Environmental signals 2000

European Environment Agency
regular indicator report

European Environment Agency

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Foreword

This first edition of *Environmental signals* marks the beginning of a new period in reporting on the environment for policy-makers and the public by the European Environment Agency. Previous reports such as *Europe's environment: the second assessment* and *Environment in the European Union at the turn of the century* are comprehensive documents containing detailed information to support the development of strategic, long-term environmental policies and to provide general public information. The EEA will continue to produce these comprehensive 'state and outlook' reports; the next edition is planned for 2003/2004. In between, the EEA will issue regular indicator-based reports, which we have called *Environmental signals*. The Environmental signals 2000-edition contains data up to 1997 and in a few cases 1998, which clearly reveals relevant trends. It is expected that establishing a regular reporting routine will improve the actuality of the data and the capacities for delivering short-term environmental outlooks, in order to better describe today's situation.

Why 'Environmental signals'? The indicator-based assessments in this annual series will provide signals on progress in implementing environmental policies and integrating them with other policies (connected to annual economic and social indicators of progress). The signals will be positive and negative – reflecting progress towards or counter to the aims of current environmental policies.

Although I would have preferred it, this report does not contain only positive signals. Negative trends are also apparent: in the increase in waste generated, in energy consumption and recently in the intensity of pesticide use. In addition, a number of indicators are developing in a positive direction but too slowly to reach policy targets before the agreed date (e.g. greenhouse gas emissions and air quality) or to prevent major harm to the environment (e.g. water abstraction).

In my opinion, these negative trends can be attributed to the slow integration of the environment in sectoral policies. Current developments in some sectors – notably transport, tourism and agriculture – do not match the sectors' environmental requirements, for example as regards land use and territorial development. This prevents them from developing along a more sustainable path.

The difficulties encountered in the integration process demonstrate that there is a lack of reference and guidance concerning the fundamental questions related to sustainable development. What do we expect from transport policies: more transport or easier access to work, schools, shops, relatives and friends? What do we expect from the agricultural sector: more or better food, care of natural resources and supply of services (water, landscapes, leisure, etc.)? And what do we expect from the energy sector: more energy or improvements in the quality of life through better design of buildings and appliances, physical planning and renewable energy? These questions not only affect the sectors concerned, they are intertwined with every European's role as a consumer. What do we expect from our future? Do we expect economic development at the cost of natural capital, or improved quality of life for ourselves and generations to come through efficient and sustainable use of natural resources?

As stated in the Amsterdam Treaty, the EU has already decided to move towards an improved environment and sustainable development. The sixth environmental action programme announced by Margot Wallström (EU Environment Commissioner), EU and national contributions to the Rio+10 process and, above all, the participation of many businesses, municipalities and citizens in these processes, should show the way forward to the new century.

Yearly *Environmental signals* reports from the EEA – together with the ongoing sectoral indicator exercises (for transport, energy, agriculture, etc.) requested by the European Council – should tell us how we are progressing. They should also tell us about trends and prospects. The indicator exercises will help us to identify not only the worst cases ('name and shame') but also the best practice and success stories ('name and reward') for specific issues. It should also be possible to find out what is happening at sectoral, national, regional and local levels. The indicators should also foster a pro-active approach – allowing sectors, countries, regions, local communities and companies **to compete** for environmental excellency, better quality of life and more sustainable business.

We should be up to the challenge. It will not be easy: a reinforcement of our information system is required to assure sufficient and reliable data and to provide trends and prospects. However, the benefits are huge. I hope that the indicators in this report form a useful first step on the way.

Domingo Jiménez-Beltrán
Executive Director
November 1999

1. Introduction

The first in a series

This report is the first in a series of regular indicator-based reports produced by the European Environment Agency for high-level policy-makers in EEA member countries and the European Union. Its aim is to use environmental indicators to report on progress in a number of policy areas. The report also starts to assess – with a limited selection of indicators – the reasons behind the rate of progress made in some of the main environmental policy areas.

Another important aim of this report is to raise questions, such as: why is there so much progress in country X and why have policy measures for problem Y not yet shown any result?

The limited space in this report means that it is not possible to provide all the information necessary to answer these questions. For background information on European environmental problems, readers should refer to recent state-of-the-environment reports from the EEA (EEA, 1998; EEA, 1999a). In addition, the EEA web site (http://www.eea.eu.int) provides a gateway to detailed environmental information at European, EU and national levels. The site's data service gives access to most of the statistics on which the indicators in this report are based, thus allowing readers to create their own version of the indicators. An inventory of current environmental policy targets and sustainability reference values (the STAR database) provides additional information on national and multinational policy targets.

This report deals with a selection of environmental problems currently at the centre of policy debate and for which recent data is available. A number of other issues such as coastal zone management and soils will be added in subsequent editions, and some of the issues dealt with in this edition will be revisited less frequently. For example, the current topic of wetlands from the standpoint of nature and biodiversity may be repeated after three or four years, and the status of other habitats may be covered in editions in between. In each edition, a subtopic will also be chosen for waste, water stress and environmental taxes. An overview of future topics is given at the end of each chapter.

Some of the indicators may be revisited less frequently; other indicators might not feature again because they are intermediate products on the way to developing more stable indicators. Several of the indicators in this report, such as those in the chapter on wetlands, are under development. Others have international agreement and are, in principle, stable. However, for some of these only the first year or a first generation of the indicator can be presented due to data problems; the chapters on waste, water stress and eutrophication contain a number of such indicators. A final group of indicators can be designated as stable and a time series can be presented. These indicators refer to targets and give a clear picture of progress or lack of progress – in short, the indicator conforms to the OECD criteria for good environmental indicators. The indicators in the air pollution and climate change chapters belong to this category.

The EEA hesitates, however, to call the current collection of indicators (or even the sub-set of stable indicators) 'the EEA set of environmental indicators'. The EEA approach is that, while streamlined reporting on the state of the environment in Europe needs agreed sets of indicators, each report in turn should make its own selection and its own presentation of this family of indicators. In the coming years, the EEA and its Topic Centres will publish sets of indicators for each environmental issue dealt with by the EEA. Agreement will be sought on these selections and attempts will be made to stabilise the indicators identified.

1.1. Indicator selection and presentation

The two main criteria for the selection of indicators in this report were: policy relevance for most EEA member countries; and adequate data from a sufficiently large number of member countries.

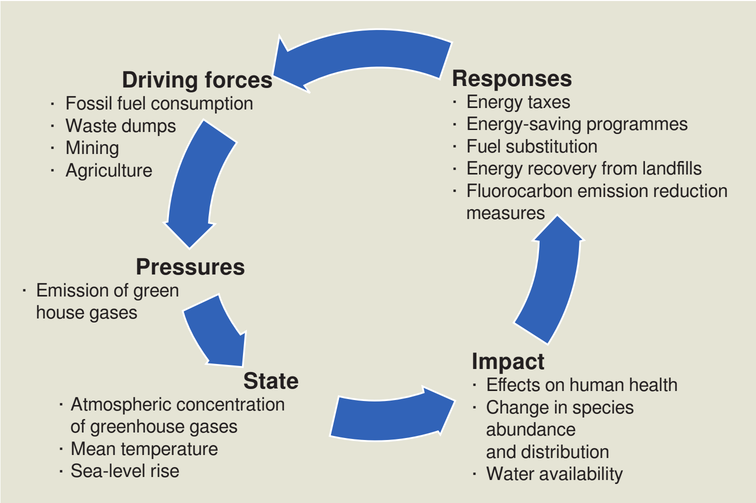
Although the indicators and their analysis are placed within the DPSIR framework (**D**riving forces - **P**ressure - **S**tate - **I**mpact -

Response; see Figure 1.1), no attempt has been made to provide indicators for each of the D-P-S-I-R categories. As most of the policy action is at the D and the P side of the causal chain, the most policy-relevant indicators show developments in Driving forces or Pressures. Some State indicators have been included in this report because of public attention (e.g. increase in UV-radiation through depletion of the ozone layer) or because policies have quality targets (e.g. air pollution or global air temperature). Response indicators are difficult to provide due to a lack of data. However, they are included in a number of chapters – stratospheric ozone depletion, wetlands and, of course, environmental taxes.

Indicators that span DPSIR categories provide an insight into processes in the environment and the development of links between human activities and the environment (EEA, 1999b). The sectoral chapters of this report (energy use, energy sector, transport, agriculture and industry) contain a number of eco-efficiency indicators combining D and P. The eutrophication chapter (see Figures 13.2 and 13.4) uses a combined presentation of D and P to show relations between variables. Pilot graphs from the Netherlands (see Figures 10.16 and 10.17) in the chapter on air pollution effectively combine D, R and P in one analysis.

The indicators provided are a mixture of various types of indicators (see EEA, 1999b). To fulfil the aim of providing a precise assessment of progress made, as many as possible *performance indicators* (indicators including or linked with targets) have been included in this report. However, the report also contains a significant number of *descriptive indicators*. Descriptive indicators show the development of a variable, but are not connected with a concrete policy target. Qualitative targets for these indicators ('to increase…', 'to stabilise…') may, however, be included in policy papers. *Eco-efficiency indicators* are, as mentioned above, included in the sectoral chapters.

Figure 1.1. **DPSIR diagram climate change**



Source: EEA

Within the framework outlined above, indicators are presented in a standard format. Most of the indicators are presented at an international level, showing totals for EU Member States or EEA member countries. This is particularly relevant where there are international agreements on action to tackle continental or global problems (e.g. greenhouse gas emissions) or where general environmental processes occur (e.g. the infringement of wetlands by infrastructure projects). Where possible and relevant, national breakdowns are provided. These graphs can play a major role in benchmarking national environmental performance – raising questions about the discrepancy between forerunners and slow performers. As well as providing detailed statistics, the comparative tables provided at the end of most chapters are intended to perform the same role.

In some chapters, indicators showing a general development, such as in energy supply, are accompanied by a sub-indicator highlighting specific trends that require attention. For these sub-indicators, the rate of change is often important. Although the absolute magnitude of these developments may be small in comparison with the total, they can represent significant new trends. Examples of these 'significant signals' are the rapid growth in organic farming and the slow increase in renewable energies.

Each chapter also contains a box describing a new and interesting response to environmental degradation. While each of these 'success stories' may be small and its individual effect not visible in European statistics, the overall effect of these and many other unquoted actions by households, industries and administrations are spearheading the positive trends demonstrated by many of the indicators in this report.

The use of indicators for benchmarking country or sector performance and the 'significant signals' will be further explored in subsequent editions of this report.

The smiley faces in the boxes next to each indicator aim to give a concise assessment of the indicator:

☺ positive trend, moving towards target

😐 some positive development, but either insufficient to reach target or mixed trends within the indicator

☹ unfavourable trend

Unless explicitly stated, the assessment is based on the whole period shown in the indicator.

1.2. Ongoing environmental indicator development

In recent years, discussions on environmental indicators have expanded from those describing changes in the state of the environment to an interrelated family of indicator sets (see Figure 1.2).

In line with the broadening of environmental policy towards integration of environmental issues in other policy fields, sector indicators have been developed. These show links between the activities of societal sectors (transport, energy, forestry, etc.) and the environment. As well a sector's absolute burden on the environment and the development in its eco-efficiency, sectoral indicators deal with a sector's development in size and character and its specific responses to environmental problems.

Within the EU, working groups have been set up to develop indicator sets and progress reports to report to the respective Councils. This work has reached various stages.

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. While publishing the current report, the European Environment Agency also produced an assessment of the progress made in integrating environment in transport policies (EEA, 2000). Chapter 5 includes some of the most important indicators out of the list of 30.

For *energy and the environment* a draft list of indicators has been produced, but this list has not yet been formally approved. The list makes a distinction between energy use and energy generation, which is also reflected in this report: Chapter 3 (energy use) and Chapter 4 (the energy sector) contain a selection of the main indicators. Eurostat has produced a statistical pocketbook of energy indicators, including most of the indicators selected for the energy-environment reporting mechanism (Eurostat, 1999).

For *agriculture and the environment*, discussions on a reporting mechanism started only recently. Chapter 6 is based mainly on work by the Organisation of Economic Cooperation and Development (OECD) on agri-environmental indicators.

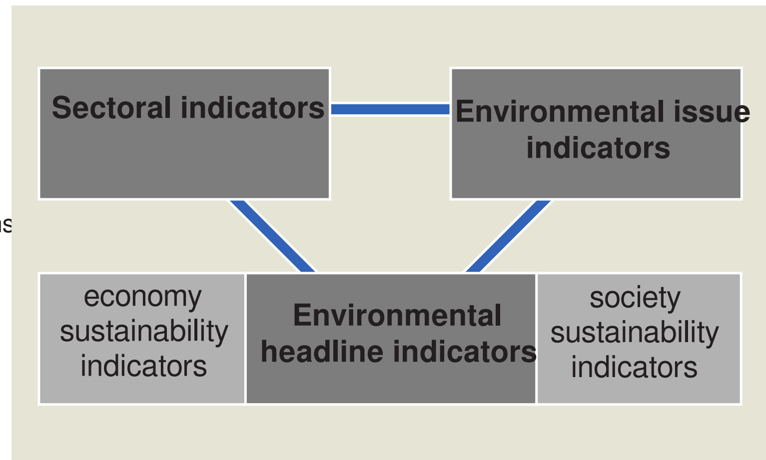
Other sectors and policy fields – including industry, development and the internal market – have also been urged to produce strategies for the integration of environmental concerns and to develop indicators to follow progress. However, there has been little development so far in these areas.

Sector indicators and traditional environmental indicators exist side by side and are interrelated. Issue indicators on pollutant emissions can show sectoral contributions (for example, see the chapters on climate change and air pollution), while sector indicators can show the evolving contribution of a sector to environmental issues (see the sector profiles and eco-efficiency diagrams in the sectoral chapters).

Broadening the scope of environmental policies has also created the need to communicate the main issues to other stakeholders. For example, a Minister of the Environment may have to explain all his concerns in five sentences to his colleague in transport. This need led to the concept of 'environmental headline indicators' (Figure 1.2).

The purpose of environmental headline indicators is to provide simple and clear information to decision-makers and the

Indicator initiatives Figure 1.2.



Source: EEA

general public about the key factors determining the state of the environment and whether we are moving towards environmental sustainability. Sets of headline indicators are, by definition, small. A proposed set of EU environmental headline indicators contains 10 issue indicators. A similar number of headline indicators for sectors could probably be added.

Because EU environmental headline indicators were developed while this report was being compiled, it was not possible to incorporate the full set of environmental headline indicators. However, the following indicators are also included in the list of EU environmental headline indicators:

- emissions of the greenhouse gases carbon dioxide, methane and nitrous oxide (see Figure 8.1);
- number of days population exposed to pollutants at levels above EU standards (see Figures 10.3 and 10.5);
- emissions of acidifying gases (see Figure 10.6);
- emissions of ozone precursors (see Figure 10.7);
- nitrogen and phosphorus concentrations in large rivers (see Figure 13.1);
- total freshwater abstraction (see Figure 12.2);
- gross inland energy consumption (see Figure 3.2);
- passenger transport by different forms of transport (see Figure 5.3).

1.3. The future of this report

The EEA's mission statement points to the provision of timely, targeted and reliable information. One of the practical consequences of the concept 'targeted information' is the co-ordination of major EEA reports to policy events such as ministerial conferences, drafting of white papers and strategic planning processes. This current report was prepared just before the European Council held in Helsinki in December 1999 with the aim of drawing together the threads of EU sectoral reporting mechanisms on integration and the issue of their co-ordination with environmental issue indicators.

After a thorough evaluation of the current report, next editions are expected to appear in the summer of 2001 for the Göteborg European Council and in 2002 to serve a number of political processes, including the Rio +10 Conference and the next pan-European environment ministers' conference in the Environmental Programme for Europe process to be held in Kiev.

1.4. References and further reading

EEA (1998). *Europe's environment. The second assessment*. European Environment Agency, Copenhagen.

EEA (1999a). *Environment in the European Union at the turn of the century*. Environmental assessment report No 2. European Environment Agency, Copenhagen.

EEA (1999b). *Environmental indicators: typology and overview*. Technical report No 25. European Environment Agency, Copenhagen.

EEA (1999c). *A checklist for state of the environment reporting*. Technical report No 15. European Environment Agency, Copenhagen.

EEA (2000). *Are we moving in the right direction? Indicators on transport and environment integration in the EU.* (In preparation). European Environment Agency, Copenhagen.

Eurostat (1999). *Integration indicators for energy*. Key indicators series. European Communities, Luxembourg.

Country groupings used in this report:

EU: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the UK

EEA: EU + Iceland, Liechtenstein and Norway

Nordic countries: Finland, Iceland, Norway and Sweden

Central Europe: Austria, Belgium, Denmark, Germany, Ireland, Liechtenstein, Luxembourg, the Netherlands and the UK

Southern Europe: France, Greece, Italy, Portugal and Spain

2. Integration of sectors and the environment

At its meeting in Cardiff in June 1998, the European Council called for its respective Councils to develop strategies to integrate the environment into their policies and to develop indicator sets to support assessment of progress. Sectoral indicators can be used to describe progress made in individual sectors, but they also serve to compare sectors. The restricted selection of indicators used in the present report points to movements away from targets in the transport and energy sectors; in both sectors price incentives run counter to the targets. In agriculture, the indicators suggest continued intensification on the one hand and an increase in agri-environmental management (in limited areas) on the other.

Integration of the environment in sectoral policies was already mentioned in the fifth environmental action programme as a main policy concern. The European Council in Cardiff gave the impetus to the practical organisation of developing integration strategies and the related reporting on progress. Progress by sector is assessed in the following chapters, based on a restricted set of indicators. This chapter attempts to assess how the various sectors are progressing compared to each other.

Although the sectors differ considerably, some common features in the integration process can be identified (EEA, 1999a and 1999b):

- What are the determining characteristics in the *size and shape of the sector* with regard to the environment? How have these developed over time? For example, the main issue for transport is the development of total mobility and division between the various forms of transport; for energy, the concerns are the development of energy use and the choice between fossil fuels, renewables and nuclear energy; for agriculture, the main characteristics are the amount of agricultural production and the production system used.
- How have the sector's beneficial and harmful *influences on the environment* changed?
- How has the *eco-efficiency* of the sector developed, or in other words: is the sector delivering its products and services with less use of resources and energy and less pollution per unit of output?
- What has been the progress in implementing *integration measures:* market integration, management integration and institutional integration?

