).*

EEA and ETC/AE assist the European Commission in its tasks regarding inventories. EEA and ETC/AE prepare the annual EU greenhouse gas inventory, and contribute to the annual assessment report on progress towards achieving the EU Kyoto Protocol target, which needs to be prepared by the Commission.

3. Ongoing developments in inventory methodologies

The main inventory methodologies (IPCC 1996 Guidelines) and UNECE (EMEP/CORINAIR Atmospheric Emission Inventory Guidebook, 1999) continue to be improved and refined as new research results and data becomes available. As a result the estimates continue to be improved for example by inclusions of new source sectors and by improving the accuracy of estimates for existing sectors.

Within the IPCC-OECD-IEA Programme on Inventories, to be continued in 1999/2000 by the IPCC Task Force on Inventories, guidance is being developed on *Good Practices* as well as on *Managing Uncertainties (IPCC, 1999).* The guidance document was finalised in 2000. Guidance will include advice on choice of methodology, emission factor, activity data, and uncertainties, and on a series of quality assessment and quality control procedures, which may be applied during the preparation of inventories.

The UNECE Task Force on Emission Inventories and Projections will continue to improve the Guidebook, also taking into account increasing requirements for pollutants not yet regulated within CLRTAP, such as fine particulates ($PM2.5/PM_{10}$). Furthermore it is expected that the results from the IPCC work on good practices and managing uncertainties will be of use also for UNECE/CLRTAP.

These ongoing developments are expected to improve inventories further and reduce the uncertainties, regarding all relevant quality aspects (*consistency, comparability, transparency, completeness).* Section 7 of this report deals with some of the current experiences.

Of particular importance is the need for further work by countries, assisted by EEA, it's ETC/AE and the two convention secretariats, to achieve consistent time series over the full period of relevance (from 1980 onwards for UNECE/CLRTAP and from 1990 onwards for UNFCCC). This can in many cases involve recalculation of (parts of) earlier estimates.

As requirements for reporting of emissions data under CLRTAP and UNFCCC become more detailed, differentiated national databases for different purposes should merge towards a single coordinated database. It is expected that such coordinated national emission databases will improve the quality of the estimates because of the consistent use of the required socio-economic statistics and of other common elements. Also increased cooperation between national organisations responsible for compiling the inventories and the national statistical offices, that are responsible for much of the required socio-economic statistics, is expected to lead to increased quality and timeliness of inventories and indicators.

Annex 2: European Topic Centre on Air Emissions

To assist the EEA, European Topic Centres, funded by the EEA, have been established for a number of topics, such as the European Topic Centre on Air Emissions (ETC/AE). The ETC/AE is led by the German Federal Environmental Agency (UBA) and organisations in seven EU Member States. An important task of the work programme of ETC/AE is to set up an annual European air emission inventory from the year 1990 onwards (Corinair: CORe INventory of AIR emissions), based on official national inventories, including national total emissions and emissions by source sector. The latest emissions data collected by EEA have been published in EEAs main assessment reports, and are also available on the EEA website (http://www.eea.eu.int/).

ETC/AE furthermore assists countries to report their national emission inventories to the various international obligations in a complete, comparable, consistent, transparent and timely way.

In 1998 ETC/AE made available to participating countries a software package (CollectER, Collect Emission Register and ReportER, Report Emission Register), which incorporates SNAP97, to enable countries to report to all EU legislation and other international obligations mentioned above. In addition a software package to estimate national emissions from road transport was made available (COPERT2 and in 1999 the first version of COPERT3). For more information see the relevant EEA Technical Reports (reference list and EEA website).

In 1998 ETC/AE, with EMEP and the UNECE TFEIP, developed the SNAP nomenclature, resulting in SNAP97 as used and presented in the second edition of the Guidebook. SNAP97 covers additional activities that are sources of the heavy metals and persistent organic pollutants and is fully consistent with the IPCC nomenclature.

The EU PHARE Programme provided the necessary funds to make the extension of EIONET to central and eastern European countries possible. In 1998, a consortium of three organisations was contracted by the Commission for a period of two years to form the PTL/AE. PTL/AE is led by ATMOTERM (Poland) and consists of organisations in two other countries (Slovak Republic, Bulgaria).

The PTL/AE work programme was jointly developed with ETC/AE in order to coordinate the common technical tasks and to ensure that ETC/AE and PTL/AE work together as a joint extended European Topic Centre on Air Emissions.

Annex 3: Inventory quality

1. Introduction

The intended use of data and models is relevant for any analysis of the concept of quality and quality criteria. Two major fields of application of air pollution data and models can be discerned (Pulles and Builtjes, 1998; Pulles and Mareckova, 1998):

- For policy purposes:
    - Monitoring of progress of environmental policy;
    - Compliance checking, both of individual polluters with respect to permits and emission standards and of countries in relation to international treaties and protocols;
- For scientific purposes, including the assessment of the effectiveness of abatement strategies.

If data are being used in (inter) national policy making, users will be mainly interested in the acceptance of the data by the different institutions involved in a specific policy process. Users in scientific applications will be very eager to know the quality of the data in terms of the 'true values'. From this we might derive three different perspectives on the concept of data quality in emission inventories. Table 12 summarises these perspectives. The perspective on data quality will also influence the perspective on 'truth' and 'quality' and hence on *verification* and *validation* of emission inventory data and of models. For a more elaborate analysis of these concepts see the chapter on Verification and Validation in the *Joint EMEP /CORINAIR Atmospheric Emission Inventory Guidebook*, Second edition (EEA/UNECE, 1999) and Pulles and Builtjes (1998).

Table 12: Perspectives on data quality depend on the intended user of the data (Pulles et. al., 1998)

	Perspective	High quality if …
'Scientist'	Scientific debate: search for weaknesses and errors; falsification	… It produces predictions that are confirmed
'Policy maker'	Political debate: search for consensus and agreement; compromise	… Everybody involved agrees
'Lawyer'	Judicial debate: search for proof or doubt; persuasion	… It convinces a judge or jury

2. Inventory quality

This section concentrates on the policy perspective of inventory quality. In these perspective important attributes, determining the quality of an inventory, are:

- *Timeliness*: the inventory should be delivered on time, as required in the various reporting obligations (conventions, their protocols; EU legislation). Policy makers cannot wait until all scientific problems have been solved;
- *Transparency*: this concept is used to represent the condition of being clear and free from ambiguity. The term implies that data collected and reported by different organisations can be easily understood by others. This means that

assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory. This attribute also relates to the concept of '*verifiable*', which is used in the Kyoto protocol;

- *Comparability*: in policy applications inventories are often used for comparisons, either between different sources, between different countries or with respect to targets set by conventions (including protocols) or legislation. The important aspect of comparability between countries means that countries should use the agreed formats and methodologies for the particular pollutant or source sector. These could be e.g. either the EMEP/CORINAIR format, the IPCC format or for specific purposes the NACE (socio-economic) format.
- *Consistency*: an inventory is consistent if the same methodologies are used for the base years and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources and sinks.
- *Completeness*. This means that the inventory covers all sources and sinks and all gases and other pollutants, for which reporting is required, using the appropriate agreed formats and methodologies (as also mentioned under '*comparability*')
- *Accuracy*: accuracy is a measure of the true value (exactness) of a measurement or estimate. Estimates should be accurate in the sense that they are systematically neither over or under true emissions or removals, as far as can be judged, and that uncertainties are reduced as far as practicable. Appropriate methodologies conforming to guidance on *good practices* should be used to promote accuracy (such as the IPCC Draft Good Practice Guidance (IPCC, 1999)).