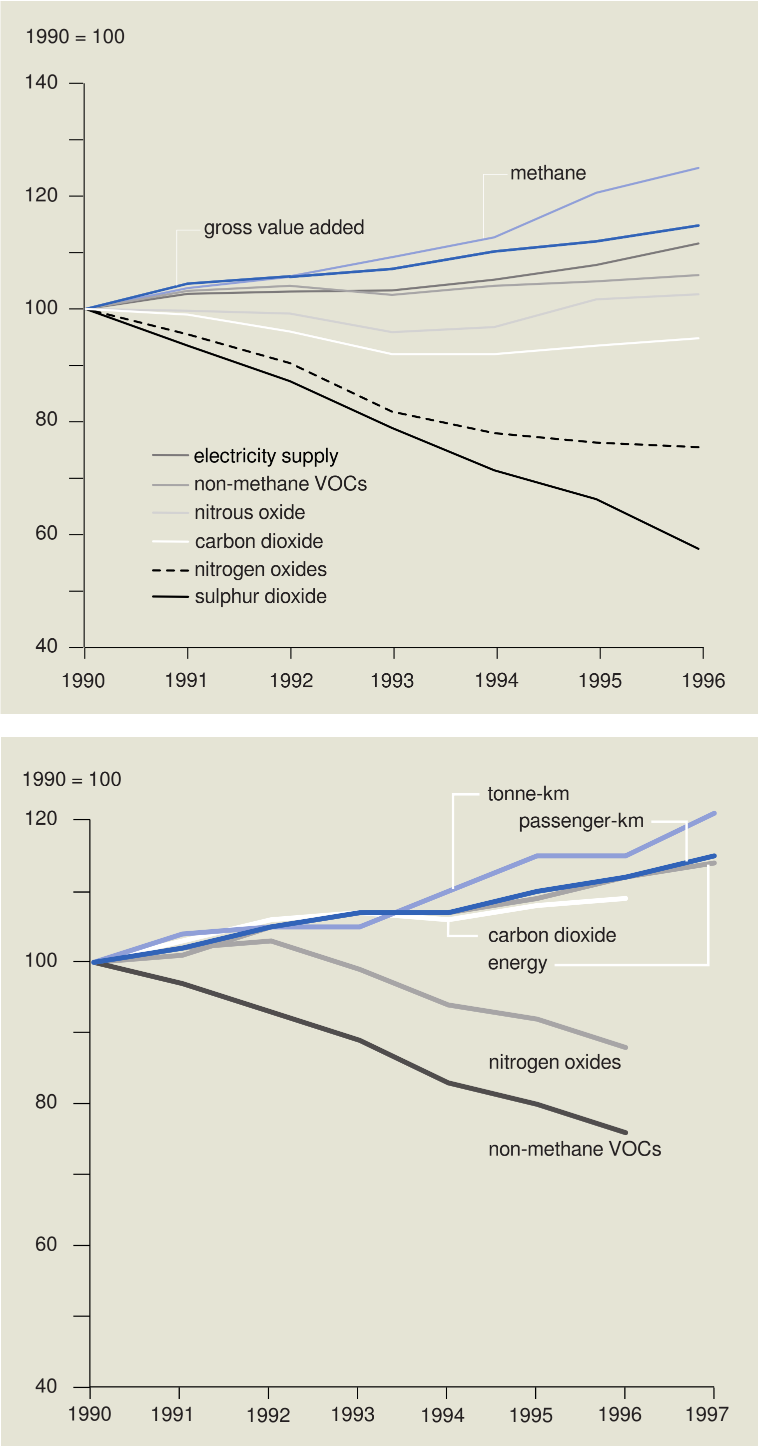
2.1. Progress towards integration

Developments in the size and shape of the sectors show a mixed picture. In transport, there is a clear trend away from policy targets: passenger and goods transport have increased steadily, with road transport increasing faster than other forms (see Figures 5.3 and 5.4). Energy shows a similar picture: the amount of energy used has increased, with fossil-fuel energy showing the greatest increase and use of renewables increasing only slowly (see Figures 3.3 and 3.4). In agriculture, the indicators suggest a split into areas with continuing intensive farming – with increased fertiliser and pesticide use per hectare (see Figures 6.3 and 6.5) – and more areas under special management contracts. For industry, there is insufficient data for such an assessment, which would need to take into account worldwide developments in trade and globalisation.

Progress in environmental efficiency shows common trends in all sectors. Little significant breaking of the link between developments in production and emissions has yet occurred, apart from sulphur dioxide emissions (Figure 2.1). Sulphur dioxide and nitrogen oxide emissions have fallen, but less progress has been made in reducing carbon dioxide emissions. The transport sector shows a strong link between transport, energy use and carbon dioxide emissions. In the energy sector, the slight breaking of the link between carbon dioxide emissions and output is mainly due to the shift from coal and oil to natural gas in power plants, and to increased production of nuclear energy. Eco-efficiency gains in the crucial sectors of transport and agriculture have been less than those in industry and energy.

Unfortunately, eco-efficiency assessments are currently limited to air pollution and a selection of inputs used in the sectors.

Figure 2.1. **Eco-efficiency in the four sectors based on emissions of major air pollutants**



Source: EEA

Consistent and systematic data on waste production and other influences on the environment is not yet available.

Reporting on progress in the implementation of typical integration measures is currently limited to the theme of 'getting the price right', i.e. economic instruments. A more qualitative overview of progress in integration is in preparation (EEA, 2000b).

Although taxes are a large part of energy prices, the real price of almost all fuels has fallen during the past 10 years (Figure 3.5). There is therefore no economic incentive to save energy. A similar development has taken place in the transport sector. Data from Denmark and the UK (EEA, 2000a) shows that the price of public transport has increased more quickly, and to a higher level, than private transport. The incentive provided by transport prices thus also opposes policy aims. More policy initiatives are therefore needed for both energy and transport to reverse these trends.

In agriculture, economic instruments have been used for many years via management contracts for environment and landscape conservation. Compared with the total funds available for agriculture, these agri-environmental measures are small. There is far less experience in including the monetary costs of the negative environmental effects of agriculture in the price of agricultural products. Only three EU Member States and Norway have introduced pesticide taxes, and only two (including Norway) a tax on fertilisers (see Chapter 6). Given the possible trend towards local intensification of agriculture, taxes and levies on agricultural inputs and outputs may become more important in the future.

The industrial sector is mainly confronted with levies, which are not included in available statistics on taxes (see Chapter 15). Most of these levies are directed towards the outputs of industrial processes and, as in the agricultural sector, taxes on inputs (resource taxes) are not common.

2.2. References and further reading

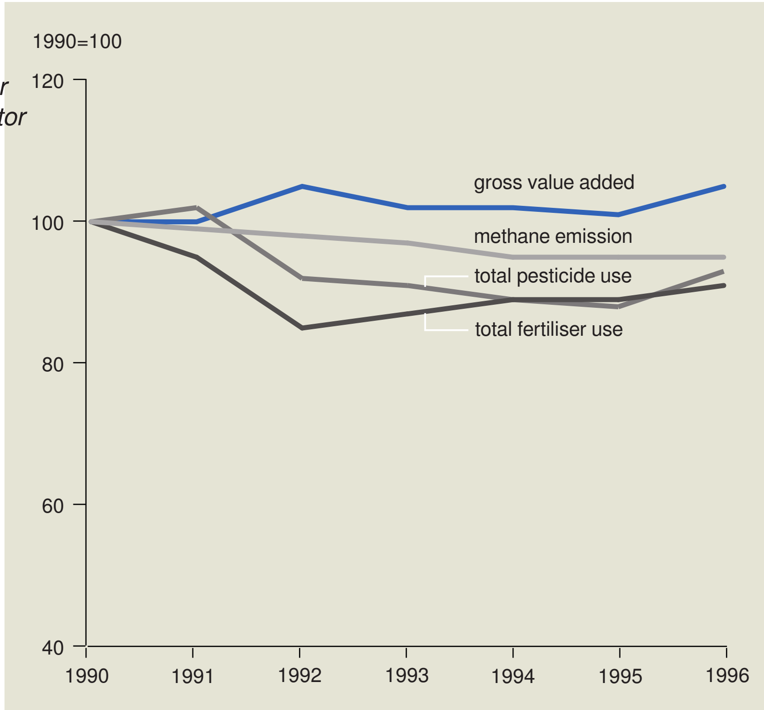
EEA (1999a). *Environment in the European Union at the turn of the century*. European Environment Agency, Copenhagen.

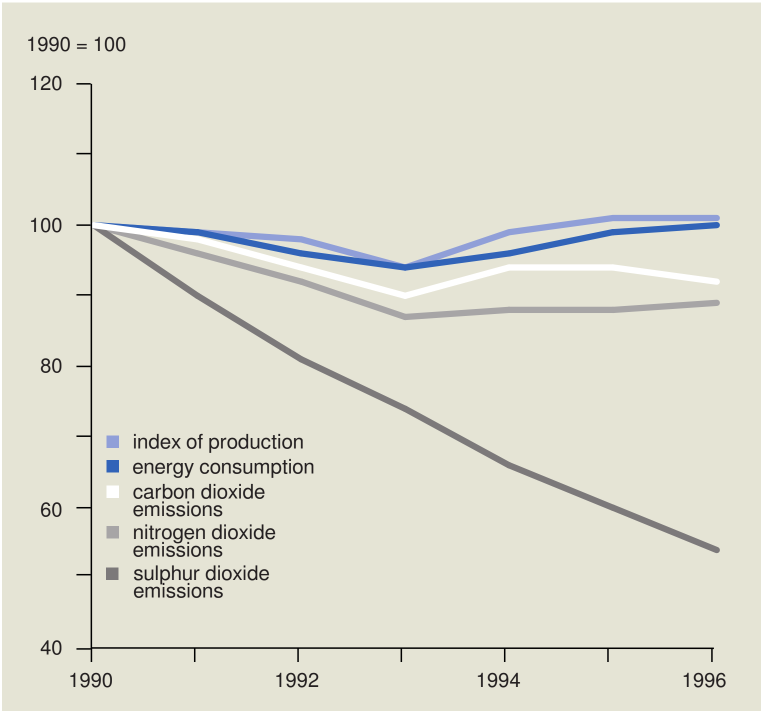
EEA (1999b). *Towards a common framework for the assessment of progress in environment-sector integration*. (In preparation). Technical report. European Environment Agency, Copenhagen.

EEA (2000a). *Are we moving in the right direction? Indicators on transport and environment integration in the EU.* (In preparation). European Environment Agency, Copenhagen.

EEA (2000b). *Monitoring progress towards integration.* (In preparation). European Environment Agency, Copenhagen.

Eco-efficiency in the four sectors based on emissions of major air pollutants Figure 2.1.





Source: EEA

3. Energy use

indicator	policy issue	DPSIR	assessment
energy intensity	does economic growth still require additional use of energy?	driving force	☹
energy supply	have we been successful in reducing total energy use?	driving force	☹
renewable energy share in energy supply	is the share of renewables increasing?	driving force	☹
energy prices	are prices developing in a direction that stimulates less use of energy?	driving force	☹
taxes on energy	are taxes developing in a direction that stimulates less use of energy?	response	😐

Energy use in EEA member countries increased during the period 1985-97. Real prices were at low levels for almost all fuels during this period, which may partly explain why we consume so much energy. At the same time, energy taxes have not compensated for the underlying fall in energy prices.

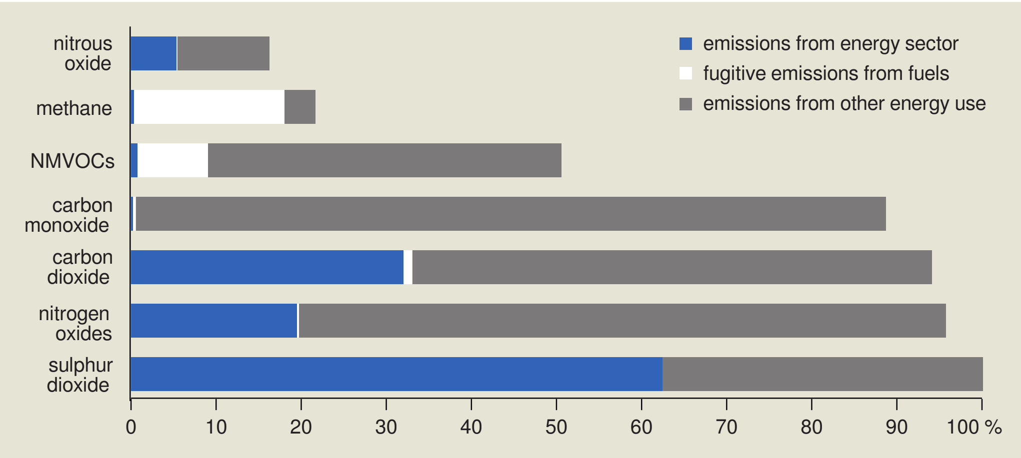
This chapter deals with energy as it is generated, transformed and used in all parts of society. The next chapter concentrates on the energy sector, i.e. the economic sector responsible for the production of energy necessary for the other sectors (transport, domestic, industry).

General energy policy in the EU is based on three 'pillars' or basic aims: overall competitiveness; security of supply; and protection of the environment (European Commission, 1995). Of key importance to the last objective is to achieve internationally agreed targets for greenhouse gas emissions (see Chapter 8) and air pollutants (Chapter 10); energy use is responsible for most of the main emissions for which targets have been agreed (Figure 3.1).

Sulphur dioxide emissions from energy use fell significantly between 1980 and 1996 (see also Figure 10.8). In 1996, the EU as a whole met the sulphur dioxide emission targets for 2000 set by the UNECE Convention on Long Range Transboundary Air Pollution (CLRTAP) Second Sulphur Protocol. Nitrogen oxide emissions also fell during the same period (see also Figure 10.10), but to a lesser extent.

Figure 3.1. **Air emissions from energy use as a percentage of total air emissions in EU Member States, 1996**

Source: EEA-ETC/AE



Total carbon dioxide emissions in the EU from all sources (including the use of energy) were the same in 1996 as in 1990 (see Figure 8.3). Carbon dioxide emissions in the EU from the use of energy – the main source of this greenhouse gas – increased by nearly 1.5 % between 1990 and 1996. This increase underlines the need for further initiatives in this area in order to reach the Kyoto Protocol target.

Factors contributing to emission reductions are listed in Chapters 8 and 10.

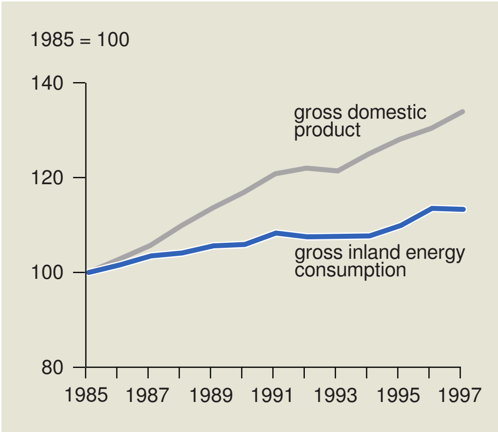
3.1. Trends in energy intensity

Energy use in EEA member countries has continued to increase over the past decade (Table 3.1). Energy intensity, i.e. the amount of energy needed to produce a unit of gross domestic product (GDP), has declined only gradually. This decrease has been insufficient to allow GDP to grow without an increase in energy use (Figure 3.2). Between 1985 and 1997, the GDP in EEA member countries grew, in real terms, by 34 % compared with a 13 % increase in energy supply. Energy intensity fell by an average of 1.4 % per year during 1985-97. Most of the decrease in energy intensity occurred between 1985 and 1990, when the annual average decrease was 2.0 %. Much less progress (-0.9 %) was observed between 1991 and 1997. Similar levels were observed in the EU.

It is difficult to determine the effect of energy-efficiency initiatives, such as the EU's THERMIE and SAVE programmes, environmental agreements and eco-labelling, on the overall decrease in energy intensity. The observed decrease in the EEA member countries is considered not to be notably higher than the normal improvement expected from 'business-as-usual' investment in new capital stock and measures to save money by avoiding energy wastage, i.e. autonomous energy-efficiency improvement. The limited decrease in energy intensity in the EU during 1991-1997 is below the forecast in the European Commission's conventional wisdom baseline scenario for 1990-2000 (European Commission, 1996). This suggests there is room for further energy-efficiency initiatives and better implementation of existing initiatives.

During the period 1985-1997, the primary energy source in EEA member countries has been oil (Figure 3.3). Coal was the second most important fuel in the 1980s, but has

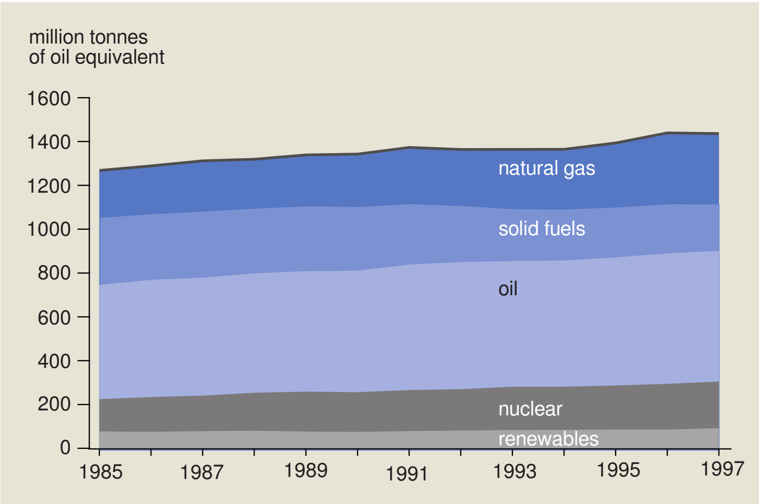
Energy supply compared with gross domestic product in EEA member countries, 1985-1997 Figure 3.2.



Note: Gross inland energy consumption is defined as the total supply of energy used in the transformation to other products (notably electricity and heat) and for energy consumption.
Source: Eurostat

☹ Economic growth continues to demand additional energy use. The link between growth in gross domestic product and increased energy use has not been broken.

Energy supply sources in EEA member countries, 1985-1997 Figure 3.3.



Source: Eurostat

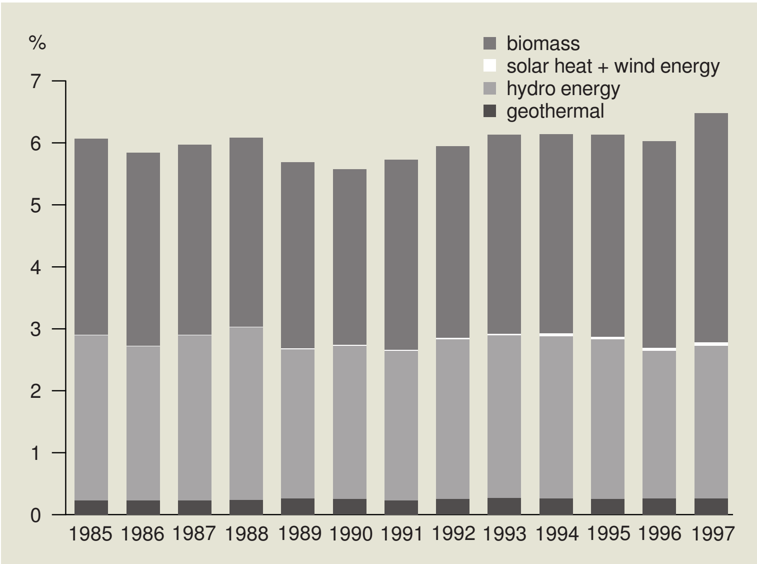
☹ Energy supply in EEA member countries continues to depend on fuels with significant environmental impacts or risk of impacts (fossil fuels and nuclear power).

been displaced by gas since 1992. Gas consumption increased from 16 % of gross inland energy consumption in 1985 to 21 % in 1997 – an increase of around 50 %. In 1997, nuclear power increased to almost 15 % of gross inland energy consumption. Renewable energy sources contributed just over 6 % (and 5.8 % in the EU) in 1997 (Figure 3.4 and Table 3.2).

Despite some growth in the use of renewables, the potential of this energy source to reduce carbon dioxide and other pollutant emissions is some way from being realised. The EU target of 12 % use of renewable energy by 2010 will require significant additional initiatives.

Due to the small starting base, the contribution of 'high-profile' renewables (wind and solar) to the energy supply is marginal. However, there has been significant growth in many EEA member countries. Growth in the use of wind power and solar heat has been strong, in relative terms, in Germany, Denmark and Greece as a result of public and private interest in developing wind power in Germany and Denmark, and solar water heaters in Greece.

Figure 3.4. **Renewables' share of energy supply in EEA member countries, 1985-1997**



Source: Eurostat

☹ Renewable energy sources continue to contribute only a small share to the energy supply in EEA member countries.

Policies to increase the contribution of renewable energies include the EU's THERMIE and ALTENER programmes and national grant programmes for the support of renewable energy. In some EU Member States, prices for electricity produced from renewable energy are guaranteed. The European Commission is currently drafting a proposal for a directive to make current national systems of support to electricity from renewable sources compatible within the context of EU liberalised electricity markets. There are also bottom-up initiatives in some Member States whereby consumers can buy 'green electricity' at a premium, either through funds or directly (see box 'Empowered customers' in Chapter 4).

In 1996, renewables' share of electricity generation amounted to 9.3 % on average in the EU, but with considerable variation across EU Member States (see Figure 4.5).

3.2. Trends in energy prices

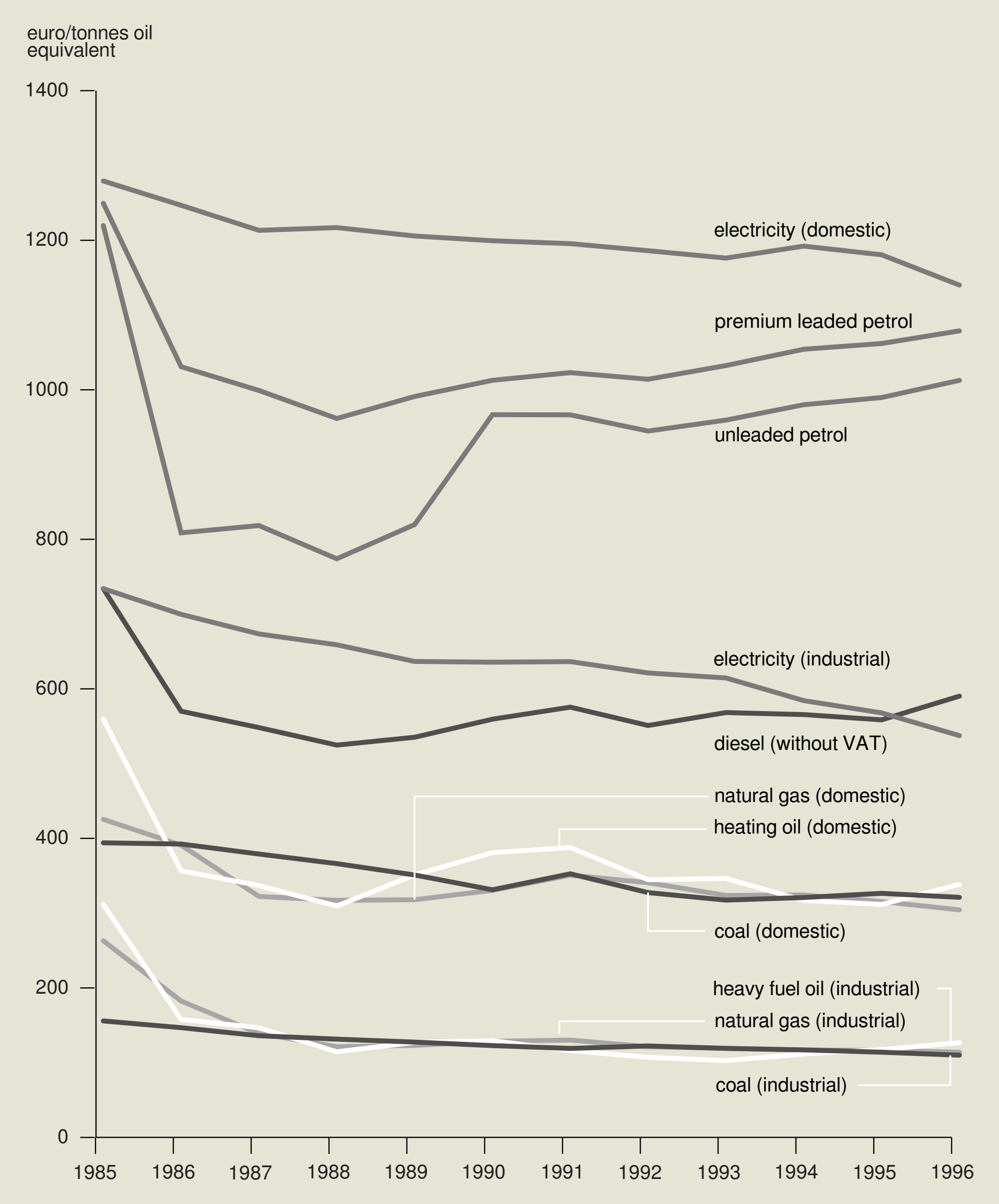
A likely reason why so much energy is used is that energy prices are low (Figure 3.5). Historically, energy demand fell sharply only after the price rises sparked by the 1973 and 1979 oil crises.

The drop in fuel prices since 1985 was mainly caused by the crash in oil prices in 1986, and the fact that other fuel prices are often indexed to the oil price. Other factors included the process of energy market liberalisation in some EU Member States and the increased liberalisation of world trade with newly accessible supplies of fuel. The continued development of the liberalised EU internal energy market is also expected to lead, within the current policy framework, to some reduction in prices.

Prices for heavy fuel oil and natural gas for industry showed the largest fall between 1985 and 1996 (an average of 7.9 % and 7.3 % per year respectively). Domestic electricity and premium leaded petrol fell the least, the former falling by 1 % per year in real terms over the period and the latter by 1.3 %.

During the 1990s, prices rose in real terms for transport fuels. However, demand for transport fuels showed little response – demonstrating the 'low elasticity of transport demand to price'. Diesel remains significantly cheaper than unleaded petrol. This offers little incentive for private car owners to switch from diesel to less-polluting unleaded petrol.

Average real (1990) energy prices in EU Member States, 1985-1996 Figure 3.5.

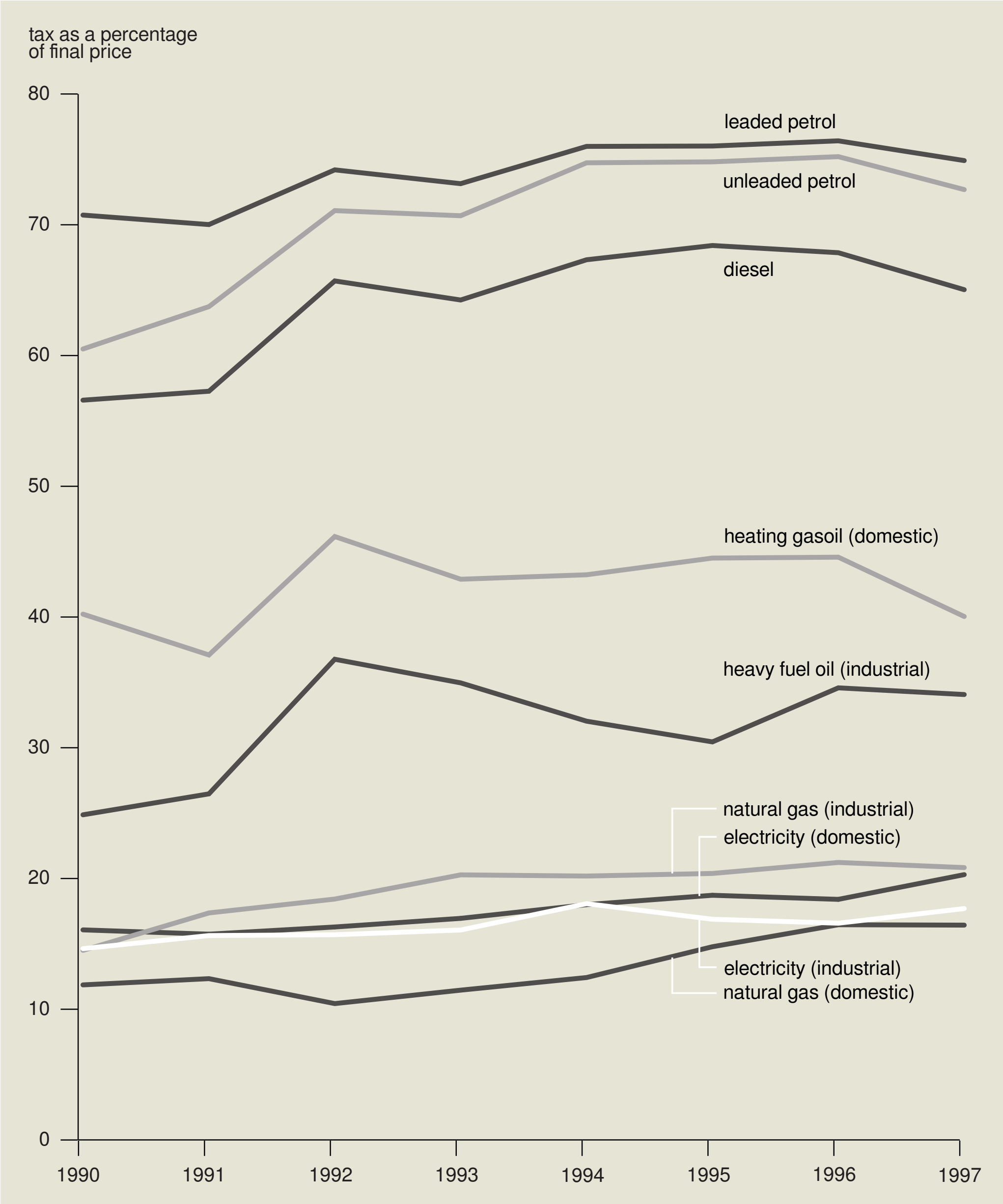


Notes: The prices shown are real prices, i.e. the effect of inflation has been removed. 1990 values were used to deflate. Most of the prices shown are final prices, with all taxes included. Value-added tax has been excluded for industry and for diesel. See Eurostat (1999) for an explanation of the calculation of EU average prices.
Source: DG Energy

☹ Between 1985 and 1996, the price of all fuels remained, in real terms, at low levels, offering little incentive to reduce fuel use.

Figure 3.6. **Taxes as a percentage of final energy prices in EU Member States, 1990-1997**

Note: The tax component of industrial energy prices includes both non-deductible taxes and value-added tax.
Source: Eurostat



Taxes, as a percentage of final prices, have risen for almost all fuels. However, the fall in underlying prices and/or little link between demand and price has given no incentive to reduce energy use.

Without the increase in taxes for many fuels (Figure 3.6), final fuel prices would have fallen still further between 1990 and 1997, and the incentive to increase fuel use could have been even greater.

However, fuel taxes reflect more of an interest in raising revenue than in reducing fuel use. Revenue from energy taxes in the EU rose from around ECU 100 billion in 1990 to ECU 158 billion in 1997 (see Chapter 15). Apart from increased taxation levels, this rise reflects growth in consumption.

Taxation policies differ between fuel type and between the domestic, industrial and transport sectors. Taxes are highest for transport fuels and much lower in industry – often with exemptions for particularly energy-intensive industries. Low taxes for industry reflect government policies not to harm the competitiveness of their industries in international markets.

At 16 % of the final price, domestic taxes on natural gas were the lowest of all the fuel taxes in 1997. Heating-gas oil taxes were much higher. Low taxes reflect, in part, political concerns about tax rises increasing domestic heating costs. Energy is often regarded as a basic consumer right for which governments are responsible to ensure availability, delivery and a fair price through regulatory and taxation instruments.

Gross inland energy consumption per capita in EEA member countries Table 3.1.

Unit: tonnes oil equivalent (toe) per capita

	1985	1990	1991	1992	1993	1994	1995	1996	1997
Austria	3.1	3.3	3.5	3.2	3.2	3.2	3.3	3.4	3.5
Belgium	4.4	4.7	4.9	5.0	4.8	4.9	5.0	5.3	5.4
Denmark	3.8	3.5	3.9	3.7	3.8	3.9	3.9	4.4	4.1
Finland	5.5	5.7	5.8	5.6	5.8	6.0	5.7	6.0	6.4
France	3.7	3.9	4.1	4.0	4.1	3.9	4.0	4.2	4.1
Germany	4.6	4.5	4.3	4.2	4.1	4.1	4.1	4.3	4.2
Greece	1.8	2.2	2.2	2.2	2.2	2.3	2.3	2.4	2.4
Iceland	7.2	8.2	7.7	7.7	7.9	7.9	8.0	8.4	n/a
Ireland	2.5	2.9	2.9	2.9	2.9	3.1	3.1	3.2	3.4
Italy	2.4	2.7	2.8	2.8	2.7	2.7	2.8	2.8	2.9
Luxembourg	8.5	9.3	9.7	9.7	9.7	9.3	8.1	8.2	8.0
Netherlands	4.2	4.5	4.6	4.6	4.6	4.6	4.8	4.9	4.8
Norway	4.9	5.1	5.2	5.2	5.4	5.4	5.4	5.3	5.6
Portugal	1.2	1.7	1.8	1.9	1.9	1.9	2.0	2.0	2.1
Spain	1.9	2.3	2.4	2.4	2.3	2.5	2.6	2.6	2.7
Sweden	5.6	5.5	5.6	5.3	5.3	5.6	5.7	5.8	5.7
UK	3.6	3.7	3.7	3.7	3.7	3.8	3.8	4.0	3.8
EU	3.46	3.61	3.67	3.62	3.60	3.60	3.67	3.80	3.76
EEA	3.48	3.63	3.69	3.64	3.63	3.62	3.70	3.82	3.78

Notes: Liechtenstein excluded from all EEA totals. Iceland not included in the EEA total for 1997.
Source: Eurostat

Table 3.2. **Renewable energy share of gross inland energy consumption in EEA member countries**

Notes: Liechtenstein excluded from all EEA totals. Iceland not included in the EEA total for 1997 and 1996 data used for its specific renewables share.
Source: Eurostat

	Share (all renewables) (%)								Share in 1997 (%)		
	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**Hydro**	**Biomass, waste**	**Geothermal, wind, solar, other**
Austria	22.4	20.7	23.3	24.3	22.4	23.1	23.4	23.3	10.9	12.4	0.0
Belgium	1.6	1.5	1.5	1.4	1.4	1.6	1.5	1.4	0.0	1.1	0.2
Denmark	6.3	6.4	6.7	6.9	7.0	7.3	6.8	8.0	0.0	7.1	0.8
Finland	18.5	18.2	19.2	19.7	19.2	21.4	19.8	20.7	3.2	17.0	0.5
France	5.4	7.0	7.2	6.9	7.4	7.3	6.9	6.6	2.2	4.3	0.1
Germany	1.6	1.6	1.7	1.7	1.8	1.9	1.8	2.3	0.4	1.7	0.1
Greece	5.0	5.5	5.0	5.2	5.1	5.4	5.4	5.3	1.3	3.6	0.5
Iceland	63.2	65.5	64.3	63.4	62.8	64.4	61.8		18.1	0.0	43.7
Ireland	1.6	1.7	1.6	1.6	2.2	2.0	1.6	1.8	0.5	1.3	0.0
Italy	5.4	5.9	5.9	6.1	6.4	5.6	6.0	7.9	2.1	4.0	1.8
Luxembourg	1.3	1.2	1.3	1.2	1.3	1.4	1.2	1.4	0.2	1.2	0.0
Netherlands	1.3	1.3	1.3	1.3	1.4	1.4	1.7	2.0	0.0	1.9	0.1
Norway	52.2	46.6	48.2	47.4	45.1	47.6	42.5	41.2	38.3	2.9	0.1
Portugal	15.8	15.6	13.2	15.9	16.0	13.9	17.9	16.9	5.3	11.3	0.3
Spain	6.7	6.6	5.7	6.5	6.5	5.7	7.2	6.5	2.8	3.6	0.1
Sweden	24.6	22.7	26.4	27.3	23.8	25.6	22.7	26.7	11.8	14.9	0.0
UK	0.5	0.5	0.7	0.7	0.9	1.0	0.9	0.9	0.2	0.7	0.0
EU	4.7	5.0	5.2	5.3	5.4	5.3	5.4	5.8	1.8	3.7	0.3
EEA	5.5	5.7	5.9	6.0	6.0	6.0	5.9	6.4	2.4	3.7	0.3

3.3. References and further reading

European Commission (1995). *An energy policy for the European Union – White Paper of the European Commission.* COM(95)682 final. European Commission, Brussels.

European Commission (1996). *European Energy to 2020. A scenario approach*. Energy in Europe, special issue. European Commission, Brussels.

European Commission (1997). *The White Paper for a Community strategy and action plan*. COM(97)559 final. European Commission, Brussels.

European Commission (1998a). *Strengthening environmental integration within community energy policy*. COM(1998)571 final. European Commission, Brussels.

European Commission, DG Energy (1998b). *Energy in Europe. 1998 annual energy review, special issue.* European Commission, Brussels.

Eurostat (1999). *Integration indicators for energy*. Key indicators series. European Communities, Luxembourg.

4. The energy sector

indicator	policy issue	DPSIR	assessment
thermal power plant energy efficiency	has the sector improved the overall efficiency of its main process?	driving force	😐
energy sector emission intensity	has the sector succeeded in de-linking emissions from its economic activity?	pressure	😐
electricity supply by source	has the sector become less dependent on fossil fuels?	driving force	☹
renewables' share of electricity generation	... and increased the share of renewable energy?	driving force	😐
CHP share in electricity generation	... and explored all possibilities for combined heat and power?	driving force	😐

Fossil fuels (coal, oil, gas) are still the predominant energy source for electricity production. Nuclear power is an important source in a number of EEA countries. Despite recent high growth rates in wind and solar power in a few Member States, renewable energy sources contribute little to electricity generation. Hydro power (mostly large hydro plants) remains the main renewable energy source. Use of combined heat and power (CHP), despite significant developments in a small number of Member States, remains low compared to the EU target.

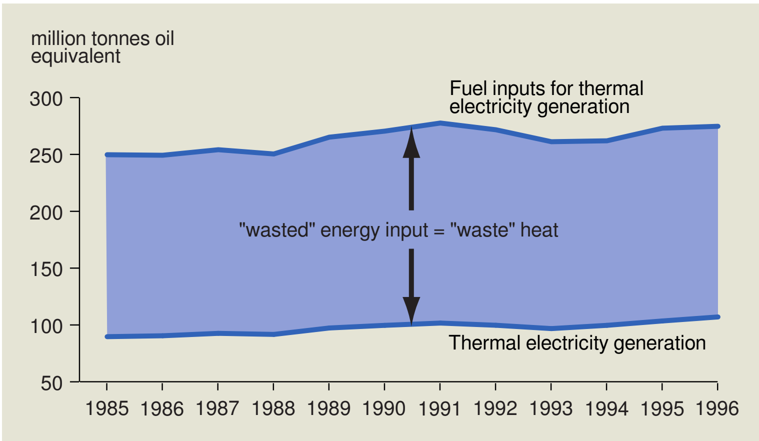
Electricity generation is the energy sector's main activity, with almost half the electricity produced in thermal power plants using fossil fuels. The overriding driver in the sector is EU and national policy to liberalise energy markets and to encourage competition. Increased competition could result in more efficient generating technologies. However, any environmental benefits associated with this development could be offset as increased competition may reduce energy prices. This, in turn, may increase the demand for energy and thus increase emissions. Within these macro developments, and given the current growth in energy consumption, an important internal aim for the sector is to increase the environmental efficiency of its own production.

4.1. Energy sector eco-efficiency

The efficiency of conventional thermal electricity generation showed only a gradual improvement from 36 % in 1985 to 39 % in 1996, mainly due to 'business-as-usual' improvement and replacement of installations (Figure 4.1). In other words, about 60 % of energy input is 'lost' as heat during the process of producing electricity. Not all the heat produced is wasted, as some waste heat is used in local applications. Additionally a few countries have invested in combined heat and power plants for district heating and industrial use (see Figure 4.6). Given the limited size of these applications, the order of magnitude of energy losses in the EU does not change much. Limited

Thermal power plant energy efficiency in EU Member States

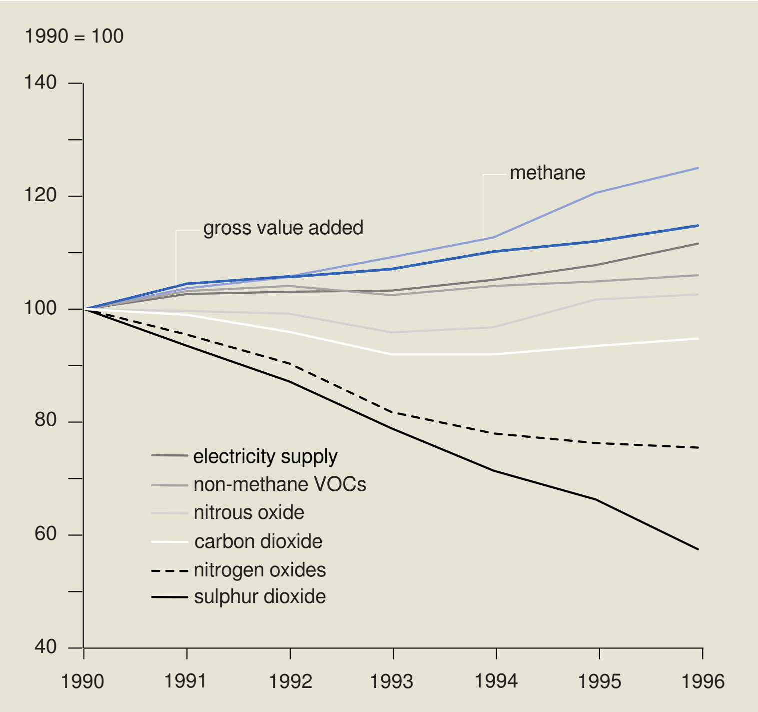
Figure 4.1.