In the policy makers' perspective, inventory quality is not just a mathematical expression of data quality (such as 'accuracy'). The concepts of '*transparency*', '*comparability*', '*consistency*' and '*completeness*' should refer to the guidelines agreed, at a political level, for the relevant convention (including protocols) or legislation. If it can be shown by the compilers and/or reporters of the inventory that such guidelines have been followed, then a high quality inventory, on all of these aspects, is ensured. Detailed inventory quality aspects and requirements for these, as mentioned above, should therefore be dealt with in the reporting guidelines. Currently this is done already to a large extent in the new UNFCCC reporting guidelines, but less so in other reporting guidelines (e.g. CLRTAP). Once these aspects and the related requirements are incorporated in the reporting guidelines and experiences with use of these guidelines has increased, these aspects will be incorporated increasingly into the policy makers' perspective of inventory quality.

3. Why improve inventory quality?

From the point of view of policy makers and the scientific community any emission inventory can be improved. Improving an inventory however might mean different things:

1. From the scientific point of view, this would mean:
    - Proving that the inventory is complete and correct;
    - Decreasing uncertainties in the inventory.

Environmental assessment in most cases makes use of models, ranging from air quality models to global climate models to integrated assessment models. Therefore from the scientific perspective the necessary improvements of emission inventories should be determined by accuracy requirements put on the emission data specifically for the use in such models. However such requirements are not often placed on emission inventories in quantitative terms.

2. From the policy makers' point of view improving an inventory would mean:
   - A further harmonisation of methods and methodologies to increase consistency, comparability and transparency;
   - Improving procedures to ensure timely delivery of the inventory.

In this perspective, inaccuracies in an inventory are less important when all inventories have the same inaccuracy. And even more so: when emission reduction targets have been negotiated and agreed on the basis of inaccurate and/or incomplete information, data to check compliance perhaps should use methodologies with the same inaccuracies.

Form these various perspectives, the issue of uncertainty is dealt with differently amongst scientists and policy makers: scientists will try to decrease the uncertainties, while policy makers will call for management of uncertainties (this last aspect is also reflected in the approach taken by IPCC in developing it's guidance on 'good practice and management of uncertainties').

4. Validation and verification

Whenever an inventory is available, it can either be 'validated' or 'verified' or both. The concepts 'verification' and 'validation' are frequently used in discussing the quality of emission inventories. The EMEP/CORINAIR Guidebook defines the two as follows:

Validation — Validation is the establishment of sound approach and foundation. This *internal checking* of the inventory is meant to ensure that it has been compiled correctly in line with reporting instructions and guidelines and that the calculations are arithmetically correct. The legal use of validation is to give an official confirmation or approval of an act or product.

Verification — The term verification is used to indicate truth or to confirm accuracy and is used to represent the ultimate reliability and credibility of the data reported. This will call for *external checking*, using independent estimates by other organisations, models, measurements, etc.

These definitions are used in this section. They are compatible with the definitions as given in the draft background paper for an expert group meeting within the IPCC/OECD/IEA programme of national greenhouse gas inventories (Eggleston, 1998).

Table 13: Relevance of validation and verification for scientific and policy applications of inventories

	In scientific applications	In policy applications
Validation	Not important for scientific applications but is needed when data or analyses are used in policy applications	Very important: official acceptance is the critical test in the political arena
Verification	Very important: if the scientific applications of the inventory are satisfied then the effort was a success	Important only in a relative sense that data can be repeated and that two data sets can be compared

5. Three levels of inventory quality

In line with the analysis as presented above, there can be three levels of inventory quality:

1. Procedural quality, to be established by applying ‘good practice’ and ‘quality assurance/quality control’ procedures, assuring adequate documentation and error free arithmetic;
2. Consistency, comparability, completeness and transparency, to be established in some kind of interaction between the responsible inventory compiler and the receiving body assuring that the inventory is compiled according to the guidelines and that it is comparable to other countries’ inventories
3. Accuracy (and completeness), to be established in primarily scientific assessments of the inventory involving independent estimates or measurements assuring the ‘truth’ in the values stored in the inventory.

These three levels of inventory quality will be relevant with respect to national inventories in a cyclic way. Scientific knowledge is brought in while defining the guidelines, including the default emission factors. Once guidelines are accepted, good practice and QA/QC procedures can help in compiling the inventories in such a way that application in national and international environmental policy is possible. The international bodies, receiving national inventories, must validate them with respect to consistency, comparability and transparency. Once emission inventories are available, verification studies might be used to check the methods as prescribed in the guidelines and ‘science’ can suggest amendments to the guidelines and the default emission factors therein.

In such a cyclic process, inventory quality can be and is already being improved in an ongoing process. The development of the tools (Guidebooks and software) within the CORINAIR programme of the European Environment Agency might very well contribute to this.

Annex 4: Emission data

1. Introduction

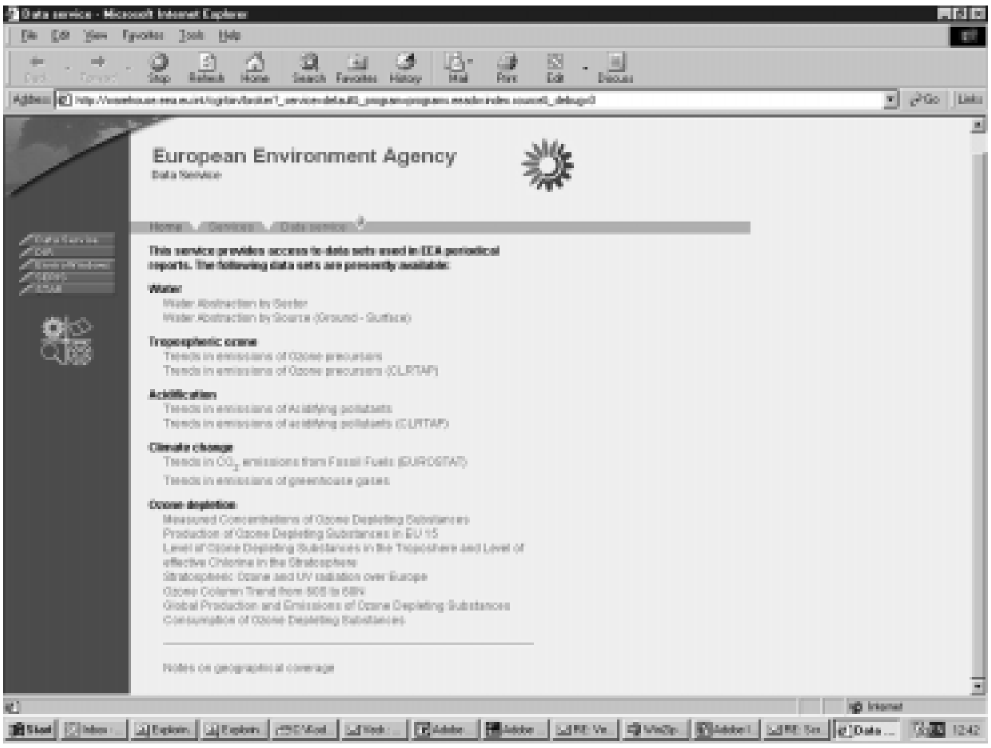
Most emission data used and presented in this report, and in addition more detailed data, are available on the EEA Internet (website) at:
http://www.eea.eu.int/ http://service.eea.eu.int/

Go to:
Data service
Climate change: trends in emissions of greenhouse gases (CO_2, CH_4, N_2O)
Tropospheric ozone: trends in emissions of ozone precursors (CO, NMVOC)
Acidification: trends in emissions of acidifying pollutants (SO_2, NO_x, NH_3)

In all cases the user can make use of various applications by country and pollutant, which the user can select:

- View graphics;
- View tables;
- Download tables (spreadsheets).