😐 The average efficiency of thermal power plants is increasing steadily, but slowly.

Note: Thermal power generation is defined as the process of electricity production using combustible fuel sources (coal, natural gas, oil, waste or biomass) or existing heat sources (geothermal energy).
Source: Eurostat

Figure 4.2 **Energy sector eco-efficiency, EU Member States**



Notes: Emissions from public electricity and heat production, petroleum refining and the manufacture of solid fuels. This definition of the energy sector corresponds to the 1A1 energy industries category under the IPCC reporting framework. As defined here, the energy sector does not include fugitive emissions. When fugitive emissions from the exploration, production, storage and transport of fuels are taken into the account, methane levels fall both relative to gross value added and in absolute terms.
Source: EEA-ETC/AE; NTUA

Although the link between acid gas emissions (sulphur dioxide and nitrogen oxide) and the energy sector's economic and electricity outputs has been broken, greenhouse gas emissions from the sector have at most fallen only slightly.

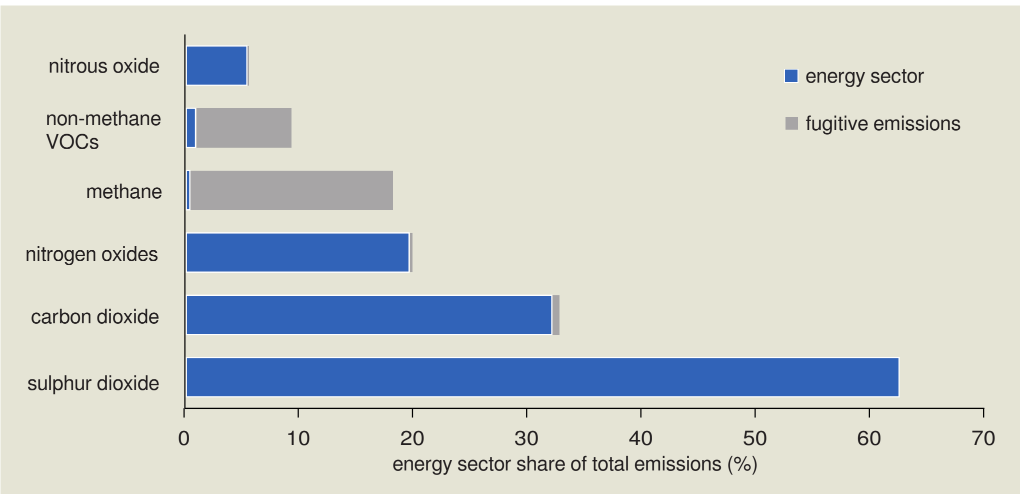
efficiency improvements mean that end-of-pipe treatment and process changes (including fuel switching) have produced most of the reduction in the sector's environmental impact. Until now, this approach has proved successful for most traditional air pollutants, but not for carbon dioxide (Figure 4.2). The energy sector has an important role to play in solving climate change and acid rain issues as it is the main source of sulphur dioxide emissions and a significant source of carbon dioxide and nitrogen oxide emissions (Figure 4.3).

The decline in sulphur dioxide emissions (Figure 4.2) has been partly due to the Large Combustion Plant Directive, which sets limits on emissions of sulphur dioxide, nitrogen oxides and particulates from power stations and has led to a number of technical improvements. In addition, the shift from coal to gas for electricity production contributed to the reduction in carbon dioxide emissions and also the reduction in acid gas emissions. The shift from coal to gas was due to the increased availability of gas supplies, legislative changes in the EU and in some Member States to allow gas to be used for electricity generation, the reduction of coal subsidies in a number of Member States, and the liberalisation of EU electricity and gas markets. Restructuring of the power sector in the former east Germany also contributed to reductions in carbon dioxide and acid gas emissions.

The Integrated Pollution Prevention and Control (IPPC) Directive requires plants to use Best Available Techniques (BAT) to tackle pollution, and thus may help to

Figure 4.3. **Energy sector's share of total emissions in EU Member States, 1996**

Notes: Emissions from public electricity and heat production, petroleum refining and the manufacture of solid fuels. This definition of the energy sector corresponds to the 1A1 energy industries category under the IPCC reporting framework. As defined here, the energy sector does not include fugitive emissions. Fugitive emissions include here emissions from the exploration, production, storage and transport of fuels.
Source: EEA-ETC/AE

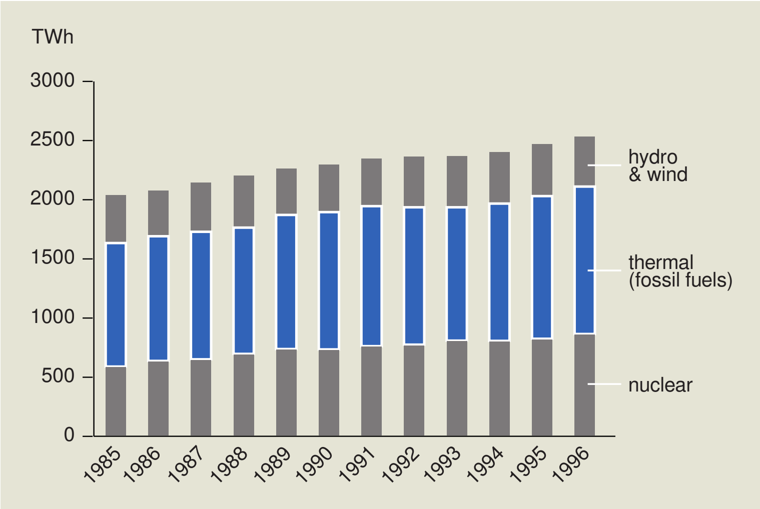


☹ Fossil fuels remain the predominant source of fuel for thermal power. Nuclear power, with its particular environmental impacts and risks, has become an increasingly important source of electricity in a number of EEA member countries.

further reduce emissions from the sector. However, the Directive has just come into force for new plants, and will take effect for existing plants only in 2007.

The energy sector also produces significant amounts of waste, and past activities have resulted in soil contamination. The sector is a major user of natural resources: the fossil fuels themselves, water for cooling (see Figure 12.3), hydro power, land and raw materials. Nuclear power plants have the risk of nuclear accidents and subsequent radioactive releases, and also generate radioactive waste. Water pollution and wastewater discharges are other issues for the sector.

Electricity supply in EEA member countries Figure 4.4.



Note: Fossil fuels are the main fuels for thermal production of electricity. Less than 5 % of thermal electricity is produced from biomass and geothermal sources.
Source: DG Energy

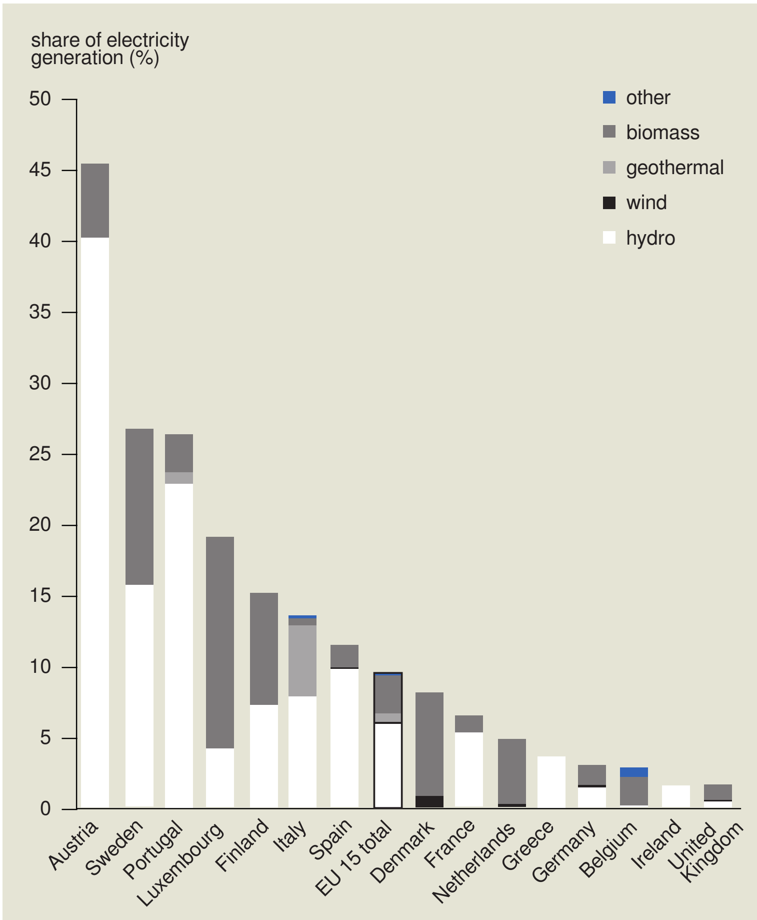
4.2. Trends in the electricity sector

In 1996, 48 % of the electricity in EEA member countries was generated by thermal power (mainly using fossil fuels), 34 % by nuclear power and the remainder by hydro and wind power (mostly hydro) (Figure 4.4). The figures for the EU are 52 % and 35 % respectively.

Austria, Portugal and Sweden have the highest contribution of renewables in their electricity generation (Figure 4.5), while Sweden, France and Italy contribute the greatest share to total EU generation of electricity from renewable energy sources. Hydro power is by far the largest renewable energy source for electricity generation in the EU. Most hydro power is produced in large plants, which can have considerable impacts on ecosystems.

Significant progress in the production of electricity from wind and solar sources has been made, such as wind power in Denmark and Germany. However, the actual contribution of 'green' electricity remains far short of its potential and more could be done in the

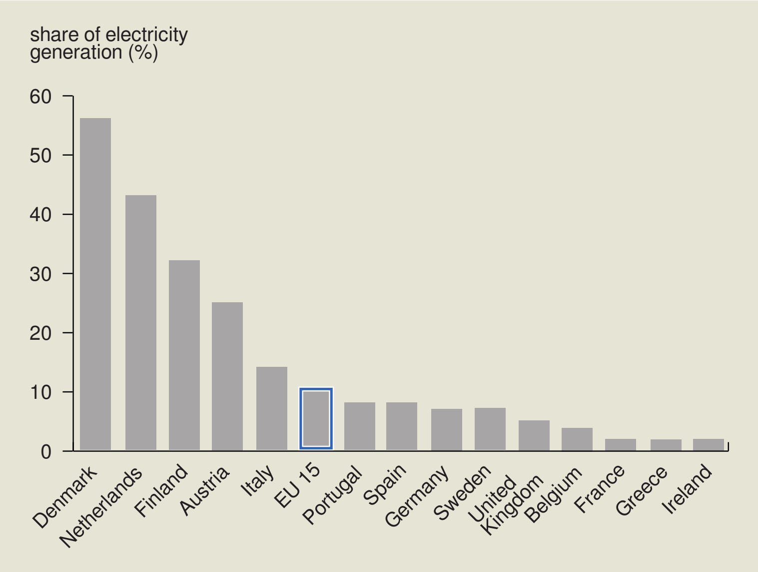
Renewables' share of electricity generation in EU Member States, 1996 Figure 4.5.



Source: DG Energy

☺ Renewable energy sources generate significant quantities of electricity in only a few EU Member States. Wind power, despite recent high growth rates, contributes only marginally in a few Member States. Solar power contributes even less.

Figure 4.6. **CHP's share of electricity generation in EU Member States, 1996**



Source: Eurostat

The use of combined heat and power (CHP) is significant in a few EU Member States, but for the EU as a whole it is still low compared with the EU target.

Empowered customers

Most people enjoy a long hot soak in the bath every now and then, but how many realise that just one bath a week in addition to a daily shower adds 223 kWh to an average household's annual energy bill?

Most people find it difficult to appreciate the significance of these figures. Customers of Vattenfall AB, a Swedish energy company, can now use models on the Web to calculate their consumption and to simulate their household's impact on the environment. Householders can then make an informed decision about the level of environmental impact they cause.

Vattenfall offers its customers several different kinds of electricity. As well as electricity produced from mixed sources (the default option), customers can buy electricity generated using wind and hydro power with different levels of environmental certification.

Many Swedish householders and companies are switching to environmentally certified wind- and hydro-generated electricity, even though prices are slightly higher. Vattenfall reports a five-fold increase in sales of wind power and a 2.5 times increase in sales of hydro-generated electricity since June 1998.

Source: www.vattenfall.se; see 'huset'

renewables electricity sector to help reach the EU target of 12 % of gross inland energy consumption produced by renewable energies by 2010.

CHP generated only 10 % of the electricity in EU Member States in 1996. Targets for increasing combined heat and power (CHP) generation have been set by the EU and some Member States; the EU target for 2010 is an 18 % share for CHP in EU electricity production. Several Member States use CHP extensively – notably Denmark, Finland and the Netherlands, and to a lesser extent Austria (Figure 4.6).

4.3. Indicator development

This chapter focuses mainly on power generation. Analysis of refineries, an important part of the sector, would provide a more complete overview of the energy sector. While data availability is generally good, the response indicators for combined heat and power, renewable energies, use of price mechanisms and energy efficiency, and analysis of their effectiveness in reducing environmental impacts need further attention.

For the future, indicators on the sector's generation of waste, use of natural resources, water pollution and wastewater discharges also need to be considered.

4.4. References and further reading

European Commission, DG Energy (1998). *Energy in Europe, 1998 annual energy review, special issue.* European Commission, Brussels.

European Commission (1997). *A Community strategy to promote combined heat and power (CHP) and to dismantle barriers to its development.* COM (97)514 final. European Commission, Brussels.

IEA/OECD (1999*). International Energy Agency/OECD balances 1996-97.* International Energy Agency/OECD, Paris.

5. Transport

indicator	policy issue	DPSIR	assessment
transport eco-efficiency	has the sector been successful in becoming more environmentally efficient?	pressure	😐
passenger transport demand	has the modal splidt developed towards more environmentally friendly modes?	driving force	☹
freight transport demand	has the modal split developed towards more environmentally friendly modes?	driving force	☹
price of transport fuels	are fuel prices developing in a direction stimulating less use of road transport?	driving force	😐

Rapidly growing transport volumes, especially for road transport and aviation, have over the past decades offset environmental gains from technology improvements. Demand management policies are needed to de-link transport growth from economic growth and to improve the balance between various modes of transport. Current transport revenues only partly cover the significant external costs of the sector, and current prices tend to favour private road transport over public transport.

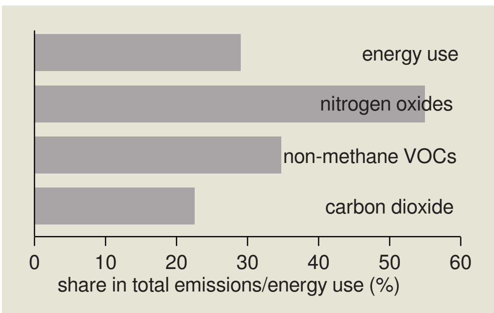
Essential for economic activity and welfare, transport is contributing more and more significantly to a number of environmental and human-health problems – particularly climate change, acidification, ground-level ozone formation, local air pollution, noise, land take and habitat disruption. The Common Transport Policy (European Commission, 1998) offers a framework to bring together the supply of a secure transport system with environmental and safety improvements. In a recent policy statement on the Common Transport Policy for 2000-2004, the European Commission stated that it: *'will give particular attention to measures designed to reduce the dependence of economic growth on increases in transport activity and any such increases on energy consumption, as well as the development of less environmentally damaging energy alternatives for transport'.*

5.1. Transport eco-efficiency

Transport is highly reliant on the use of non-renewable fossil fuels and is therefore a major contributor to greenhouse gas emissions (particularly carbon dioxide emissions; Figure 5.1). Energy and carbon dioxide efficiency (i.e. energy use per passenger and per freight transport unit) has shown little or no improvement since the early 1970s (Figure 5.2). The increasing use of heavier and more powerful vehicles – together with decreasing occupancy rates and load factors – has outweighed increases in vehicle energy efficiency due to technological advances. As a result, growing transport volumes led to about a 14 % increase in energy consumption and a 12 % increase in carbon dioxide emissions between 1990 and 1996. These trends show that to reduce the sector's energy consumption and emissions, policies should now focus on demand-management measures to curb growing transport volumes together with technical efficiency improvements.

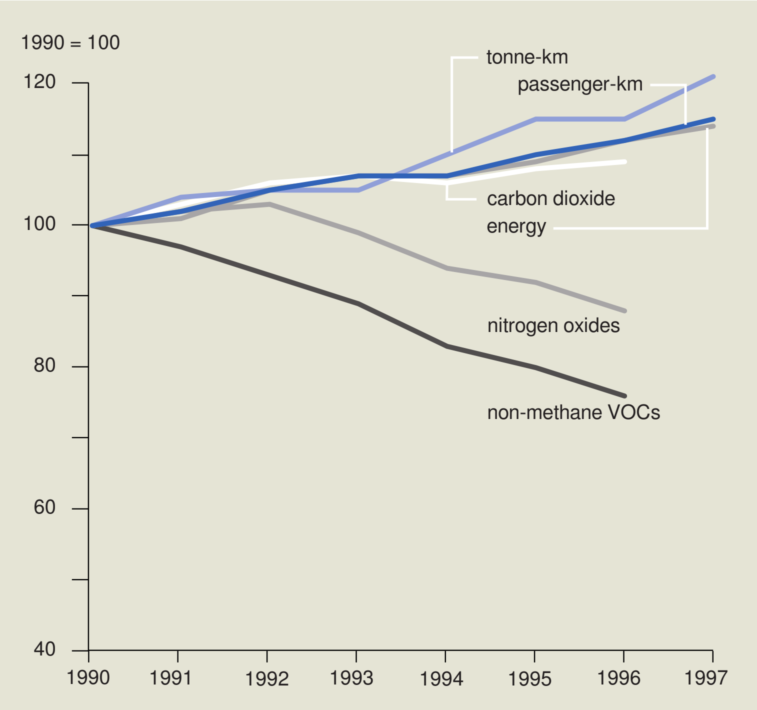
By 2010, transport is expected to be the largest single contributor to EU greenhouse gas emissions. This may jeopardise the EU's achievement of its target of an 8 % reduction in greenhouse gas emissions by 2008-2012 under the Kyoto Protocol (see Chapter 8).

Transport environmental profile in EU Member States, 1996 — Figure 5.1.



Source: EEA-ETC/AE and Eurostat

Figure 5.2. **Transport eco-efficiency (air emissions) in EU Member States**



Source: EEA-ETC/AE and Eurostat

Limited improvements in transport eco-efficiency have occurred in EU Member States.

On the positive side, emissions of non-methane volatile organic compounds and nitrogen oxides have been falling since 1990 (Figure 5.2) – mainly due to the introduction of catalytic converters in vehicle exhausts. However, the decrease has been slower than expected as increasing transport demand has partly offset engine improvements. Transport continues to be a major contributor to acidification and air-quality problems (Figure 5.1). In future, a significant further reduction of road emissions is expected to be realised through the implementation of directives resulting from the Auto-Oil programme (see Chapter 10).

Traffic noise is a key urban problem, but harmonised country information is not available. However, it is estimated that over 30 % of people in the EU are exposed to high road-traffic noise levels, ± 10 % of people to high rail noise levels, and possibly a similar proportion to aircraft noise. Transport infrastructure takes land and may constitute a barrier against the movement of species. It thus has a direct influence on the occurrence and distribution of animal and plant species (see Figure 14.3).

5.2. Trends in transport

Passenger and freight transport have more than doubled over the past 25 years, with the strongest growth being in air and road transport (Figure 5.3, Figure 5.4 and Table 5.1). During recent decades there has been a dramatic shift towards road transport: the car increased its share of passenger transport from 65 % to 74 % between 1970 and 1997, and trucks now account for 45 % of total freight transport compared with 30 % in 1970.

Between 1970 and 1997, passenger and freight transport in the EU increased by an annual average of 2.8 % and 2.6 % respectively, while GDP growth over the same period was 2.5 %. For road and air-passenger travel particularly, the boost in demand can be attributed to higher incomes, a fall in transport prices in real terms and changes in travel patterns (for example as a result of urban sprawl). In turn, the demand and intensity of freight transport is closely linked to changes in the volume and structure of the economy and to infrastructure supply.

Infrastructure supply strategies (resulting in an increase in motorway length by 195 % between 1970 and 1996, while rail infrastructure lengths declined slightly) have over the past decades enhanced the shift to road transport. Actions under the EU Common Transport Policy to revitalise rail and to promote inland waterways, combined transport and public transport have not yet managed to break this trend. However, some positive signs can be noted, such as better performance from short-sea shipping and more high-speed rail lines. Better coordination of transport and spatial planning (urban and regional), and the use of telecommunications would also help to increase accessibility while at the same time reducing the need for mobility. However, these demand-management measures are poorly reflected in the Common Transport Policy.

5.3. Prices and taxes

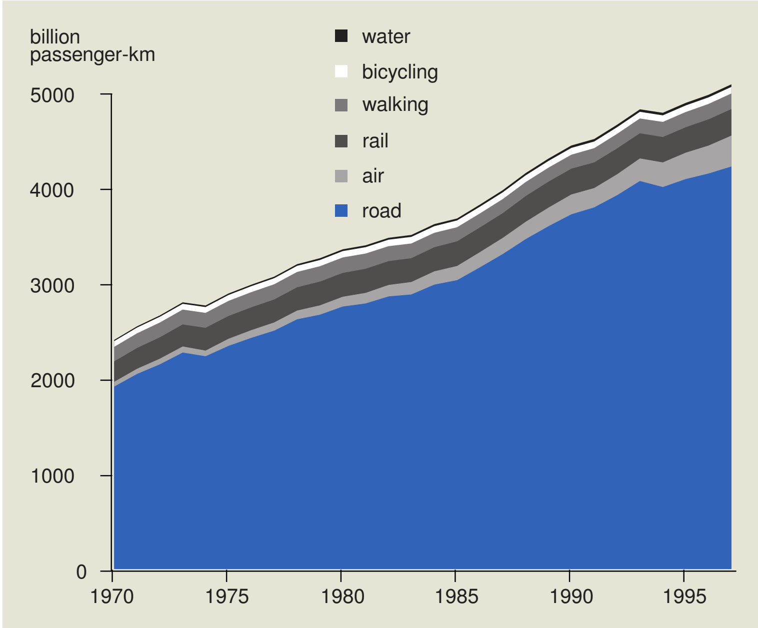
Pricing is one of the key policy tools for promoting an environment-friendly balance between different forms of transport.

However, current prices tend to favour private road transport over public transport. For example, rail and bus fares have increased more rapidly than gross domestic product (GDP) over the past decade, while the price of driving a private car has largely remained stable (EEA, 2000). This distribution of prices between private and public services is partly because road-transport fuel prices (the perceived marginal cost of driving a private car) have increased only slightly during the 1990s (Figure 3.5 and Figure 5.5). A number of strategies to achieve fair and efficient pricing were initiated in the Common Transport Policy action plan 1995-2000.

Current transport revenues only partly cover the sector's significant external costs. The external costs caused by road and rail noise, local air pollution, climate change and accidents are estimated at around 4 % of GDP; infrastructure wear and tear and congestion add to this economic loss. Costs not borne by consumers in 1991 are estimated to have been 70 % of the total for road and 62 % for rail (EEA, 1999). It is expected that internalisation of external costs will result in technological improvements and increases in operational and organisational efficiency. The overall effect on demand for mobility and modal shares is likely to be smaller and will also depend on the provision of efficient alternatives, e.g. to road transport. It is estimated that transport volumes (both passenger and freight transport) would be 10-15 % lower in the medium term under an internalisation policy than if current trends continued (ECMT, 1998).

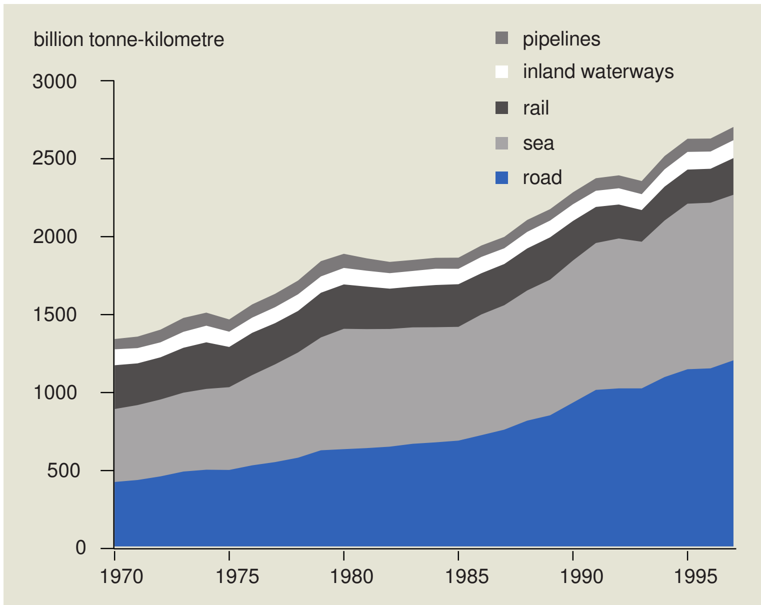
Fuel taxes provide the biggest contribution to revenues from all environmental taxes (energy, pollution and transport taxes (see Chapter 15). Fuel prices vary substantially between Member States, with some countries showing an upward and some a downward trend. Fuel taxes are mainly used to encourage a shift towards more environment-friendly fuels. Fuel tax differentiation has, for instance, been a major factor in the phasing-out of leaded petrol in the EU. In 1998, leaded petrol was 4-17 % more expensive than unleaded petrol and up to 58 % more expensive than diesel. As a result, the market share of unleaded petrol reached 75 % in 1997 and leaded petrol is expected to be completely phased out by 2005. Increased fuel taxes tend to stimulate energy savings through technical-efficiency improvements and thus reduce fuel demand.

Passenger transport in EU Member States Figure 5.3.



Source: Eurostat

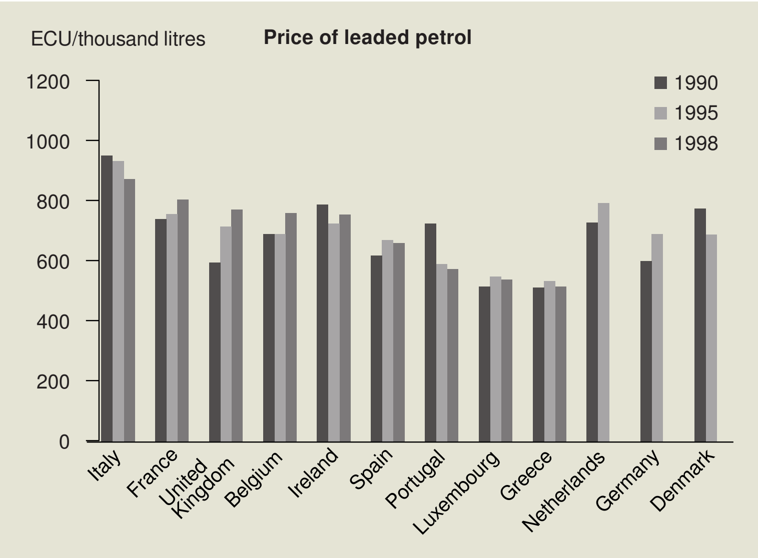
Freight transport in EU Member States Figure 5.4.

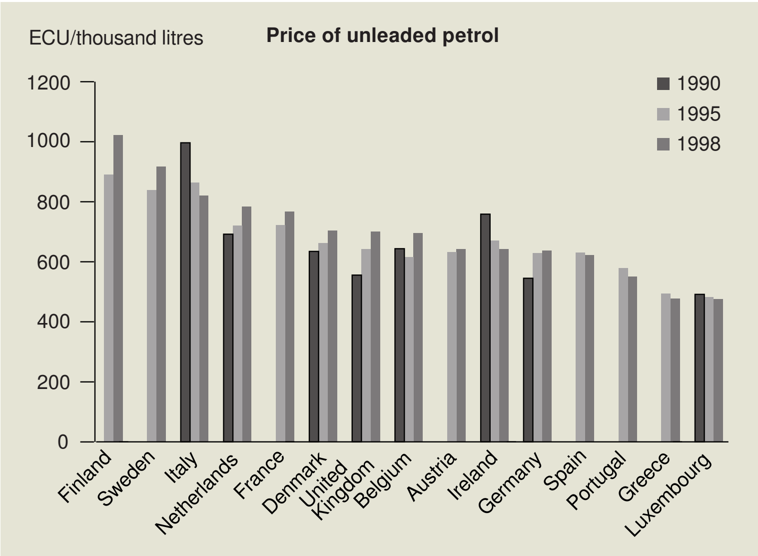


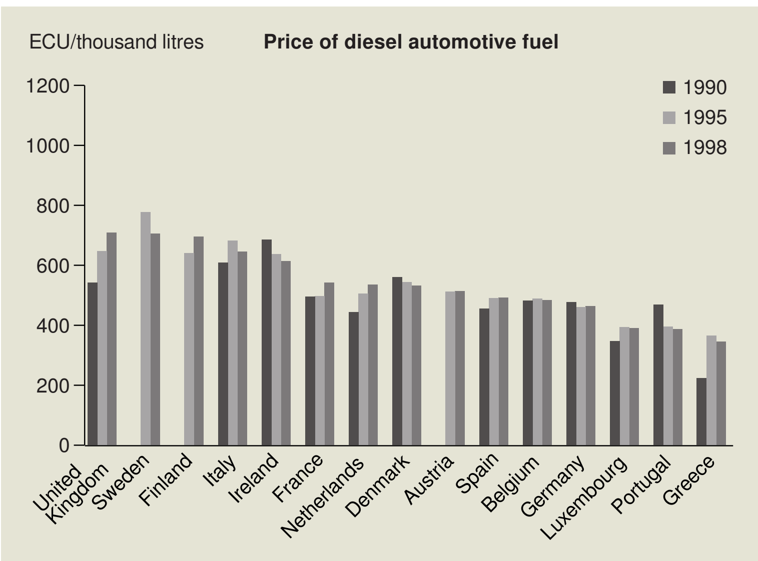
Source: Eurostat

☹ Passenger and freight transport volumes have more than doubled over the past 25 years. Road transport is the most important mode of transport.

Figure 5.5. **Prices of transport fuels in EU Member States**







Prices of transport fuels have increased only slightly since 1990.

One way of making existing transport tax structures more efficient is by shifting from national charges (e.g. annual vehicle excise duties) towards more territorial charges (e.g. road pricing through distance charges or tolls). Introduction of marginal cost-based charges, such as electronic kilometre charges for trucks, is deemed necessary to complement fuel taxes (ECMT, 1999). Road pricing is already applied to motorways in some countries and, in a few cases, in inner city areas. However, the share of revenues from transport taxes (which excludes taxes on motor fuels) in the total general tax burden did not change between 1980 and 1997 (see Figure 15.2), demonstrating the lack of a clear-cut shift to green tax reform in this area.

Price changes are only one factor influencing transport demand: convenience and security also have a strong influence on individual decisions over whether and how to travel.

5.4. Indicator development

This chapter contains some of the 31 indicators on transport and environment integration being developed within the EU Transport and Environment Reporting Mechanism (TERM) (EEA, 2000). Improved accuracy and consistency of air emissions estimates is a priority – particularly for greenhouse gases. Improved breakdowns by transport mode are still needed for many of the environmental pressure indicators.

Future work will include improving or adding TERM indicators on health impacts of air pollution from transport, traffic noise annoyance, habitat fragmentation, transport prices and taxes, transport externalities and energy efficiency of passenger and freight transport. Analysis of the effectiveness of the use of response measures such as economic instruments (prices, subsidies, taxes) would also be desirable.

Note: Based on the 1990 rate for the ECU. Leaded petrol is no longer sold in Austria, Denmark, Finland, Germany, the Netherlands and Sweden.
Source: Eurostat

Cycle-friendly employers in Nottingham

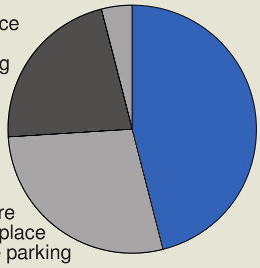
Car travel is increasing throughout Europe, but over half of all car journeys are less than 6 km in length and 10 % are for local trips covering distances of less than 1 000 metres. Short car journeys are particularly bad for the environment.

In the UK, a fifth of all cars on the road contain people travelling to and from work. Several major cycling charities – including Sustrans and the Cycle Touring Club – have teamed up to provide employers with information on how to draw up Green Commuter Plans for their employees. Advice is given on access routes, safe parking, raising awareness among employees, providing changing facilities and offering incentives to use bicycles and public transport for business trips.

Poor safety on the road is often mentioned as a key obstacle to cycling to work. In Nottingham, the Boots Company plc contributed to a shared cycle/pedestrian path leading to a site entrance. Other companies in Nottingham have provided money to improve the city's cycling infrastructure.

Source: Sustrans information sheet on cycle friendly employers. www.sustrans.org.uk

Results of a travel survey in Nottingham of factors encouraging commuting by bicycle



5.5. References and further reading

ECMT (1998). *Efficient transport for Europe – policies for internalisation of external costs*. European Conference of Ministers of Transport, Paris.

ECMT (1999): *Efficient transport taxes: international comparison of the taxation of freight and passenger transport by road and rail.* (In preparation). Paris.

EEA (1999). *Environment in the European Union at the turn of the century*. European Environment Agency, Copenhagen.

EEA (2000). *Are we moving in the right direction? Indicators on transport and environment integration in the EU.* (In preparation). European Environment Agency, Copenhagen.

European Commission (1995). *Towards fair and efficient pricing in transport*. (COM(95)691. European Commission, Brussels.

European Commission (1998). *The Common Transport Policy – sustainable mobility: perspective for the future.* European Commission, Brussels.

Average annual car-passenger transport per capita — Table 5.1.

Unit: 1 000 passenger-km/capita

	1980	1990	1992	1993	1994	1995	1996	1997
Austria	6.3	8.1	8.8	8.5	8.5	8.5	8.2	8.3
Belgium	6.6	8.1	8.4	8.6	8.8	9.0	9.1	9.2
Denmark	7.4	10.4	10.9	11.1	11.4	11.7	12.1	12.4
Finland	7.1	10.3	10.0	9.8	9.7	9.8	9.8	10.0
France	8.4	10.3	10.8	11.0	11.2	11.4	11.6	11.7
Germany	6.6	8.6	8.9	9.0	8.9	8.9	8.9	9.0
Greece	2.9	4.8	4.9	5.2	5.4	5.6	5.9	6.1
Ireland	8.2	10.4	10.9	11.2	11.5	11.8	12.1	12.5
Italy	5.7	9.2	10.6	10.6	10.5	10.7	10.8	11.0
Luxembourg	7.4	10.5	11.0	11.3	11.4	11.5	11.3	11.5
Netherlands	7.6	9.1	9.1	9.2	9.5	9.5	9.4	9.7
Portugal	4.2	6.6	7.3	8.4	9.1	10.0	10.6	11.0
Spain	5.1	7.3	7.8	8.0	8.1	8.4	8.6	8.9
Sweden	8.0	10.5	10.6	10.4	9.6	9.9	10.5	10.6
UK	7.0	10.4	10.3	10.2	10.3	10.4	10.6	10.7
EU	**6.6**	**9.1**	**9.5**	**9.6**	**9.7**	**9.8**	**9.9**	**10.1**

Source: DG Transport; Eurostat

6. Agriculture

indicator	policy issue	DPSIR	assessment
eco-efficiency in agriculture	has the sector made progress?	pressure	😐
livestock numbers	what have been the developments in environmental aspects of agriculture: ... with regard to eutrophication?	driving force	😐
fertiliser consumption per hectare	- „ -	driving force	😐
irrigated land	... with regard to water stress?	driving force	☹
pesticide consumption per hectare	... with regard to water quality	driving force	☹
area with organic farming	... with regard to less environment-burdening farming systems?	response	☺

Agriculture has become more environmentally efficient overall, but pressures seem to remain at the same level, notwithstanding wide regional disparities. This is mainly due to continuing intensification – and the resultant use of large and environmentally-critical amounts of pesticide and fertiliser. On the other hand, the area of agricultural land under management contracts or farmed organically has increased.

The agriculture sector, which represents 2.3 % of EU gross domestic product and 5.3 % of employment, is clearly subject to structural changes under the Common Agricultural Policy (CAP) and its subsequent reforms. The size and diversity of agriculture have also been substantially influenced, and will remain so, by changing consumer demands, changing rural patterns, technological advances and globalisation of the economy. These trends are seen as having positive as well as negative effects on the sector's performance with regard to environmental quality and nature conservation.

The concept of the 'multifunctionality' of agriculture, as underlined by Agenda 2000, tries to capture the various challenges for the sector: to produce food, fibres and energy sources; to preserve the rural environment and landscape; and to contribute to the viability of rural areas and a balanced regional development. From an environmental point of view, balancing these various aims is equal to improving eco-efficiency, i.e. reducing the burden on the environment while maintaining a certain level of output. Eco-efficiency in agriculture is tentatively expressed in this report by comparing methane emissions and selected inputs with developments in the gross value added (which is approximately total income) of agriculture (Figure 6.1).

6.1. Some eco-efficiency aspects in agriculture

Since 1980, gross value added in agriculture has increased by about 25 % – a slower rate of growth than in other sectors. Part of the increase is due to productivity gains and part due to increasing consumer demand for luxury products with a high added value. At the same time, fertiliser use has fallen and stabilised (Figure 6.3) without affecting yield. Yields have been boosted by plant technologies that increase the weight of the edible part of the crop compared with the non-edible part. In addition, more use has been made of organic manure. The fall in methane emissions is associated with improved utilisation of animal feeds in intensive livestock production and with the decline in cattle (Figure 6.2).

These changes suggest that improvements in the eco-efficiency of the agricultural sector are largely due to independent developments in production efficiency as a result of agricultural research and farmers' behaviour.

However, while efficiency has improved in economic terms, the quantity of inputs per hectare has either stayed constant or increased in recent years (Figure 6.3 and

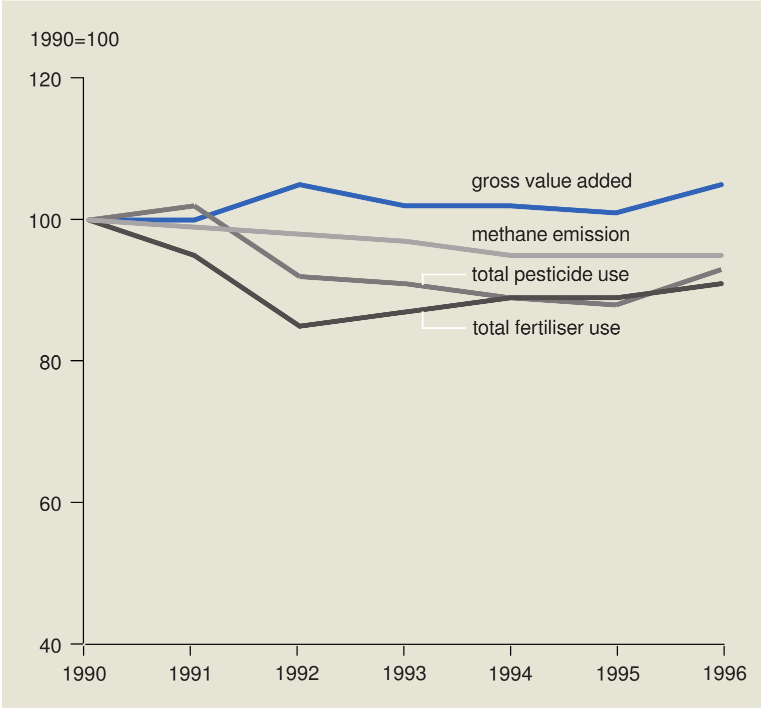
☹ Overall, eco-efficiency in agriculture has improved only slightly since 1990.