Examples from EEAs public Data Service



Notes and footnotes to data tables:

Notes

Data source: ETC-AE (Corinair Database November 1999). In addition: country data, consistent with the EEA report Environmental Signals (EEA, 2000). Furthermore additional data for PHARE Central and Eastern European countries have been used (data collection by PHARE Topic Link Air Emissions, December 1999).

Figures in Red are estimates by the ETC-AE, in order to achieve consistent EU15 time series. This is done either by means of interpolation (for missing data between years with reported data) or by using the data of the latest reported year (for years 1994, 1995 or 1996).

Figures in Blue are data submitted by countries, for the EEA report Environmental Signals (EEA, 2000).

General notes for greenhouse gases:
In the total GHG emissions per country HFCs, PFCs and SF_6 are excluded due to lack of data. However these only account for about 1.3 % of the EU total.
The values for Denmark are not adjusted for imports/exports of electricity for Denmark. The burden-sharing target for Denmark applies to adjusted emission estimates (base year and commitment years) and, if taken into account, will give a 0 % change of total GHG emissions between 1990 and 1996.
Emissions and removals due to land-use change and forestry (LUCF) are excluded in all tables and graphs in this report because of major uncertainty in their estimates.
Global warming potential used (from IPCC, 1996): CO_2 1, CH_4 21 and N_2O 310, SF_6 23900, to give total GWP emissions in (million) tonnes CO_2 equivalent. The other pollutants HFC and PFC are in fact mixture, with different GWP values depending on the circumstances. The UK uses for HFC a GWP of 6000 and for PFC 7370. In this report these factors are used for those countries reporting HFC and PFC emissions only in tonnes and not in tonnes CO_2 equivalent.

General notes for acidifying gases:
Factors used to weigh by their acidification impact (g acid equivalent per g): SO_2 1/32, NO_x 1/46, NH_3 1/17. These are multiplied with the emissions data to give total emissions in acid equivalents.

General notes for ozone precursor gases:
Factors used to weighted by their tropospheric ozone forming potential (TOFP) (g TOFP equivalent per g): NMVOC 1, NO_x 1.22, CH_4 0.014, CO 0.11. These are multiplied with the emissions data to give total emissions in TOFP equivalents.

Footnotes

Footnotes to the tables:

1: No CLRTAP target
2: Data not validated by country (by 6th December 99)
3: N_2O emission is not included
4: Base year is different from 1990. Other base years (than 1990): Hungary (average of 1985-1987),
Bulgaria, Poland (1988), Romania (1989).
5: Sectors as defined in chapter 1 in this report

2. Climate change (emissions of CO_2, CH_4, N_2O, HFC, PFC and SF_6)

2.1. Total greenhouse gases

EU15 Percentage change in total emissions of CO_2, CH_4 and N_2O (global warming potential weighted) since 1990 compared with individual country's Kyoto Protocol (and EU burden sharing) targets

Country	1990 – 1996 (negative = reduction)	1990 to (2008 – 2012) Kyoto target
Luxembourg	-45 %	-28 %
Germany	-11 %	-21 %
United Kingdom	-6 %	-13 %
France	1 %	0 %
Austria	3 %	-13 %
Spain	3 %	15 %
Ireland	5 %	13 %
Italy	6 %	-6 %
Greece	7 %	25 %
Iceland	9 %	10 %
Sweden	11 %	4 %
Finland	11 %	0 %
Belgium	12 %	-8 %
Netherlands	12 %	-6 %
Norway	13 %	1 %
Portugal	7 %	27 %
Denmark	32 %	-21 %
EU15 total	-1 %	-8 %

PHARE countries percentage change in total emissions of CO_2, CH_4 and N_2O (global warming potential weighted) since 1990 and countries base year (where different) compared with individual country's Kyoto Protocol (and EU burden sharing) targets

Country	1990 – 1996 (negative = reduction)	Base – 1996 (negative = reduction)	base year to 2012 Kyoto target
Lithuania [3]	-53 %	-53 %	-8 %
Latvia	-49 %	-49 %	-8 %
Estonia	-43 %	-43 %	-8 %
Bulgaria [4]	-29 %	-36 %	-8 %
Romania [4]	-16 %	-28 %	-8 %
Slovak Republic	-24 %	-24 %	-8 %
Poland [4]	-5 %	-23 %	-6 %
Hungary [4]	-9 %	-22 %	-6 %
Czech Republic	-19 %	-19 %	-8 %

EU member states total emissions of CO_2, CH_4 and N_2O (global warming potential weighted) 1980-1996 and country's Kyoto Protocol (and EU burden sharing) targets (ktonnes of CO_2 equivalents)

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996	Kyoto target 2008-2012
Austria	78934	74483	73727	77971	72040	71158	72798	74155	75665	64143
Belgium	69963	66213	136845	143425	143349	141818	146766	148028	152626	126582
Denmark	83599	81032	70163	80902	75710	77400	80677	77227	92480	55429
Finland	64890	60890	70190	63880	60935	61707	69978	71897	77803	70190
France	653474	538474	545979	570513	556902	532127	531573	538490	549962	545979
Germany	1303083	1269904	1201117	1149679	1094172	1073215	1055410	1053782	1063405	948882
Greece	66519	77519	103886	103597	105219	105708	107203	108549	110874	129858
Iceland	2439	2439	2565	2484	2609	2714	2678	2693	2792	2822
Ireland	56663	56663	56663	56030	56885	56580	58095	59061	59446	64029
Italy	502391	484140	521034	504845	514951	504724	503666	530470	552314	487167
Liechtenstein										
Luxembourg	11148	11148	14114	13323	12532	11742	12661	7745	7805	10162
Netherlands	207798	195124	208946	215132	213048	214560	215473	224203	233348	196409
Norway	46817	46192	47130	45641	45789	47860	50048	50359	53345	47601
Portugal	67972	67972	67972	70727	74691	71883	72840	72839	72839	86324
Spain	286136	287402	301431	301633	310653	301598	313519	325530	311220	346646
Sweden	96024	81024	69467	63103	63957	63940	66390	65916	76893	72246
United Kingdom	750641	711507	726655	727494	704103	678995	675197	664082	683678	635823
EU15 total	**4299234**	**4063494**	**4168190**	**4142254**	**4059147**	**3967153**	**3982247**	**4021973**	**4120357**	**3834962**

PHARE countries total emissions of CO_2, CH_4 and N_2O (global warming potential weighted) 1990-1996 and country's Kyoto Protocol targets (ktonnes of CO_2 equivalents)

	1990	1991	1992	1993	1994	1995	1996	2008-2012 Kyoto target	Change 90-96
Bulgaria [4]	123432	101882	92343	91257	82375	87542	*87542*	125211	-29 %
Czech Republic	189825	175332	161223	154711	147307	148104	153736	174659	-19 %
Estonia	40719	39814	30210	24180	24925	22654	23121	43563	-43 %
Hungary [4]	86528	87922	79058	78979	77169	77843	79132	95522	-9 %
Latvia	35663	29400	25542	22077	19192	19195	18058	32800	-49 %
Lithuania [3]	47472	50190	36560	29655	29970	21479	22185	47440	-53 %
Poland [4]	458950	*449030*	439110	*439041*	438973	*437759*	436545	530429	-5 %
Romania [4]	229196	179764	172080	175644	168219	198294	191863	243686	-16 %
Slovak Republic	72229	63997	58840	55439	52080	54237	55113	66696	-24 %

2.2 CO_2

EEA18 countries CO_2 emissions 1980 – 1996 (ktonnes)