Figure 6.5). This is due to two trends: a steady decrease in the area of agricultural land and more intensive production (with more value added per hectare). Such a development is fully in line with the CAP. At the start of the CAP, the major issue was product price support; since the 1992 and 1999 revisions, most CAP funds have been allocated to support farm incomes and provide compensatory payments, with agri-environmental programmes receiving only a relatively small share of the budget. The protected production regime – with a possibly higher use of non-farm resources than otherwise would be the case – stimulated intensification. In these circumstances, integrating and implementing environmental policies to reduce nitrogen surpluses, pesticide residues and/or water use is a challenge. This may partly explain the slow progress made in integrating environment in the agricultural sector.

The scale on which these developments have occurred and are managed differs significantly within Europe. The pattern and diversity of agriculture reflects Europe's geography and political history. North-west Europe is generally associated with large-scale, highly productive arable or livestock production, while mixed and fragmented patterns of production are typical of southern Germany, France and northern-central Italy (Potter, 1997). Agriculture in southern Europe tends to be less intensive. Nonetheless, parts of northern Europe also have important extensive farming systems, such as upland areas and mountain regions, while southern Europe has some intensive agriculture, such as intensive horticultural crop production.

The net balance between the positive aspects of farming (e.g. maintenance of cultivated landscapes and rural areas, carbon sequestration, water management) and the negative aspects (e.g. poor water quality, overuse of water, air pollution, loss of biodiversity, soil degradation and waste) differs between regions. It depends on a number of factors, ranging from natural ones (soil, water availability, climate) to farm management practices (intensification/extensification, agro-environment measures).

Eco-efficiency in agriculture in EU Member States Figure 6.1.



Source: EMEP, IPCC, ECPA, OECD, FAO and Eurostat

6.2. Trends in agriculture

Over past decades, EU agriculture has become more specialised and concentrated in areas with the lowest production costs. This process, driven largely by technological change and cheaper and faster transport, has been accomplished by increasing intensification on the best land and in key production areas near important markets. For example, 80 % of the EU's intensive production occurs in coastal areas of the North Sea and the English Channel. Higher labour costs and declining prices have also contributed to the reduced viability of farming in marginal areas where afforestation, marginalisation or even complete abandonment occur in some places.

Over the past 20 years, the area of land in productive agriculture fell by 5 % and the amount of arable land increased at the expense of permanent grassland. However, farmers manage 44 % of Europe's land area, a fact that underlines agriculture's key role in society.

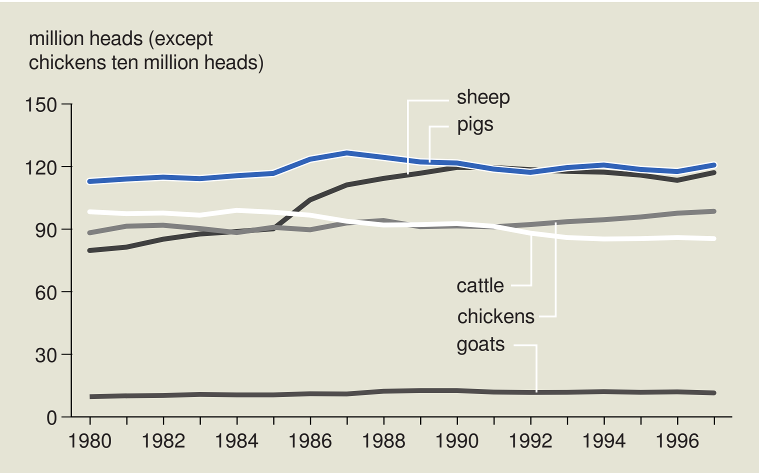
Efforts to curb pressures on the environment include the production of Codes of Good Agricultural Practice, giving guidance to farmers and advisors on how to minimise emissions to the environment (MAFF, 1988). Many Member States have introduced measures in response to the Nitrates Directive, but have generally not met its requirements. Some Member States have introduced pesticide and fertiliser taxes, and agro-environment measures following the 1992 CAP reform. Under Agenda 2000, Member States are expected to develop Codes of Good Agricultural Practice embracing the whole range of agriculture inputs of environmental relevance.

6.2.1. Livestock numbers

Apart from cattle, overall numbers of pigs, poultry, sheep and goats have increased (Figure 6.2), but the total agricultural area used by these types of farms has fallen. This reflects the trend towards specialisation and intensification. Recent food scares, concern about farm-animal welfare and the risks associated with feedstuffs fed to farm animals have raised questions about some modern farming systems.

High densities of animal populations are associated with excessive concentrations of manure – and an increased risk of water pollution (see Chapter 13). The contribution of livestock to gaseous emissions is also significant – about 80-90 % of total EU ammonia emissions (from animal housing) and 45 % of total methane emissions arise from animal husbandry (see Figures 10.12 and 8.4).

Figure 6.2. **Livestock numbers in EEA member countries**



Notes: Chicken numbers are expressed as 10 million heads.
Goat numbers not included for Denmark, Ireland, Sweden and the UK.
Chicken numbers not included for Liechtenstein.
Source: FAO

Livestock numbers in EEA member countries have increased overall. In certain regions, farms have become more concentrated and the efficiency of livestock production has increased.

6.2.2. Fertiliser use

The downward trend in the use of inorganic fertiliser (nitrogen and phosphorus) has recently been reversed (Figure 6.3 and Table 6.1). The use of manure to supplement or replace inorganic fertilisers may explain some of the initial decrease.

Legislation such as the Nitrates Directive and Agri-environment Regulation EEC/2078/92 also seek to limit nutrient losses to freshwater bodies. During the mid-1990s, Norway and Sweden introduced fertiliser taxes – with Sweden aiming to reduce nitrogen consumption by 20 % by 2000 (Pretty, 1998). Opinion is divided as to whether these instruments have had an appreciable effect on reducing fertiliser use.

Agriculture continues to be the main source of nitrate pollution in Europe. The nitrogen surplus in the EU did not fall between 1990 and 1995 (see Figure 13.3), affecting water quality and potentially human health.

6.2.3. Irrigated land

Agriculture is a major consumer of water (30 % of total water use in EEA member countries; see Figure 12.3) compared with other sectors. Between 1980 and 1996, the area of irrigated land expanded significantly (by about 15 %), particularly in southern Europe (Figure 6.4). For example, the irrigated area in France more than tripled from 870 000 hectares to 2.5 million hectares between 1980 and 1995.

The main irrigated crop in terms of area is maize. Irrigation is also used on other annual or permanent crops to boost or stabilise yields as well as to ensure high-quality produce. The expansion of irrigated area has increased the demand and use of non-farm resources, thus exerting other burdens on the environment besides water stress. More efficient ways of irrigating land such as drip irrigation have reduced dosage rates, but this improvement has often been offset by an increase in the irrigated area.

The loss of agricultural habitats associated with the drier, traditionally less intensive

Use of nitrogen and phosphorus fertilisers has decreased overall, but this trend has been reversed since 1992. Despite these reductions, crop yields have continued to increase.

farming systems of southern Europe is also of concern.

6.2.4. Pesticide use

The amount of pesticide (including insecticide, fungicide, herbicide and other plant protection products) used in terms of active ingredient has fallen since the early 1990s, both in absolute amounts and in application rate (Figure 6.5). The 1992 CAP reform may have contributed to a decrease in the average use of pesticide per hectare. Another factor is the simultaneous improvement in pesticides – making them more effective and application-specific, but also more toxic. However, a slight increase in use has occurred since 1995. Denmark, Finland, France, Germany, the Netherlands and Sweden have set targets to reduce pesticide use. Such an aim is also suggested by the European Commission's fifth environmental action programme. Nevertheless, modern agriculture continues to rely heavily on this non-farm resource.

With a few exceptions such as atrazine, residue concentrations do not appear to be falling despite EU legislation relating to pesticide residues in treated crops, surface drinking waters and groundwater (EEA, 1999).

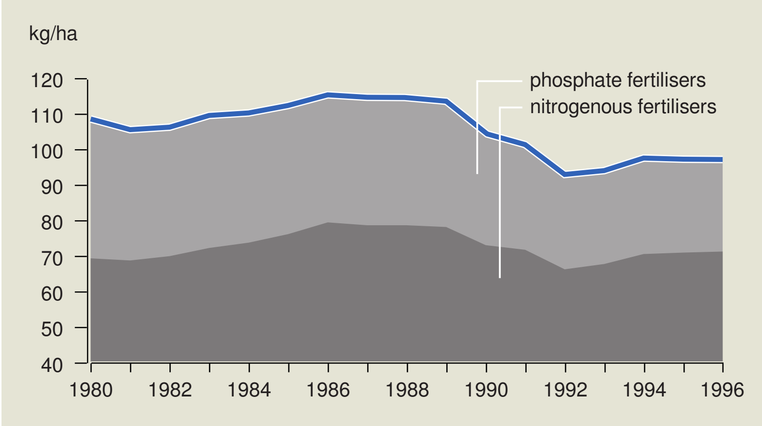
6.2.5. Environment-friendly farming methods

While technical change has driven down costs for most agricultural products, many consumers are now expressing a preference for food produced using more traditional systems and giving priority to farm-animals' welfare. At the same time, the 1992 CAP reform introduced measures to reward farmers for public services such as maintenance of landscapes and to induce farmers to reduce the environmental impact of their activities through measures such as favouring organic production.

The area under organic farming in EEA member countries increased tenfold between 1985 and 1997 (Figure 6.6). This rate

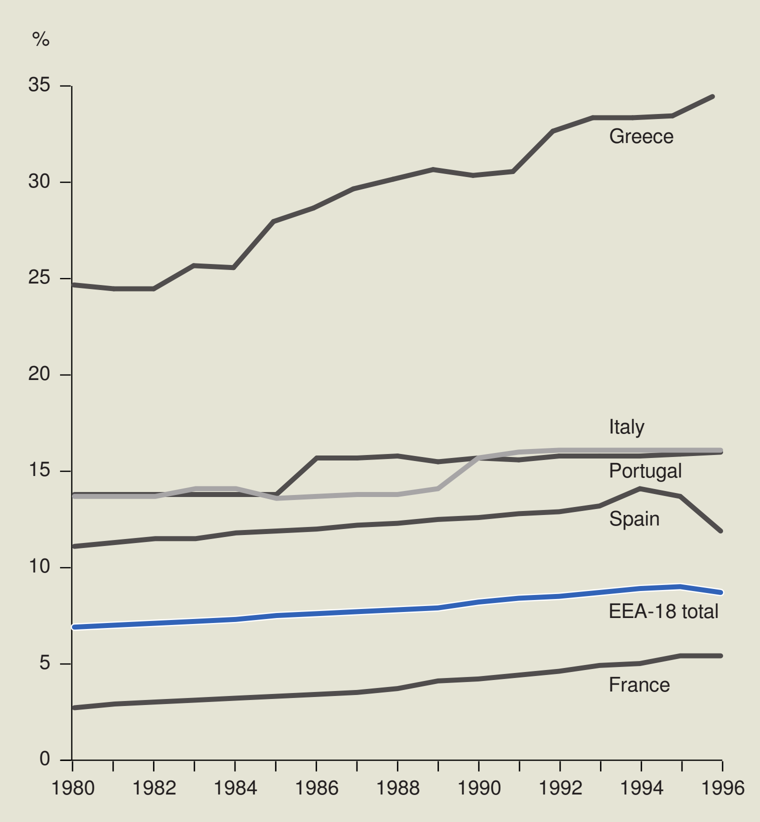
The area of irrigated land has increased slightly, notably in southern European countries.

Fertiliser consumption per unit area of agricultural land in EEA member countries Figure 6.3.



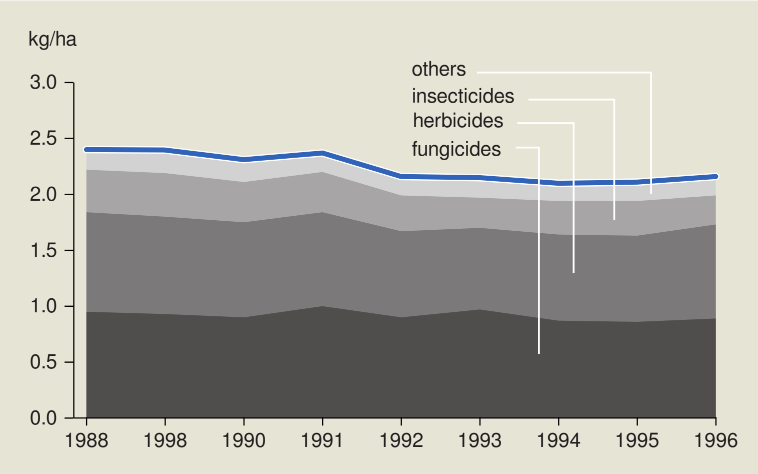
Note: Liechtenstein not included.
Source: FAO

Irrigated land as a percentage of total land area in southern and total EEA member countries Figure 6.4.



Note: Data for Iceland, Ireland and Liechtenstein not included in total.
For Denmark and the Netherlands, data shows all areas that can be irrigated (i.e. farms have equipment for irrigation) and no distinction is made between total irrigated areas and actual irrigation.
Source: FAO, Eurostat/NewCronos

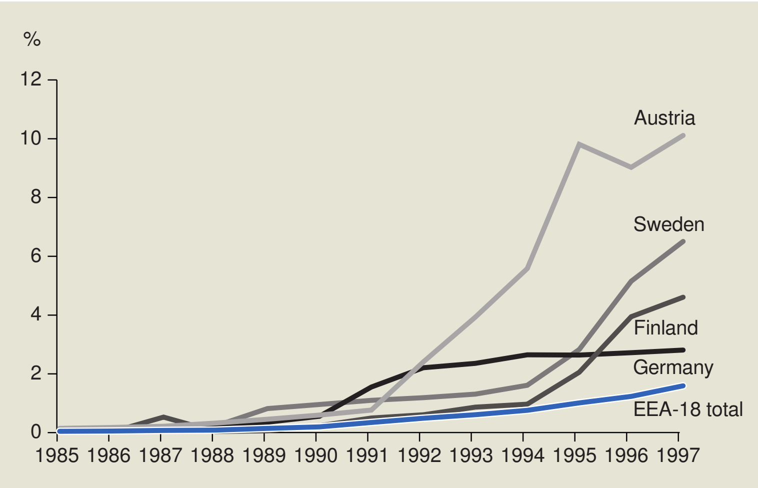
Figure 6.5.	**Average pesticide consumption per unit area of agricultural land in EEA member countries**



Note: Weight of active ingredients used.
Source: Eurostat; FAO; ECPA; OECD

☹ Despite greater awareness of the harm pesticides cause to the environment and human health, dependence on pesticides has not diminished.

Figure 6.6.	**Area under organic farming as a percentage of total agricultural area in EEA member countries**



Note: Accuracy of data varies between countries.
Source: FAO; Eurostat; Lampkin

☺ The rate of uptake of organic farming has increased significantly. However, only a small number of Member States have set targets to expand the area under organic farming, and the area of EEA member countries under organic farming remains low at less than 2 %.

of growth continues. However, the total area (2.9 million hectare) remains small at just under 2 % of total agricultural land. The increase in organic farming is unlikely to have had a significant effect yet on the total environmental burden from agriculture.

Organic farming should not be considered the ultimate solution to agriculture's environmental problems. Individual organic farms often vary widely, and the environmental benefits of organic farming are dissimilar and diverse. Other forms of farming systems such as Integrated Crop Management also contribute to reducing the environmental burden from agriculture. Nevertheless, the area under organic farming is a useful indicator of progress towards more environment-friendly agriculture.

Another indicator of environment-friendly developments in agriculture is the area under specific management contracts. Agreements that give more attention to maintaining biodiversity and landscape are now in place covering more than 22 million hectares (20 % of the utilised agricultural area of the EU). This exceeds the target set in the EU's fifth environmental action programme of 15 % coverage of agricultural land.

While all Member States made use of the opportunities under the agri-environmental Regulation 2078/92, the extent of uptake varies considerably from more than 60 % of farms in Austria, Finland and Sweden to 7 % or less in Belgium, Greece, Spain and Italy. However, area alone gives no indication of the environmental performance of the scheme as many of the programmes lack precision in their protective objectives and have no monitoring provisions (Birdlife International, 1996).

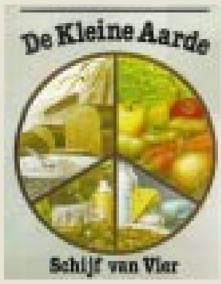
Expenditure on management contracts remains extremely modest relative to the total CAP budget (only 4 % of the European Agriculture Guidance and Guarantee Fund). It is sometimes more profitable for farmers to receive an EU payment for arable set-aside than to enter an environmental scheme. Despite these limitations, the 1992 CAP reform have heightened awareness of the environmental importance of agriculture.

6.3. Indicator development

This chapter has a strong focus on agricultural inputs and thus on the negative environmental impacts of agriculture. In future editions, agri-environment indicators (currently under development) – including indicators on farmers' activities in landscape management – will also show the positive impact of agriculture on landscapes and biodiversity. Similar examples of farmers' activities, together with indicators on price premiums, could contribute to a better coverage of response indicators. More attention might be given to the spatial diversity in agriculture together with better indicators on intensification and extensification processes.

At the same time, existing indicators will be improved to express their environmental significance more clearly, e.g. irrigated area might include quantity of water and its source, fertiliser use might include nutrient balances, and pesticide use might include toxicity data.

Agricultural footprints



The population of Europe is rising (now nearly 375 million), while the land area used for agriculture in Europe is falling. At the same time, meat consumption per capita has increased by 0.5 kg since 1990. Every kilo of meat produced uses 5-21 kg of animal feed, which has to be grown somewhere. Many countries rely on imports of animal fodder. The Netherlands is an extreme example, where the agricultural industry uses about 2.5 times the available agricultural land area in the Netherlands for growing fodder, by using land in other countries.

In addition, the 94 kg/year of meat eaten on average by European adults is far in excess of the recommended 12-15 % of calorie intake from protein sources. Overeating is a contributing factor to reported increases in obesity – one of today's main preventable causes of ill-health.

For the past 25 years, the Dutch institution De Kleine Aarde has been promoting these findings. De Kleine Aarde was set up as an experimental and educational centre for organic agriculture, food and sustainable building. The centre has developed a 10-point sustainable agriculture 'menu' and a pie-diagram guide to a healthy diet focusing on non-meat products. The diagram, which illustrates the relative proportions of foodstuffs needed for a balanced diet, is part of the centre's campaign to halve meat consumption in the Netherlands. It has also been adopted by the official food and health information offices for use in their campaigns.

Source: http://ificinfo.health.org/brochure/pyramid.htm; http://www.pz.nl/dekleineaarde/huis.htm

Nitrogen and phosphorus fertiliser consumption per unit area of agricultural land in EEA member countries Table 6.1.

Units: kg/ha

	1980	1985	1990	1991	1992	1993	1994	1995	1996
Austria	70.5	72.8	60.4	58.7	54.5	53.6	52.2	52.9	48.6
Belgium + Luxembourg	191.6	188.6	177.9	167.4	155.1	148.3	146.8	145.8	145.8
Denmark	167.0	172.1	173.4	160.9	144.0	138.8	136.4	124.7	125.6
Finland		139.9	126.6	95.5	101.3	111.1	110.9	119.2	117.8
France	123.5	123.2	125.5	125.6	105.0	107.4	111.1	113.9	119.2
Germany			132.9	130.7	128.0	118.1	129.3	125.2	125.4
Greece	126.1	160.4	156.2	148.5	145.0	119.7	120.2	123.9	127.4
Ireland	73.6	78.2	112.1	111.2	111.0	121.9	125.6		
Italy	99.9	98.2	88.1	92.6	90.7				
Netherlands	280.0	287.8	231.4	234.5	230.8	221.6	237.2	229.7	233.8
Portugal		45.3	57.31	51.9	51.2	50.4	50.3	52.1	56.9
Spain	50.6	52.4	59.31	56.6	47.0	54.5	57.8	55.2	57.8
Sweden		132.2	78.77	65.0	77.0	83.3	78.7	85.6	79.3
UK	89.0	110.5	106.65	97.7	89.1	96.0	102.2	100.6	101.2
Iceland	10.18	8.7	7.70	8.0	8.5	7.8	7.2		
Norway	184.4	168.4	149.2	143.4	140.3	137.0	137.6		
EEA	**108.2**	**111.5**	**104.0**	**100.9**	**92.6**	**93.8**	**97.2**	**96.9**	**96.8**
EU	**109.3**	**112.7**	**105.3**	**102.1**	**93.7**	**94.9**	**98.5**	**98.1**	**98.0**

Notes: Total nitrogen and phosphorus fertilisers. Liechtenstein not included. Totals for EU and EEA include estimates for missing years and countries.
Source: FAO; Eurostat/NewCronos

6.4. References and further reading

EEA (1999). *Groundwater quality and quantity in Europe*. Environmental assessment report No 3. European Environment Agency, Copenhagen.