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996
Austria	65000	60000	62042	66440	60531	59535	61068	62427	64026
Belgium	48000	44250	114882	121420	121591	119519	124393	125576	129654
Denmark	63000	61000	52277	62940	57652	59356	63344	59532	73236
Finland	54000	50000	59300	53000	52422	53110	59253	60900	66400
France	503000	388000	395506	419935	410523	390419	389215	395852	408764
Germany	1105000	1076000	1014501	976950	927308	917268	904112	904488	918932
Greece	48000	59000	85367	85057	86989	87436	88742	90293	91956
Ireland	30719	30719	30719	31643	32373	31937	33324	34116	34819
Italy	364000	345000	431169	404000	415000	403000	411902	436975	448495
Luxembourg	10334	10334	13300	12533	11767	11000	11998	7078	7098
Netherlands	167000	150000	161400	166900	165200	167500	168300	177200	186200
Portugal	47123	47123	47123	48869	52998	50255	50841	50841	50841
Spain	226000	220000	226423	227515	234945	226197	237446	247703	228920
Sweden	82000	67000	55443	55218	56207	56183	58438	58108	63352
United Kingdom	603164	567278	584171	588003	573613	559627	556152	547887	566785
EU15 Total	**3416340**	**3175704**	**3333622**	**3320423**	**3259118**	**3192341**	**3218527**	**3258976**	**3339478**
Iceland	2000	2000	2147	2068	2197	2302	2265	2284	2376
Norway	33000	32000	35203	33609	34251	35907	37948	38196	41140

PHARE countries CO_2 emissions 1990 – 1996 (ktonnes)

Country	1990	1991	1992	1993	1994	1995	1996	Change 90-96
Bulgaria [4]	84	66	60	62	60	62	*62*	-26 %
Czech Republic	165	153	140	135	128	129	133	-20 %
Estonia	38	37	28	22	23	21	21	-43 %
Hungary [4]	72	67	61	61	59	60	60	-16 %
Latvia	25	19	16	14	12	12	11	-55 %
Lithuania	40	*42*	*29*	*22*	22	15	16	-59 %
Poland [4]	381	*376*	372	*372*	372	*372*	373	-2 %
Romania [4]	173	136	130	130	123	153	155	-10 %
Slovak Republic	60	53	49	46	43	45	46	-23 %
Phare total	**1037**	**950**	**884**	**865**	**842**	**870**	**877**	**-15 %**

EU15 Total CO_2 emissions by sector[5] 1980 – 1996 (ktonnes)

Sector	1980	1985	1990	1991	1992	1993	1994	1995	1996
Energy			1155291	1143553	1108757	1062573	1062818	1080523	1095790
Industry			787415	769130	743909	712567	736237	742412	727983
Transport			707415	725572	747300	755586	752810	760970	769901
Other			683501	682169	659153	661615	666662	675071	745804
Total	**3416340**	**3175704**	**3333622**	**3320423**	**3259118**	**3192341**	**3218527**	**3258976**	**3339478**
Target 2000 (stabilise at 1990 levels)	3333622	3333622	3333622	3333622	3333622	3333622	3333622	3333622	3333622

2.3 CH_4

EEA18 countries CH_4 emissions 1980 – 1996 (ktonnes)

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996
Austria	438	464	460	448	446	449	451	450	447
Belgium	603	603	603	605	608	619	593	582	592
Denmark	479	452	350	353	358	372	353	355	425
Finland	244	244	244	244	243	247	245	255	270
France	2924	2924	2924	2926	2886	2871	2805	2746	2618
Germany	6117	5918	5571	5013	4654	4267	4022	3900	3573
Greece	439	439	439	440	440	442	451	456	458
Ireland	811	811	811	798	802	805	807	814	800
Italy	2176	2231	2161	2390	2362	2461	2321	2372	2555
Luxembourg	24	24	24	24	24	24	22	22	24
Netherlands	971	1177	1292	1309	1256	1225	1203	1172	1181
Portugal	781	781	781	827	822	819	834	834	834
Spain	1473	1819	2181	2162	2254	2305	2332	2370	2589
Sweden	284	284	284	240	235	235	241	236	261
United Kingdom	3875	3720	3637	3588	3494	3139	2904	2876	2814
EU15 Total	**21639**	**21892**	**21763**	**21366**	**20885**	**20281**	**19584**	**19442**	**19441**
Iceland	15	15	14	14	14	14	14	14	14
Norway	407	425	317	322	328	333	340	343	345

PHARE countries CH_4 emissions 1990 – 1996 (ktonnes)

Country	1990	1991	1992	1993	1994	1995	1996	Change 90-96
Bulgaria [4]	1420	1358	1250	1117	826	901	901	-37 %
Czech Republic	778	711	668	633	613	599	573	-26 %
Estonia	105	102	91	80	80	68	63	-40 %
Hungary [4]	545	914	809	792	776	789	813	49 %
Latvia	186	183	150	105	98	101	93	-50 %
Lithuania	378	*390*	*360*	*355*	*370*	299	285	-25 %
Poland [4]	2801	*2638*	*2474*	*2471*	2467	2360	2252	-20 %
Romania [4]	1976	*1734*	1661	*1626*	1534	*1531*	1527	-23 %
Slovak Republic	396	372	348	319	304	309	314	-21 %

EU15 CH_4 emissions by sector[5] 1990 – 1996 (ktonnes)

Sector	1980	1985	1990	1991	1992	1993	1994	1995	1996
agriculture			9222	9155	8992	8983	8751	8726	8767
energy			51	53	54	55	57	61	63
industry			80	79	80	78	76	80	78
transport			245	234	229	221	213	213	208
other			12166	11845	11531	10944	10487	10361	10324
Total (EU15)	**21639**	**21892**	**21763**	**21366**	**20885**	**20281**	**19584**	**19442**	**19441**

2.4 N_2O

EEA18 countries N_2O emissions 1990 – 1996 (ktonnes)

Country	1990	1991	1992	1993	1994	1995	1996
Austria	7	7	7	7	7	7	7
Belgium	30	30	29	30	32	33	34
Denmark	34	34	34	33	32	33	33
Finland	19	19	11	11	18	18	19
France	287	288	277	263	269	274	278
Germany	225	218	223	214	216	217	224
Greece	30	30	29	29	29	28	30
Ireland	29	25	25	25	25	25	25
Italy	143	163	162	161	139	141	162
Luxembourg	1	1	1	1	1	1	1
Netherlands	66	67	69	69	71	72	72
Portugal	14	15	14	14	14	14	14
Spain	94	93	92	87	87	90	90
Sweden	26	9	9	9	9	9	26
United Kingdom	213	207	184	172	187	180	186
EU15 Total	**1218**	**1204**	**1166**	**1126**	**1137**	**1144**	**1202**
Iceland	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Norway	17	17	15	16	16	16	16

PHARE countries N_2O emissions 1990 – 1996 (ktonnes)

Country	1990	1991	1992	1993	1994	1995	1996	Change 90-96
Bulgaria [4]	30	23	19	17	18	21	*21*	-31 %
Czech Republic	26	23	23	21	22	22	29	13 %
Estonia	2	2	2	2	1	1	1	-48 %
Hungary [4]	11	4	5	5	5	5	5	-54 %
Latvia	23	20	19	17	17	16	16	-28 %
Poland [4]	63	*56*	50	*50*	50	*52*	54	-14 %
Romania [4]	49	25	25	36	41	41	16	-67 %
Slovak Republic	13	11	9	7	7	8	8	-38 %

EU15 N_2O emissions by sector[5] 1990 – 1996 (ktonnes)

Sector	1990	1991	1992	1993	1994	1995	1996
Energy	666	669	654	641	628	630	636
Industry	64	64	63	61	61	65	66
Transport	390	381	362	330	347	344	353
Agriculture	41	44	47	52	56	60	66
Other	58	46	39	42	45	45	81
Total (EU15)	**1218**	**1204**	**1166**	**1126**	**1137**	**1144**	**1202**

2.5 Fluorocarbon gases (HFC, PFC and SF_6)

EU15 Member States reported emissions of HFC, PFC and SF_6 (ktonnes), 1995

Country	HFC	PFC	SF6
Austria	0.42	0.00	0.04
Germany	2.03	0.25	0.26
Denmark	0.75	0.00	0.02
Finland	0.11		0.00
France	0.80	0.19	0.10
United Kingdom	1.96	0.16	0.05
Italy	0.70	0.01	0.01
Netherlands	0.80	0.31	0.06
Sweden	0.15	0.06	0.05

EU15 Member Sstates GWP emissions of HFC, PFC and SF_6 (CO_2 Equivalents tonnes), 1995

Country	HFC	PFC	SF6
Austria	2526	14	846
Germany	4164	1703	6295
Denmark	4500	15	406
Finland	660	0	96
France	4821	1377	2370
United Kingdom	11735	1156	1134
Italy	4173	86	344
Netherlands	4787	2269	1458
Sweden	900	442	1195

Other estimates of EU15 fluorocarbon emissions (Mtonnes CO_2 equivalent)

	Ecofys (1998)	March Consulting Group (1998)
HFC	37	41
PFC	7	
SF_6	14	

3. Acidification (emissions of SO_2, NO_x and NH_3)

3.1. Total acidifying gases

EU15 total emissions of acidifying gases (SO_2, NO_x and NH_3 in acid equivalents) and GDP since 1980 compared with targets

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996
EU15	**1332**	**1117**	**1011**	**952**	**902**	**854**	**809**	**777**	**736**
SO_2	834	628	514	465	427	391	355	329	293
NO_x	285	273	287	285	278	267	258	253	246
NH_3	213	216	210	202	197	197	196	195	196
GDP (billion US$)	4133	4437	5193	5368	5419	5388	5546	5684	5782
Proposed NECD Target 2010	409	409	409	409	409	409	409	409	409
2010 CLRTAP Protocol Target Dec. 1999	455	455	455	455	455	455	455	455	455

EU15 Member States percentage change in Member State's total emissions of SO_2, NO_x and NH_3 (acid equivalents) since 1990 compared with Member State's targets

Country	1990 – 1996 (Negative = reduction)	1990 – 2010 Proposed NECD target	1990 – 2010 CLRTAP Protocol Dec. 1999
Germany	-53 %	-77 %	-73 %
United Kingdom	-35 %	-71 %	-68 %
Finland	-33 %	-47 %	-45 %
Netherlands	-27 %	-60 %	-53 %
Luxembourg	-18 %	-51 %	-44 %
Austria	-17 %	-38 %	-36 %
Spain	-14 %	-48 %	-46 %
France	-13 %	-47 %	-36 %
Italy	-12 %	-49 %	-49 %
Belgium	-12 %	-63 %	-50 %
Sweden	-10 %	-41 %	-38 %
Denmark	-6 %	-51 %	-55 %
Ireland	-5 %	-39 %	-38 %
Greece	6 %	-8 %	-3 %
Portugal	7 %	-53 %	-30 %
EU15 Total	**-27 %**	**-60 %**	**-55 %**

EU15 Member State total emissions of SO_2, NO_x and NH_3 (acid equivalents) since 1980 compared with Member State's targets (ktonnes acid equivalents)

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996	2010 Draft NECD	2010 CLRTAP Protocol Target Dec. 1999
Austria	22	16	12	11	10	10	10	10	10	7	7
Belgium	41	25	23	23	23	22	21	21	20	8	12
Denmark	28	25	19	21	19	18	17	17	18	9	9
Finland	27	20	17	14	13	12	12	11	11	9	9
France	185	122	121	126	118	111	109	107	106	64	77
Germany	356	363	270	219	192	178	160	148	127	62	73
Greece	25	29	30	31	31	31	31	31	31	27	29
Ireland	16	14	15	16	15	15	15	15	15	9	10
Italy	181	123	121	118	113	111	106	109	107	62	62
Luxembourg	2	1	1	1	1	1	1	1	1	1	1
Netherlands	42	35	32	31	28	28	25	24	23	13	15
Portugal	16	14	25	25	27	25	24	26	26	11	17
Spain	137	120	117	117	117	111	113	108	101	61	63
Sweden	27	21	14	13	13	13	13	13	13	8	9
United Kingdom	226	189	194	186	182	168	152	138	126	57	63
EU15	**1332**	**1117**	**1011**	**952**	**902**	**854**	**809**	**777**	**736**	**409**	**455**

3.2. SO_2

EU15 Member States percentage change in national SO_2 emissions (1990-1996) compared with targets

Country	1990 – 1996 (Negative = reduction)	1990 – 2010 Proposed NECD target	1990 – 2010 CLRTAP Protocol Dec. 1999
Germany	-71 %	-91 %	-90 %
Finland	-60 %	-55 %	-55 %
Luxembourg	-47 %	-80 %	-73 %
United Kingdom	-46 %	-87 %	-83 %
Austria	-43 %	-56 %	-57 %
Sweden	-34 %	-44 %	-44 %
Netherlands	-33 %	-75 %	-75 %
Spain	-26 %	-67 %	-66 %
Belgium	-25 %	-76 %	-67 %
France	-24 %	-83 %	-68 %
Italy	-20 %	-66 %	-70 %
Ireland	-17 %	-84 %	-76 %
Denmark	-1 %	-58 %	-70 %
Portugal	3 %	-61 %	-53 %
Greece	7 %	7 %	7 %
EU15 Total	**-43 %**	**-78 %**	**-75 %**

PHARE countries percentage change in national SO_2 emissions (1990-1996) compared with targets

Country	1990 – 1996 (Negative = reduction)	1990 – 2010 CLRTAP target Dec. 1999
Slovak Republic	-58 %	-80 %
Lithuania	-58 %	-35 %
Latvia	-50 %	-10 %
Estonia [1]	-50 %	
Czech Republic	-50 %	-85 %
Slovenia	-42 %	-86 %
Hungary	-36 %	-46 %
Romania [2]	-32 %	-30 %
Bulgaria	-30 %	-57 %
Poland	-26 %	-56 %

EEA18 countries SO_2 emissions 1980 – 1996, compared with 2010 targets (ktonnes)

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996	2010 Draft NECD	2010 CLRTAP Protocol Dec. 1999
Austria	400	195	91	83	63	60	56	52	52	40	39
Belgium	828	400	322	326	310	289	251	243	242	76	106
Denmark	450	339	182	243	190	156	155	150	181	77	55
Finland	584	382	260	194	141	124	112	96	105	116	116
France	3338	1470	1250	1369	1201	1061	1009	958	947	218	400
Germany	7514	7732	5321	3996	3307	2945	2473	2118	1543	463	550
Greece	400	500	509	552	554	550	531	553	543	546	546
Ireland	222	140	178	179	161	157	177	161	147	28	42
Italy	3757	1901	1650	1539	1394	1333	1272	1322	1322	566	500
Luxembourg	24	17	15	15	14	14	13	9	8	3	4
Netherlands	490	258	202	173	172	164	146	147	135	50	50
Portugal	266	198	362	352	420	356	336	373	373	141	170
Spain	3072	2574	2266	2223	2195	2060	2065	1927	1685	746	774
Sweden	491	266	119	96	88	87	82	79	78	67	67
United Kingdom	4862	3729	3731	3548	3459	3143	2687	2351	2025	496	625
EU15 Total	**26698**	**20101**	**16459**	**14887**	**13670**	**12498**	**11365**	**10539**	**9386**	**3633**	**4044**
Iceland	18	18	24	23	24	25	24	24	24		
Liechtenstein	0.4	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1		
Norway	137	98	53	44	36	35	34	34	33		