Birdlife International (1996). *Nature conservation benefits of plans under Agri-environment Regulation 2078/92*. Birdlife International, RSPB, The Lodge, Sandy, Beds, SG19 2DL, UK.

MAFF (1998). *Code of Good Agricultural Practice for the Protection of Water.* MAFF Publications, Admail 6000, London, UK.

Potter, C. (1970). 'Europe's changing farmed landscapes' in *Farming and birds in Europe: the Common Agricultural Policy and its implications for bird conservation.* Eds: D. J. Pain and M.W. Pienkowski. Academic Press, London.

Pretty, J. (1998). *The Living Land*. Earthscan Publications Ltd, London.

Isart J. and Llerena J.J. (eds) (1996*). Biodiversity and land use: the role of organic farming.* Proceedings of 1st ENOF workshop, Bonn, 1995. European Network for Organic Farming, Barcelona, Spain.

7. Industry

indicator	policy issue	DPSIR	assessment
industry eco-efficiency	has the sector been succesful in becoming more environmentally efficient?	pressure	☺

The service sector is taking over from Europe's manufacturing industry as the cornerstone of the economy. At the same time, manufacturing industry is becoming more specialised and focused on high value added products. These developments, together with many years of regulatory controls, have led to an increase in eco-efficiency for the main air pollutants.

7.1. Eco-efficiency in industry

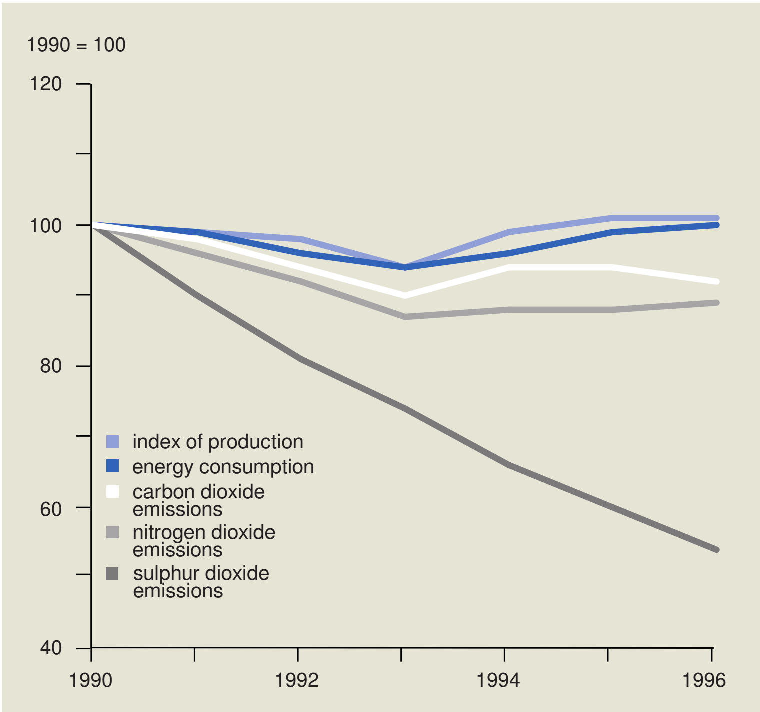
The manufacturing industry sector covers a broad spectrum of manufacturing and processing activities whose products range from raw materials to consumer goods. In 1997, manufacturing and construction accounted for around 27 % of total value added in the EU – slightly lower than the 30 % in 1990. The industry sector's share of total employed persons in the EU is also around 27 %.

The many pollutant emissions from industry have traditionally been subject to regulatory control. Whereas the range of instruments for reducing pollution from other sectors has broadened to include taxes and other instruments for directly internalising environmental costs, EU controls on industrial pollution are largely based on media-specific (i.e. air, water and waste) environmental laws. Recent developments include integrated product policy, eco-efficiency improvements, environmental agreements and eco-management.

The Integrated Pollution Prevention and Control (IPPC) Directive, which must be fully implemented in existing plants by 2007, forms the new centrepiece of EU industrial pollution control. Although restricted to large installations, it breaks new ground by establishing an integrated regulatory framework in which air, water and waste emissions are viewed as a whole under a single environmental permit issued by one regulatory authority. The IPPC Directive also demands the use of Best Available Techniques (BAT), environmental management, cleaner production and waste reduction.

Existing policies have already succeeded in reducing emissions of the main pollutants (Figure 7.1). Based on energy consumption and selected air emission data, industrial eco-efficiency appears to have improved slightly between 1990 and 1996. The industrial production index dropped steadily until 1993, but reverted to the 1990 level by 1996.

Eco-efficiency in industry in EU Member States Figure 7.1.



Note: 1990 = 100
Source: EEA; Eurostat

☺ Industrial eco-efficiency has improved for the main air pollutants, but not for energy consumption.

Trends for energy consumption and carbon dioxide follow a similar pattern, although carbon dioxide levels fell in 1996. Sulphur dioxide emissions in the EU as a whole dropped steadily during this period.

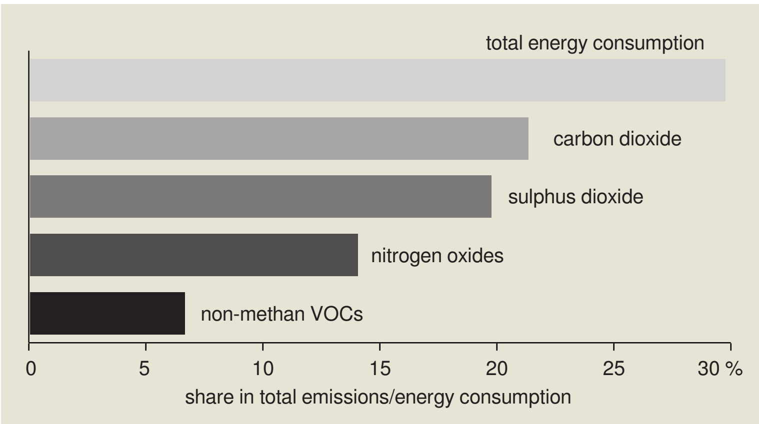
Although these total emissions suggest a positive trend in industrial eco-efficiency, they mask diverging trends between individual Member States, e.g. nitrogen oxide emissions from industry in France and Italy grew during this period. In addition, the pollutants are particularly characteristic of heavy industries such as iron and steel, petroleum refining, pulp and paper, and organic chemicals. Emissions of pollutants such as heavy metals which are more representative of European industry – notably small and medium sized enterprises (SMEs) – are not known. Wastewater and hazardous waste data has not been harmonised and is therefore not considered.

In line with its share of economic production, industry accounted for around 30 % of total energy consumption and 20 % of carbon dioxide and sulphur dioxide emissions in 1996 (Figure 7.2). This makes the sector an important stakeholder with respect to climate change and acidification issues. Its contribution to problems associated with emissions of nitrogen oxide and non-methane volatile organic compounds (NMVOCs) such as summer smog is moderate.

Industry in the EU uses an estimated 25.4 billion m^3 of water per year – some 10 % of abstracted water (see Figure 12.3). The amount used varies greatly between countries, but inconsistent inclusion of cooling water for power generation in national statistics limits comparisons. In many European countries (e.g. France, the Netherlands and the UK), industrial water demand fell throughout the 1980s and 1990s. This is mainly due to economic recession forcing plant closures in industries that use large amounts of water (e.g. textiles and steel mills) and a move towards less water-intensive service industries. Water conservation and increased recycling have also contributed to the decline. Internalisation of environmental costs for water resources is expected to be a major factor in increased conservation. Charges on water supply and wastewater treatment have been increasing steadily across the EU partly to fund infrastructure improvements and partly due to privatisation.

EU waste statistics are currently limited. However, it is estimated that manufacturing accounts for more than a quarter of the waste generated in the EU (EEA, 1999).

Figure 7.2. **Industry environmental profile in EU Member States, 1996**



Source: EEA

7.2. Trends in industry

Significant changes in the sector have taken place due to globalisation, innovation and consumer demand. Between 1985 and 1995, employment increased in only three manufacturing sectors (chemicals, plastics, and computers and office equipment) – and then only marginally (Table 7.1). In contrast, service-sector employment grew by nearly 15 % during the same period, reflecting both the overall economic shift towards services and the impact of technology on employment. This change has been driven by market liberalisation (both globally and through the Single Market) and technological innovation. However, manufacturing still provides the basis for most service activities and will therefore remain key to the EU economy. Although employment can not be correlated directly with industrial pollution, these statistics reflect important trends in the sector.

Despite declining employment in the manufacturing sectors, national income as measured by gross domestic product (GDP) has been growing steadily since 1970. In general, the disposable income of families across the EU has also increased. Consumption has shifted towards sophisticated finished goods, while basic heavy industry (e.g. iron and steel) is increasingly giving way to manufacturing processes with more value-added products.

Countries outside the EU with cheaper labour and resource costs may be assuming a greater share of heavy industrial production, as the EU's industrial sector becomes more specialised and less resource-intensive, and its service sector grows.

The beginning of a move from products to services is also noticeable within the manufacturing sector itself as producers assume responsibility for material re-use and recovery (e.g. for cars and office equipment) partly due to producer-responsibility legislation. Purchase of goods sometimes includes services for maintenance, recycling component parts, re-using/recycling packaging, etc. One aim of sustainable development policies is to shift the focus from selling products (e.g. pesticides and solvents) to providing a service function (e.g. plant protection and degreasing services), thus disconnecting economic growth from increased consumption of natural resources.

The need for environmentally responsible measures is particularly urgent in the chemicals sector, where Europe is a world leader accounting for 38 % of global turnover. Until 1993, chemical production in the EU increased roughly in line with GDP, after which it began to grow faster. This rapid pace of development has been accompanied by uncertainty: the exact number of chemicals currently on the market is unknown (estimates vary from 20 000 to 70 000) and toxicity data is lacking for most of them (thereby limiting risk assessment). The expected continuation of economic growth, coupled with increases in agricultural production, could result in a 30-50 % growth in chemical production for most EU countries by 2010. The increasing volume and variety of substances released and accumulating in the environment increases the risk of damage to human health or ecosystems.

7.3. Indicator development

Due to the lack of harmonisation in the collection and processing of environmental data at an EU level, the indicator in this chapter is limited to energy use and emissions of air pollutants. Greater accuracy and consistency of emissions estimates is a priority. Other types of environmental pressures need to be further developed such as waste generation and disposal, water pollution and resource-use efficiency.

White paper = bad paper?

The paper industry traditionally relies on the bleaching properties of chlorine to produce white paper products. A typical paper mill discharges around 35 tonnes/day of organochlorides, while a mill using chlorine dioxide discharges about 7-10 tonnes/day. Many organochlorides are persistent organic pollutants (POPs), characterised by their persistence in the environment and accumulation in living organisms. However, organochloride emissions can be avoided by adopting chlorine-free bleaching methods such as oxygen delignification. Chlorine-free methods have the added advantage of allowing mills to move towards a closed-loop system, thus reducing water and chemical use. These savings are estimated to offset the capital cost of converting a mill to chlorine-free technology in just a few years.

Today at least 55 paper mills in the world use chlorine-free technology. Most of these mills are in Scandinavia, but the technology is spreading throughout Europe with several Portuguese and Spanish mills currently converting to totally chlorine-free methods.

Levels and changes in salaried employment in the EU, 1985-1995 Table 7.1.

Sector	Employment 1995 (1 000)	Change in employment 1985-1995 (%)
Iron and steel	769	-31.3
Non-ferrous metals	216	-22.9
Non-metallic mineral products	1 388	-6.3
Pharmaceuticals	1 344	-9.9
Basic and speciality chemicals	362	2.5
Metal products	2 539	-2.5
Mechanical engineering	2 781	-11.2
Office equipment, computers and precision instruments	732	0.3
Electrical engineering	2 729	-11.7
Motor vehicles	1 967	-8.9
Aerospace equipment	356	-20.6
Food, drink and tobacco	3 069	-8.6
Textiles and clothing	2 831	-25.7
Paper, printing and publishing	2 059	-0.6
Miscellaneous manufacturing industries	2 234	-17.4
Rubber and plastics	1 205	3.0
Total manufacturing	**26 581**	**-11.4**

Source: DG Industry; Eurostat

Sustainability enterprise

The Swiss company, Sustainable Asset Management, has teamed up with Dow Jones to create a global sustainability index – the Dow Jones Sustainability Group Index (DGSGI). This index is intended to serve both as a guide to investors and a tool for benchmarking companies across different industry sectors. It is based on criteria that include: efficient, effective and economic use of human and natural resources; company management; production; growth; competitiveness, and responsiveness to social change.

The DJSGI is fully integrated with and derived from the Dow Jones Global Index. It currently contains 200 companies that represent the sustainability top 10 % for 73 separate industry groups in 33 countries. Although the DJSGI was launched only in September 1999, pilot results showed that companies which score highly on the basis of sustainability criteria also tend to show better-than-average returns on investment.

Source: DJSGI www.sustainability-index.com.

For the future, a differentiation by industry branch level is needed, for example, with respect to eco-efficiency developments. Particular attention also needs to be given to small and medium-sized enterprises (SMEs). Response indicators covering prices, taxes, subsidies and voluntary agreements together with analysis of their effectiveness, would also be desirable.

7.4. References and further reading

European Commission, DG Industry (1997). *Panorama of EU Industry, 1997.* Brussels/ Luxembourg.

EEA (1999). *Environment in the European Union at the turn of the century.* European Environment Agency, Copenhagen.

Table 7.2. **Production index in EU Member States - annual changes**

Note: Total industry = NACE Revision 1 sections C to F (i.e. including construction).
* Insufficient data available.
Source: Eurostat

Unit: percent

Country	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998
Austria	*	*	*	*	*	*	*	*	*	*
Belgium	1	8	-4	4	-8	3	6	1	4	3
Denmark	5	-1	-2	2	-4	10	5	2	6	1
Finland	*	-1	-9	-3	1	9	6	4	9	7
France	*	2	-1	-1	-4	3	2	-1	3	4
Germany	4	5	2	-1	-7	4	1	0	3	4
Greece	*	*	*	*	*	*	*	*	*	*
Ireland	3	5	3	9	6	12	19	8	15	16
Italy	7	0	0	-1	-3	3	5	-1	3	0
Luxembourg	3	1	1	0	-3	3	0	-3	5	3
Netherlands	*	1	1	-1	-2	3	2	2	2	1
Portugal	*	*	*	*	*	*	*	*	*	*
Spain	*	1	0	-5	-5	6	5	-1	5	7
Sweden	*	*	*	*	*	*	*	*	*	*
UK	*	0	-4	0	1	5	2	1	*	*
EU	*****	**2**	**-1**	**-1**	**-4**	**4**	**3**	**0**	**3**	**3**

8. Climate change

indicator	policy issue	DPSIR	assessment
emission of greenhouse gases	are the Kyoto Protocol targets within reach?	pressure	😐
carbon dioxide emissions	how are the emissions of each of the gases developing, and which sectors contribute?	pressure	😐
methane emissions	- „ -	pressure	☺
nitrous oxide emissions	- „ -	pressure	😐
fluorocarbon emissions	- „ -	pressure	☹
global and European average temperatures	is the delopment of average temperature staying below provisional 'sustainable targets'?	impact	☹

Climate change is widely recognised as a serious potential threat to the world's environment. The problem is being addressed through the United Nations Framework Convention on Climate Change (UNFCCC) and has been identified by the EU as one of the key environmental themes to be tackled. However, total greenhouse gas emissions have increased since 1990 in most EEA member countries and are projected to increase in the EU, under a baseline scenario, by 6 % between 1990 and 2010. Additional policies and measures are required to achieve the Kyoto Protocol targets. Substantial additional reductions in global emission reductions will be needed to reach potentially 'sustainable' temperature levels and concentrations of greenhouse gases in the atmosphere.

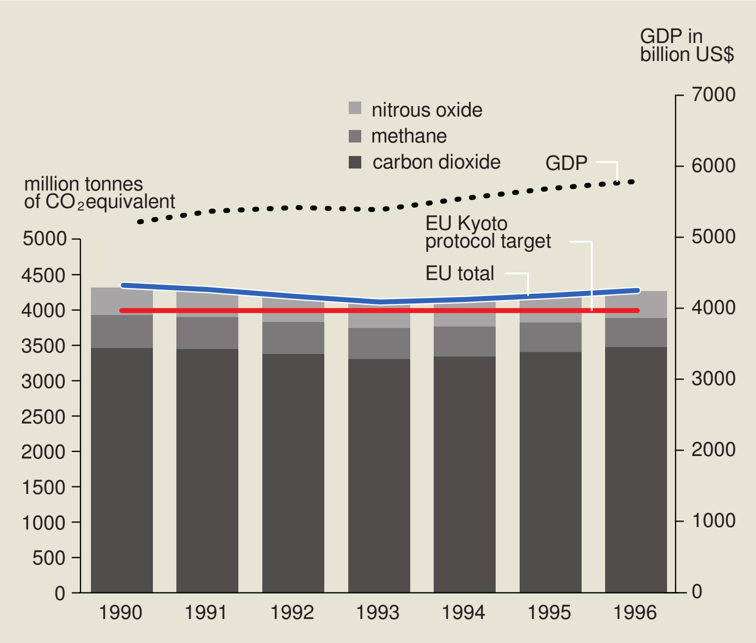
The greenhouse effect is a natural phenomenon. However, over the past century atmospheric concentrations of anthropogenic greenhouse gases – carbon dioxide (CO_2), methane, nitrous oxide and halogenated compounds such as chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride – have risen, and a considerable increase, in historic terms, in global mean temperatures has been observed. There is increasing evidence that greenhouse gas emissions from human activities are causing an enhanced greenhouse effect. This takes the form of global warming, leading to climate change (IPCC, 1996). Climate change is expected to have widespread consequences, including: sea-level rise and possible flooding of low-lying areas; melting of glaciers and sea ice; changes in rainfall patterns with implications for floods and droughts; and more climatic extremes (especially high temperatures). These effects will have major impacts on ecosystems, health, water resources and key economic sectors such as agriculture.

Globally, carbon dioxide is estimated to have made the biggest contribution to global warming (64 %), followed by methane (20 %), nitrous oxide (6 %) and halogenated compounds (10 %) (IPCC, 1996). Tropospheric ozone (see Chapter 10) also adds to global warming. Aerosols can have a cooling effect, partly offsetting global warming, but this effect is regional and short-lived. As well as contributing to global warming, CFCs are also ozone-depleting substances (see Chapter 9).

The EU Kyoto Protocol target for 2008-2012 requires a reduction of emissions of six greenhouse gases by 8 % from 1990 levels. Total EU emissions of the three main greenhouse gases have fallen by 1 % from 1990 to 1996 (Figure 8.1). Carbon dioxide makes the largest contribution to EU emissions (79 %), followed by methane (11 %) and nitrous oxide (9 %). The Kyoto Protocol target also includes HFCs, PFCs and sulphur hexafluoride; emissions of these substances are not shown in Figure 8.1 owing to lack of data from all EU Member States. Initial estimates indicate that these gases together amount to about 1 % of total EU greenhouse gas emissions.

The dominant human activity or driving force for climate change is fossil-fuel combustion (due to its carbon dioxide emissions). Other activities that contribute to

Figure 8.1. **Total EU emissions of carbon dioxide, methane and nitrous oxide**



Note: Global warming potentials used: carbon dioxide 1, methane 21, and nitrous oxide 310.
Source: EEA

Total EU greenhouse gas emissions have fallen slightly from 1990 (but only in a few Member States), while GDP has risen. However, emissions are projected to increase by 6 % between 1990 and 2010, making additional policies and measures necessary to achieve the Kyoto Protocol target.

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.