PHARE countries SO_2 emissions 1990-1996, compared with 2010 targets (ktonnes)

Country	1990	1991	1992	1993	1994	1995	1996	2010 Target	Change 90-96
Bulgaria	2020	1677	1128	1426	1480	1497	1420	856	-30 %
Czech Republic	1876	1776	1538	1419	1270	1091	946	283	-50 %
Estonia [1]	252	246	187	154	149	118	125	-	-50 %
Hungary	1010	821	709	692	691	660	651	550	-36 %
Latvia	119	90	79	73	86	59	59	107	-50 %
Lithuania	222	234	139	125	117	94	93	145	-58 %
Poland	3210	2995	2820	2725	2605	2376	2368	1397	-26 %
Romania [2]	1311	1041	951	928	912	*912*	*912*	918	-30 %
Slovenia	194	181	190	183	177	124	112	27	-42 %
Slovak Republic	543	445	380	325	239	239	227	110	-58 %

EU15 SO_2 emissions by sector[5] 1980 – 1996 (ktonnes)

Sector	1980	1985	1990	1991	1992	1993	1994	1995	1996
Energy			10213	9550	8904	8060	7296	6775	5873
Industry			3430	3070	2788	2537	2249	2058	1851
Transport			695	693	647	693	701	636	553
Other			2122	1575	1331	1208	1119	1071	1109
Total	26698	20101	16459	14887	13670	12498	11365	10539	9386
Target 2000	10698	10698	10698	10698	10698	10698	10698	10698	10698
Proposed NECD Target 2010	3633	3633	3633	3633	3633	3633	3633	3633	3633
CLRTAP Protocol target for 2010 (Dec 99)	4044	4044	4044	4044	4044	4044	4044	4044	4044

3.3. NO_x

EU15 Member States percentage change in national NO_x emissions (1990-1996) compared with targets

Country	1990 – 1996 (Negative = reduction)	1990 – 2010 Proposed NECD target	1990 – 2010 CLRTAP Protocol Dec. 1999
Germany	-30 %	-61 %	-60 %
United Kingdom	-25 %	-56 %	-56 %
Austria	-17 %	-53 %	-45 %
Netherlands	-14 %	-58 %	-53 %
Sweden	-10 %	-55 %	-56 %
France	-10 %	-64 %	-54 %
Finland	-9 %	-48 %	-42 %
Italy	-9 %	-55 %	-49 %
Luxembourg	-5 %	-65 %	-52 %
Spain	1 %	-34 %	-29 %
Belgium	3 %	-60 %	-44 %
Denmark	4 %	-55 %	-55 %
Ireland	6 %	-49 %	-43 %
Greece	9 %	-23 %	0 %
Portugal	18 %	-58 %	-25 %
EU15 Total	**-14 %**	**-55 %**	**-50 %**

PHARE countries percentage change in national NO_x emissions (1990-1996) compared with targets

Country	1990 – 1996 (negative = reduction)	1990 – 2010 CLRTAP target Dec. 1999
Latvia	-62 %	-10 %
Lithuania	-59 %	-30 %
Slovak Republic	-42 %	-42 %
Czech Republic	-42 %	-61 %
Romania	-42 %	-20 %
Estonia [1]	-34 %	
Bulgaria	-28 %	-26 %
Hungary	-18 %	-17 %
Poland	-10 %	-31 %
Slovenia	13 %	-27 %

EEA18 countries NO_x emissions 1980 – 1996, compared with 2010 targets (ktonnes)

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996	2010 Draft NECD	2010 CLRTAP Protocol Target Dec. 1999
Austria	231	220	194	198	188	175	183	170	161	91	107
Belgium	442	325	321	332	343	338	340	339	330	127	181
Denmark	282	301	280	320	274	274	272	253	291	127	127
Finland	295	275	295	290	283	282	282	259	267	152	170
France	1823	1615	1879	1941	1876	1773	1745	1726	1695	679	860
Germany	3334	3276	2709	2501	2311	2198	2042	2007	1887	1051	1081
Greece	306	306	343	353	352	349	358	358	374	264	344
Ireland	73	91	115	120	128	116	116	113	121	59	65
Italy	1638	1614	1945	1984	2010	1990	1795	1853	1768	869	1000
Luxembourg	23	21	23	23	23	23	22	20	22	8	11
Netherlands	583	589	563	551	539	519	493	497	486	238	266
Portugal	96	96	346	362	383	371	379	407	407	144	260
Spain	1068	973	1188	1240	1256	1228	1269	1249	1203	781	847
Sweden	404	426	336	337	328	323	330	309	301	152	148
United Kingdom	2502	2419	2673	2571	2497	2333	2242	2093	2018	1181	1181
EU15 Total	**13100**	**12547**	**13210**	**13122**	**12791**	**12292**	**11868**	**11654**	**11332**	**5923**	**6648**
Iceland	73	23	26	27	28	29	29	28	30		
Liechtenstein	1	1	1	1	1	1	1	1	1		
Norway	177	210	227	225	216	225	222	222	222		

PHARE countries NO_x emissions 1990-1996, compared with 2010 targets (ktonnes)

Country	1990	1991	1992	1993	1994	1995	1996	2010 Target	Change 90-96
Bulgaria	361	266	239	242	230	266	259	266	-28 %
Czech Republic	742	725	698	574	435	412	432	286	-42 %
Estonia [1]	68	63	39	38	41	42	44	-	-34 %
Hungary	238	203	183	184	188	190	196	198	-18 %
Latvia	93	61	53	46	48	42	35	84	-62 %
Lithuania	158	166	98	78	77	65	65	110	-59 %
Poland	1280	1205	1130	1120	1105	1120	1154	879	-10 %
Romania [2]	546	464	357	318	319	*319*	*319*	437	-42 %
Slovenia	62	54	55	61	66	67	70	45	13 %
Slovak Republic	225	204	190	183	173	181	130	130	-42 %

EU15 NO_x emissions by sector[5] 1980 – 1996 (ktonnes)

Sector	1980	1985	1990	1991	1992	1993	1994	1995	1996
Energy			2941	2809	2658	2405	2294	2243	2220
Industry			1794	1728	1647	1561	1578	1571	1595
Transport			7080	7246	7260	7038	6660	6517	6255
Other			1395	1339	1226	1289	1337	1323	1262
Total	**13100**	**12547**	**13210**	**13122**	**12791**	**12292**	**11868**	**11654**	**11332**
Target 2000	9008	9008	9008	9008	9008	9008	9008	9008	9008
Proposed NECD Target 2010	5923	5923	5923	5923	5923	5923	5923	5923	5923
CLRTAP Protocol target for 2010 (Dec 99)	6648	6648	6648	6648	6648	6648	6648	6648	6648

3.4. NH3

EU15 Member States percentage change in national NH_3 emissions (1990-1996) compared with targets

Country	1990 – 1996 (Negative = reduction)	1990 – 2010 Proposed NECD target	1990 – 2010 CLRTAP Protocol Dec. 1999
Netherlands	-35 %	-54 %	-43 %
Denmark	-19 %	-42 %	-43 %
Germany	-15 %	-46 %	-28 %
Belgium	-7 %	-45 %	-29 %
France	-5 %	3 %	11 %
United Kingdom	-4 %	-21 %	-11 %
Italy	-1 %	-8 %	-10 %
Portugal	-1 %	-32 %	10 %
Austria	0 %	-12 %	-13 %
Finland	0 %	-11 %	-11 %
Greece	0 %	-31 %	-32 %
Luxembourg	0 %	0 %	0 %
Ireland	2 %	-2 %	-8 %
Spain	8 %	0 %	0 %
Sweden	20 %	-6 %	14 %
EU15 Total	**-7 %**	**-21 %**	**-12 %**

PHARE countries percentage change in national NH_3 emissions (1990-1996) compared with targets

Country	1990 – 1996 (negative = reduction)	1990 – 2010 CLRTAP target Dec. 1999
Estonia [1]	-78 %	
Latvia	-62 %	0 %
Lithuania	-57 %	0 %
Czech Republic	-48 %	-35 %
Slovak Republic	-47 %	-37 %
Bulgaria	-42 %	-25 %
Poland	-27 %	-8 %
Romania	-26 %	-30 %
Hungary	-12 %	1 %
Slovenia	-8 %	-17 %

EEA18 countries NH_3 emissions 1980 – 1996, compared with 2010 targets (ktonnes)

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996	2010 Draft NECD	2010 CLRTAP Protocol Target Dec. 1999
Austria	80	82	76	73	74	75	78	78	76	67	66
Belgium	89	89	104	93	92	97	96	97	97	57	74
Denmark	141	126	122	110	114	119	113	114	99	71	69
Finland	35	35	35	35	35	35	35	35	35	31	31
France	700	700	700	690	676	666	668	668	668	718	780
Germany	835	857	764	676	655	646	650	646	649	413	550
Greece	107	107	107	107	107	107	107	107	107	74	73
Ireland	126	126	126	126	126	126	123	124	128	123	116
Italy	479	487	466	451	440	449	459	461	461	430	419
Luxembourg	7	7	7	7	7	7	7	7	7	7	7
Netherlands	234	248	226	228	180	191	166	146	146	104	128
Portugal	98	98	98	98	96	94	94	97	97	67	108
Spain	299	317	353	354	352	344	352	348	381	353	353
Sweden	54	54	51	51	61	61	61	61	61	48	58
United Kingdom	333	333	333	331	328	326	324	321	319	264	297
EU15 Total	**3617**	**3666**	**3568**	**3430**	**3343**	**3343**	**3333**	**3310**	**3331**	**2827**	**3129**
Iceland	3	3	3	3	3	3	3	3	3		
Norway	22	23	23	24	25	25	25	26	26		

PHARE countries NH_3 emissions 1990-1996, compared with 2010 targets (ktonnes)

Country	1990	1991	1992	1993	1994	1995	1996	2010 Target	Change 90-96
Bulgaria	144	124	111	109	101	99	83	108	-42 %
Czech Republic	156	134	115	99	91	86	81	101	-48 %
Estonia [1]	1	1	1	0	0	0	0	-	-78 %
Hungary	89	83	67	61	85	74	78	90	-12 %
Latvia	44	42	33	20	17	17	*17*	44	-62 %
Lithuania	84	85	81	80	80	38	36	84	-57 %
Poland	508	450	342	382	384	380	370	468	-27 %
Romania [2]	300	267	255	223	221	*221*	*221*	210	-26 %
Slovenia	24	*24*	*23*	*23*	22	22	22	20	-8 %
Slovak Republic	62	47	38	33	32	33	33	39	-47 %

EU15 NH_3 emissions by sector[5] 1980 – 1996 (ktonnes)

Sector	1980	1985	1990	1991	1992	1993	1994	1995	1996
Energy			3071	3061	2999	3013	3005	2985	2996
Industry			8	8	7	7	7	8	8
Transport			119	111	111	106	104	107	100
Other			23	24	26	32	38	54	66
			347	225	200	185	179	157	161
Total	**3617**	**3666**	**3568**	**3430**	**3343**	**3343**	**3333**	**3310**	**3331**
Proposed NECD Target 2010	2827	2827	2827	2827	2827	2827	2827	2827	2827
CLRTAP Protocol target for 2010 (Dec 99)	3129	3129	3129	3129	3129	3129	3129	3129	3129

4. Tropospheric ozone (emissions of NO_x, NMVOC, CO and CH_4)

4.1. Total ozone precursor gases

EU15 total emissions of ozone forming gases (NO_x and NMVOC, in tropospheric ozone forming potential or TOFP) and GDP since 1980 compared with targets

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996
NO_x	15982	15308	16116	16009	15605	14997	14479	14217	13825
NMVOC	15056	14947	15807	15408	14981	14473	14215	13748	13347
CO	5829	5486	5634	5431	5151	4926	4772	4643	4506
CH_4	303	306	305	299	292	284	274	272	272
GDP (Billion US$)	4133	4437	5193	5368	5419	5388	5546	5684	5782
EU 15	**37170**	**36047**	**37861**	**37147**	**36030**	**34680**	**33741**	**32880**	**31950**
EU15 (NO_x+VOC)	**31038**	**30255**	**31923**	**31417**	**30586**	**29470**	**28694**	**27965**	**27172**
Proposed 2010 NECD only NO_x+VOC	12807	12807	12807	12807	12807	12807	12807	12807	12807
Draft 2010 CLRTAP only NO_x+VOC	14711	14711	14711	14711	14711	14711	14711	14711	14711

EU15 Member State percentage change of total emissions of ozone forming gases (NO_x and NMVOC in tropospheric ozone forming potential or TOFP) since 1990 compared with targets

Country	1990 – 1996 (Negative = reduction)	1990 – 2010 Proposed NECD target	1990 – 2010 CLRTAP Protocol Dec. 1999
Germany	-36 %	-66 %	-64 %
Austria	-22 %	-59 %	-51 %
United Kingdom	-22 %	-60 %	-56 %
Ireland	-22 %	-60 %	-58 %
Netherlands	-20 %	-62 %	-57 %
France	-13 %	-63 %	-55 %
Finland	-12 %	-48 %	-41 %
Sweden	-11 %	-56 %	-54 %
Luxembourg	-6 %	-67 %	-52 %
Denmark	-5 %	-54 %	-54 %
Belgium	-3 %	-66 %	-51 %
Italy	-1 %	-56 %	-48 %
Spain	1 %	-52 %	-49 %
Greece	11 %	-34 %	-9 %
Portugal	12 %	-74 %	-51 %
EU15 Total	**-15 %**	**-60 %**	**-54 %**

EU15 Member State total emissions of ozone forming gases (NO_x and NMVOC) since 1980 compared with Member State's 2010 targets (ktonnes NMVOC equivalent)

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996	2010 Draft NECD (NO_x + NMVOC)	2010 CLRTAP Protocol Target Dec. 1999 (NO_x + NMVOC)
Austria	829	804	735	709	662	631	628	594	575	240	290
Belgium	1294	1151	844	858	877	862	875	859	849	257	365
Denmark	629	665	612	659	594	580	580	553	568	240	240
Finland	646	616	626	618	600	590	587	553	550	295	337
France	5683	5339	6002	6063	5867	5585	5414	5312	5125	1760	2149
Germany	8922	8604	7812	6949	6338	5895	5492	5241	4968	2206	2314
Greece	682	682	897	918	913	917	936	944	983	495	681
Ireland	345	367	378	379	389	360	363	357	296	127	134
Italy	5043	4838	5492	5623	5676	5637	5410	5521	5414	2022	2379
Luxembourg	67	64	66	67	66	64	62	54	56	16	22
Netherlands	1379	1389	1330	1264	1218	1157	1106	1093	1066	446	516
Portugal	439	439	1211	1248	1300	1294	1325	1345	1345	278	519
Spain	3528	3440	3914	4051	4072	4030	4091	3977	3884	1615	1702
Sweden	1185	1212	1063	1064	1019	1006	1009	957	948	404	422
United Kingdom	6501	6436	6877	6677	6439	6072	5863	5519	5324	2405	2641
EU15 Total	**37170**	**36047**	**37861**	**37147**	**36030**	**34680**	**33741**	**32880**	**31950**	**12807**	**14711**
Iceland	102	41	51	54	56	56	57	53	54		
Norway	500	594	697	687	695	720	729	737	735		

4.2. NMVOC

EU15 Member State percentage change in national NMVOC emissions (1990-1996) compared with 2010 targets

Country	1990 – 1996 (Negative = reduction)	1990 – 2010 Proposed NECD target	1990 – 2010 CLRTAP Protocol Dec. 1999
Ireland	-43 %	-69 %	-69 %
Germany	-41 %	-71 %	-69 %
Netherlands	-28 %	-69 %	-62 %
Austria	-26 %	-63 %	-55 %
Denmark	-22 %	-53 %	-53 %
United Kingdom	-19 %	-65 %	-56 %
Finland	-17 %	-47 %	-38 %
France	-16 %	-62 %	-55 %
Sweden	-11 %	-58 %	-53 %
Belgium	-9 %	-72 %	-60 %
Luxembourg	-8 %	-68 %	-53 %
Spain	0 %	-65 %	-65 %
Italy	7 %	-57 %	-48 %
Portugal	8 %	-84 %	-68 %
Greece	13 %	-47 %	-20 %
EU15 Total	**-16 %**	**-65 %**	**-58 %**

PHARE countries NMVOC emissions 1990-1996, compared with 2010 targets (ktonnes)

Country	1990 – 1996 (negative = reduction)	1990 – 2010 CLRTAP target Dec. 1999
Latvia	-72 %	-11 %
Estonia [1]	-43 %	
Czech Republic	-35 %	-49 %
Bulgaria	-32 %	-15 %
Slovak Republic	-30 %	-6 %
Lithuania	-29 %	-17 %
Hungary	-27 %	-18 %
Romania	-18 %	-15 %
Poland	-8 %	-4 %
Slovenia	17 %	-5 %

EEA18 countries NMVOC emissions 1980 – 1996, compared with 2010 targets (ktonnes)

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996	2010 Draft NECD	2010 CLRTAP Protocol Target Dec. 1999
Austria	355	361	350	323	296	284	273	269	260	129	159
Belgium	660	660	358	355	354	345	336	324	324	102	144
Denmark	203	209	179	176	170	161	166	162	139	85	85
Finland	210	210	209	204	200	195	191	186	173	110	130
France	2404	2404	2469	2466	2407	2306	2221	2156	2075	932	1100
Germany	3224	3190	3195	2781	2535	2306	2169	1981	1877	924	995
Greece	155	155	328	333	336	343	352	357	371	173	261
Ireland	197	197	180	178	179	171	174	175	103	55	55
Italy	2179	1992	2221	2293	2338	2344	2354	2371	2368	962	1159
Luxembourg	17	17	19	20	20	19	18	17	17	6	9
Netherlands	502	502	500	460	436	403	388	370	359	156	191
Portugal	199	199	640	652	668	672	690	691	691	102	202
Spain	1682	1705	1909	1973	1980	1970	1991	1937	1911	662	669
Sweden	555	555	516	517	485	483	478	457	458	219	241
United Kingdom	2514	2591	2733	2678	2576	2471	2413	2295	2221	964	1200
EU15 Total	**15056**	**14947**	**15807**	**15408**	**14981**	**14473**	**14215**	**13748**	**13347**	**5581**	**6600**
Iceland	8	8	13	14	14	14	14	12	12		
Liechtenstein	1	2	2	1	1	1	1	1	1		
Norway	180	234	310	309	331	347	358	370	368		

PHARE countries NMVOC emissions 1990-1996, compared with 2010 targets (ktonnes)

Country	1990	1991	1992	1993	1994	1995	1996	2010 Target	Change 90-96
Bulgaria	217	178	179	208	175	173	147	185	-32 %
Czech Republic	435	398	359	338	310	286	284	220	-35 %
Estonia [1]	88	82	45	42	45	47	50	-	-43 %
Hungary	167	151	144	142	163	183	189	137	13 %
Latvia	152	97	63	98	101	70	42	136	-72 %
Lithuania	111	114	68	54	54	75	79	92	-29 %
Poland	831	833	805	756	819	769	766	800	-8 %
Romania [2]	616	522	497	502	505	*505*	*505*	523	-18 %
Slovenia	42	*42*	*42*	*42*	42	44	49	40	17 %
Slovak Republic	149	*140*	*131*	122	115	*107*	104	140	-30 %

EU15 NMVOC emissions by sector[5] 1980 – 1996 (ktonnes)

Sector	1980	1985	1990	1991	1992	1993	1994	1995	1996
Energy			6287	6081	5874	5591	5207	5047	4785
Industry			966	950	947	910	868	910	907
Transport			97	101	101	100	101	102	103
Other			8456	8276	8057	7872	8039	7689	7552
Total	15056	14947	15807	15408	14981	14473	14215	13748	13347
Target 2000	10905	10905	10905	10905	10905	10905	10905	10905	10905
Proposed NECD Target 2010	5581	5581	5581	5581	5581	5581	5581	5581	5581
CLRTAP Protocol target for 2010 (Dec 99)	6600	6600	6600	6600	6600	6600	6600	6600	6600

4.3. CO

EEA18 countries CO emissions 1980 – 1996, compared with 2010 targets (ktonnes)

Country	1980	1985	1990	1991	1992	1993	1994	1995	1996
Austria	1690	1529	1286	1266	1185	1158	1130	1013	1020
Belgium	784	784	784	818	873	872	1052	1028	1035
Denmark	681	754	785	800	770	725	704	702	616
Finland	660	608	487	512	467	432	443	434	430
France	9216	8399	10903	10797	10281	9778	9320	9199	8591
Germany	14046	12134	11219	9514	8351	7703	7054	6885	6717
Greece	1338	1338	1311	1346	1288	1288	1278	1307	1357
Ireland	429	429	429	402	387	327	330	302	307
Italy	7588	7692	7894	7961	7755	7549	7573	7787	7755
Luxembourg	192	192	171	168	160	152	145	104	102
Netherlands	1381	1381	1139	1022	966	949	905	909	886
Portugal	1020	1020	1254	1300	1396	1435	1462	1326	1326
Spain	4752	4752	4778	4866	4801	4813	4719	4393	4267
Sweden	1210	1210	1211	1212	1176	1148	1142	1089	1082
United Kingdom	8008	7649	7566	7386	6972	6457	6126	5727	5475
EU15 Total	**52995**	**49871**	**51218**	**49371**	**46829**	**44785**	**43383**	**42205**	**40966**
Iceland	44	46	58	59	61	60	60	55	50
Norway	896	886	961	901	870	853	864	829	829

EU15 CO emissions by sector[5] 1980 – 1996 (ktonnes)

Sector	1980	1985	1990	1991	1992	1993	1994	1995	1996
Agriculture			900	898	777	601	602	550	653
Energy			480	473	461	448	429	438	428
Industry			6914	6257	6078	5883	6456	6553	6181
Transport			33265	32810	31537	30022	27724	26817	25622
Other			9659	8933	7976	7831	8173	7847	8082
Total	**52995**	**49871**	**51218**	**49371**	**46829**	**44785**	**43383**	**42205**	**40966**