Gases and particles emitted from aircraft directly to the upper troposphere and lower stratosphere also contribute to climate change. In 1992, carbon dioxide emissions from aircraft produced 2 % of total anthropogenic carbon dioxide emissions (accounting for around 13 % of all global carbon dioxide emissions from transport). Global aviation has grown rapidly over the past 30 years. This trend is expected to continue with passenger air travel increasing by 5 % per year and total aviation fuel use (including passenger, freight and military) by 3 % per year between 1990 and 2015 (IPCC, 1999). Under the IPCC baseline scenario, carbon dioxide emissions from global aviation are expected to grow by a factor of about three by 2050. The contribution of aircraft to global warming is expected to increase from 3.5 % in 1992 to 5 % by 2050.

8.1. Greenhouse gas policy update

The United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the 1992 UN Conference on Environment and Development in Rio de Janeiro when developed countries made a commitment to aim 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 EU, 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, methane, nitrous oxide, HFCs, PFCs and sulphur hexafluoride 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.

By September 1999, 84 Parties to the UNFCCC – including the EU and the US – had signed the Kyoto Protocol. However, only 16 Parties have ratified it and, as yet, no major developed country has ratified. The Protocol has therefore not yet entered into force. To become binding international law, it has to be ratified by 55 Parties and the developed countries that have ratified must account for at least 55 % of total carbon dioxide emissions from developed countries in 1990.

The EU and its Member States are committed to reducing emissions by 8 % below the 1990 level and the central and eastern European (CEE) countries to reductions of 0-8 %. In June 1998, a system of 'burden sharing' or 'target sharing' was agreed by EU Member States (European Commission, 1998). Table 8.1 summarises the requirements of this agreement.

An emission level of about 3 840 million tonnes of carbon dioxide equivalents is required by 2008-2012 to meet the EU target (see Table 8.1). To reach this target, a reduction of almost 600 million tonnes is required from the estimated projected emissions for 2010 under a baseline scenario of 4 420 million tonnes of carbon dioxide equivalents (see Section 8.2.1).

The Kyoto Protocol introduced three important new 'flexibility mechanisms' (the so-called Kyoto Mechanisms) to help reach the targets. These mechanisms include emissions trading between developed countries, joint implementation among developed countries, and co-operation between developed and developing countries in a 'clean-development mechanism'.

Emissions trading allows Parties that reduce their greenhouse gas emissions below their assigned amount to sell part of their emission allowance to other Parties. However, some countries, e.g. Russia, could have large quantities of unused assigned amounts of emissions available for trading. This issue is often referred to as trading in 'hot air', since it could imply that no real reduction in emissions would occur. The extent of this problem is uncertain as it depends on the economic development of countries like Russia. Some Member States have announced plans to use the Kyoto Mechanisms to reach their commitments. For example, the Netherlands has indicated it expects to fulfil 50 % of its required emission reductions in this way. To ensure that domestic measures are also taken to limit emissions, the EU Council has proposed a numerical limit on the use of Kyoto mechanisms (European Commission, 1999a).

Total emissions of carbon dioxide, methane and nitrous oxide from EU Member States and the EU 'burden-sharing' agreement Table 8.1.

	Emissions 1990 (million tonnes CO_2 equivalent)	Emissions 1996 (million tonnes CO_2 equivalent)	% change 1990-1996	Burden sharing 2008-2012 (% from 1990)	Burden sharing annual emissions 2008-2012 (million tonnes CO_2 equivalent)
Austria	74	76	3	-13	64
Belgium	137	153	12	-7.5	127
Denmark	70	90	29	-21	55
Finland	70	78	11	0	70
France	546	550	0	0	546
Germany	1 201	1 063	-11	-21	949
Greece	104	111	7	25	130
Ireland	57	60	5	13	64
Italy	521	552	6	-6.5	487
Luxembourg	14	8	-43	-28	10
Netherlands	209	233	12	-6	196
Portugal	68	77	13	27	87
Spain	301	311	3	15	347
Sweden	69	77	11	4	72
UK	726	684	-6	-12.5	636
EU total	**4 167**	**4 123**	**- 1**	**-8**	**3 840**

Note: HFCs, PFCs and sulphur hexafluoride are excluded due to lack of data. 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 the following estimates for Denmark: 76 million tonnes for both 1990 and 1996. Emissions and removals due to land-use change and forestry (LUCF) are excluded both from this table and elsewhere in the chapter because of major uncertainty in their estimates.
Source: UNFCC, 1998; UNFCCC, 1999a; EEA, 1999b

The Buenos Aires Action Plan adopted at the fourth Conference of Parties in November 1998 (UNFCCC, 1999b) includes work to be finalised in 2000 on: elaborating the practicalities of the Kyoto Mechanisms; technology transfer to developing countries; and financial mechanisms to help developing countries combat the adverse effects of climate change (e.g. through adaptation measures). Work has progressed slowly since then owing to the many complications. These were discussed at the fifth Conference of Parties in Bonn in November 1999, which set the ambitious goal of finalising much of the work plan at the next conference in the Netherlands in November 2000.

8.2. Current and future trends in greenhouse gas emissions in EEA member countries

8.2.1. Total greenhouse gases

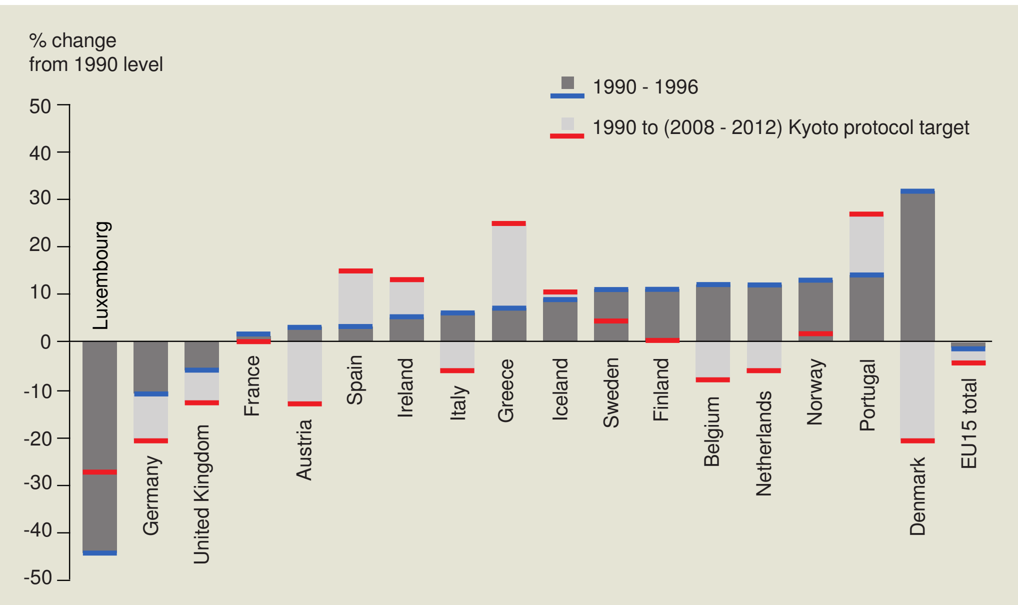
Total EU emissions of the three main greenhouse gases (carbon dioxide, methane and nitrous oxide) fell by 1 % between 1990 to 1996, while GDP increased substantially (see Figure 8.1, Figure 8.2 and Table 8.1). This suggests that there has been some decoupling between emissions and economic growth. The reasons for the small decrease are described below for the individual gases concerned. Greenhouse gas emissions from EU Member States made up 25 % of total emissions from developed countries in 1990 (EEA, 1999b; UNFCCC, 1998; UNFCCC, 1999a).

Figure 8.2 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).

Total EU emissions of carbon dioxide, methane and nitrous oxide in 2010 are projected, under a baseline scenario, to be about 6 % higher than 1990 levels at about 4 420 million tonnes of carbon dioxide equivalents (EEA, 1999a). This baseline scenario assumes future developments of the main socio-economic parameters (such as

Figure 8.2. **Percentage change in total emissions of carbon dioxide, methane and nitrous oxide in EEA member countries since 1990 and their Kyoto Protocol targets**

Notes: Global-warming potentials used: carbon dioxide 1, methane 21, and nitrous oxide 310.
Source: EEA



☹ In Iceland, Norway and most EU Member States, greenhouse gas emissions have increased since 1990. To achieve the Kyoto Protocol targets, substantial reductions in emissions of all six greenhouse gases are required in most EEA member countries.

GDP) and energy use according to a pre-Kyoto 'business-as-usual' scenario prepared by the European Commission. The scenario also assumes the implementation of policies and measures agreed by August 1997.

The 8 % reduction in EU emissions demanded by the Kyoto Protocol target equates to total emissions of the three main greenhouse gases by 2008-2012 of about 3 840 million tonnes of carbon dioxide equivalents (see Table 8.1). This requires a decrease of almost 600 million tonnes from the projected baseline scenario emissions for 2010 (EEA, 1999a). More policies and measures therefore need to be implemented in the EU to achieve the Kyoto Protocol target than were in place in 1997.

8.2.2. Carbon dioxide

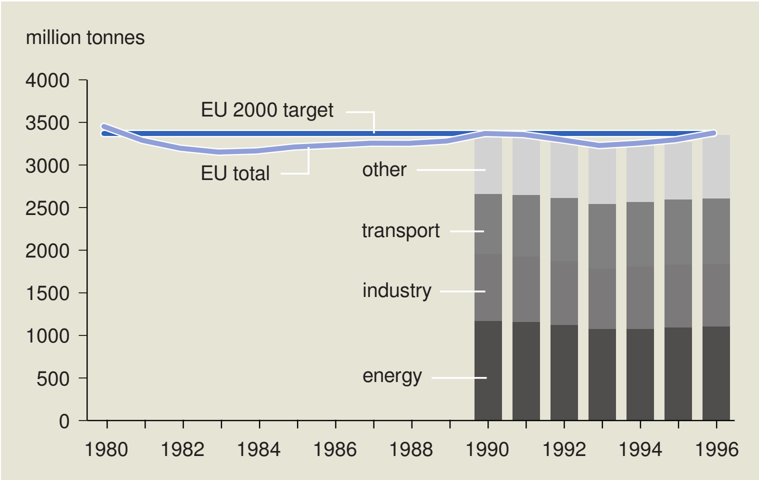
Carbon dioxide emissions from EU Member States decreased initially in the early 1990s, but started to increase again in 1994 (Figure 8.3). The energy sector (mainly power and heat generation) is the main contributor to EU emissions (32 %), followed by transport (22 %) and industry (21 %). Emissions in 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. Between 1990 and 1996, the largest emission reduction took place in Germany, mainly due to economic restructuring in former East Germany 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). Emission trends in EEA member countries are shown in Table 8.2.

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.

In the fifth environmental action programme (5EAP), the EU set a target of stabilising carbon dioxide emissions at 1990 levels by 2000. EU carbon dioxide emissions in 2000 are predicted to be ± 2 % the 1990 level (EEA, 1999a and 1999b).

The projected EU carbon dioxide emissions for 2010 based on the pre-Kyoto baseline scenario are about 8 % above the 1990 level (EEA, 1999a). Transport is the fastest-growing sector, with emissions forecast to increase by 39 % above the 1990 level by 2010. The negotiated agreement with the car industry to reduce carbon dioxide emissions from new passenger cars is not included in the pre-Kyoto baseline scenario. In contrast, industrial carbon dioxide emissions are forecast to decrease by 15 % between 1990 and 2010. Emissions from the domestic/tertiary sector are projected to remain stable due to changes in the market for electrical and heating equipment. Emissions in the power/heat production sector are projected to remain at 1990 levels until 2010, when some increase is expected due to infrastructure changes, such as the retirement of nuclear power plants at the end of their lifetime. Only Germany, Luxembourg and the UK and are projected to have lower carbon dioxide emissions in 2010 than in 1990.

Total EU carbon dioxide emissions Figure 8.3.



Note: The 2000 target is the fifth environmental action programme target of stabilising carbon dioxide emissions at 1990 levels by 2000.
Source: EEA

Total EU carbon dioxide emissions in 1996 were in line with the 5EAP target of stabilising emissions at 1990 levels by 2000. From 1990 to 1996, emissions decreased substantially only in Germany and the UK and then due to specific circumstances. Total EU emissions are projected to increase by 8 % between 1990 and 2010, with the largest increase coming from the transport sector.

Table 8.2. **Carbon dioxide emissions in EEA member countries**

Notes: If electricity import/export corrections were taken into account, the estimates for Denmark would be 59 million tonnes in 1990 and 61 million tonnes in 1996. Emissions from land-use change and forestry (LUCF) are included, but removals are excluded (see Table 8.1).
Source: UNFCCC, 1998; UNFCC, 1999a; EEA

	1990 (million tonnes CO_2 equivalent)	**1996 (million tonnes CO_2 equivalent)**	**Change (%)**
Austria	62	64	3
Belgium	115	130	13
Denmark	53	74	40
Finland	59	66	12
France	396	409	3
Germany	1 015	919	-9
Greece	85	92	8
Ireland	31	35	13
Italy	431	448	4
Luxembourg	13	7	- 47
Netherlands	161	186	15
Portugal	47	51	8
Spain	226	229	1
Sweden	55	63	14
UK	584	567	-4
EU total	**3 333**	**3 340**	**0**
Iceland	2.1	2.3	10
Norway	35	41	17

Both in 1995 and in the baseline scenario for 2010, about 50 % of carbon dioxide emissions are related to the combustion of liquid fuels. The relatively small increase (+8 %) in total carbon dioxide emissions compared with the larger projected increase in total energy consumption between 1995 and 2010 is explained by the significant shift that is occurring from solid to gaseous fuels.

8.2.3. Methane

Total EU methane emissions fell by 12 % between 1990 and 1996 (Figure 8.4), 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 during this period were: agriculture (45 %), particularly from ruminant animals (enteric fermentation and manure management); waste treatment and disposal (36 %); and other sources (17 %), mainly 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, 1998a).

Methane emissions in EU Member States are projected, under a baseline scenario, to decrease by 8 % between 1990 and 2010 (EEA, 1999a; AEA, 1998a), mainly due to a large reduction in emissions from coal mining (as coal production declines) and from agriculture (as cattle numbers fall). Reductions from the waste sector, for example through measures to collect and remove landfill gas, are not included in this baseline scenario.

8.2.4. Nitrous oxide

Total EU nitrous oxide emissions were 2 % lower in 1996 than in 1990 (Figure 8.5). 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 largest reductions appear to be due to falling 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, 1998b).

Total EU nitrous oxide emissions are projected, under a baseline scenario, to increase by 9 % between 1990 and 2010 (Ecofys, 1998b; EEA, 1999a), mainly due to increases in emissions from cars with catalytic converters. In this baseline scenario, no reductions are assumed from the industrial sector and only minor reductions from agriculture.

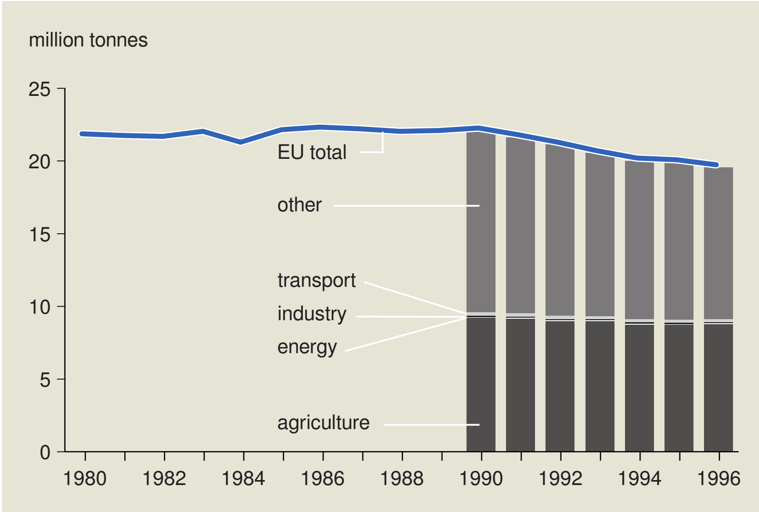
8.2.5. Fluorocarbons

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 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, 1999a). This is about 1 % of total EU emissions of total carbon dioxide, methane and nitrous oxide emissions in 1990 in terms of carbon dioxide equivalents (Ecofys, 1998a).

The largest contribution comes from HFCs (64 %), followed by sulphur hexafluoride (25 %). At present, HFCs are mainly emitted

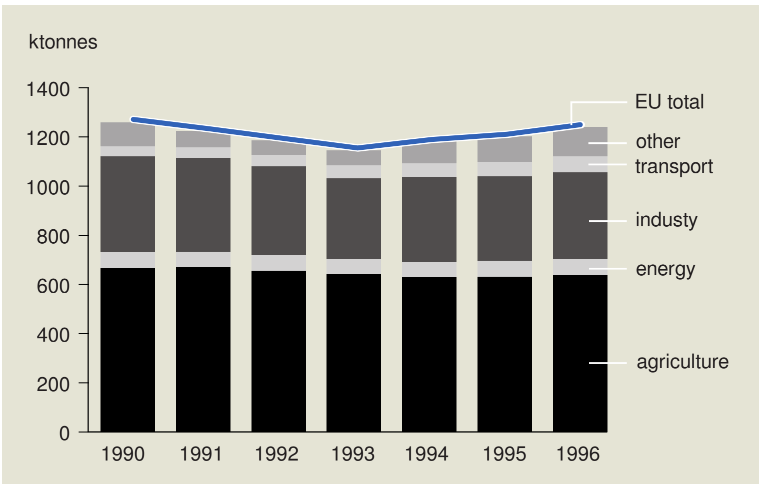
Total EU emissions of methane Figure 8.4.



Note: 'Other' includes coal mining and leaks from natural gas distribution networks and waste treatment/disposal.
Source: EEA

Total EU methane emissions have fallen since 1990, but mainly due to specific circumstances in Germany and the UK. Emissions are projected to decrease by 8 % between 1990 and 2010.

Total EU emissions of nitrous oxide Figure 8.5.



Source: EEA

Since 1990, total EU nitrous oxide emissions have decreased slightly. Emissions are projected to increase by 9 % between 1990 and 2010.

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.

An indicative emission projection for the halogenated gases has been prepared for the European Commission using the limited information available and assuming a baseline scenario (Ecofys, 1998a; March Consulting Group, 1998). In 2010, total EU fluorocarbon emissions are projected to be about 82 million tonnes of carbon dioxide equivalents – an increase of about 40 % compared with 1995 emissions of 58 million tonnes. The contribution from HFCs is expected to increase to 79 %, while the contributions from sulphur hexafluoride and PFCs are expected to decrease to 15 % and 6 % respectively by 2010. The large increase in HFC emissions is due to the use of HFCs as substitutes for CFCs and other ozone-depleting substances whose use is being phased out (see Chapter 9).

☹ Fluorocarbon emissions are currently 1 % of total EU greenhouse emissions. By 2010, they are projected to increase by 40 % from 1990 levels.

8.3. Temperature increase as an indication of climate change

Between 1856 and 1998, yearly deviations from the 1960-1990 global and European mean temperature (Figure 8.6) show an increase of 0.3-0.6 °C. The natural variations for Europe are larger than those for the world average.

Globally, 1998 was the warmest year on record and 1997 the warmest before that. This is partly due to the 1997-1998 El Niño/ Southern Oscillation, the largest on record. This phenomenon is a cycle of natural fluctuations of Pacific Ocean temperatures, resulting in large-scale changes in tropical rainfall and wind patterns. Partly because sea-surface temperatures in the tropical Pacific have moved into a cool El Niño phase, the annual global mean surface temperature in 1999 will, as expected, be substantially lower than the record year of 1998. However, it is still likely to be one of the highest 10 on record (DETR, 1999).

Under the mid-range ('business-as-usual') scenario prepared by the Intergovernmental Panel on Climate Change (IPCC), global carbon dioxide emissions are forecast to increase from 1990 levels by about a factor of two by 2050 and a factor of three by 2100 (IPCC, 1996). Increases in methane and nitrous oxide emissions are projected to be smaller, but still substantial. On this basis, the IPCC projects a 2 °C increase in global mean temperature by 2100 compared with 1990 (the uncertainty range is 1-3.5 °C). Large regional variations are, however, possible.

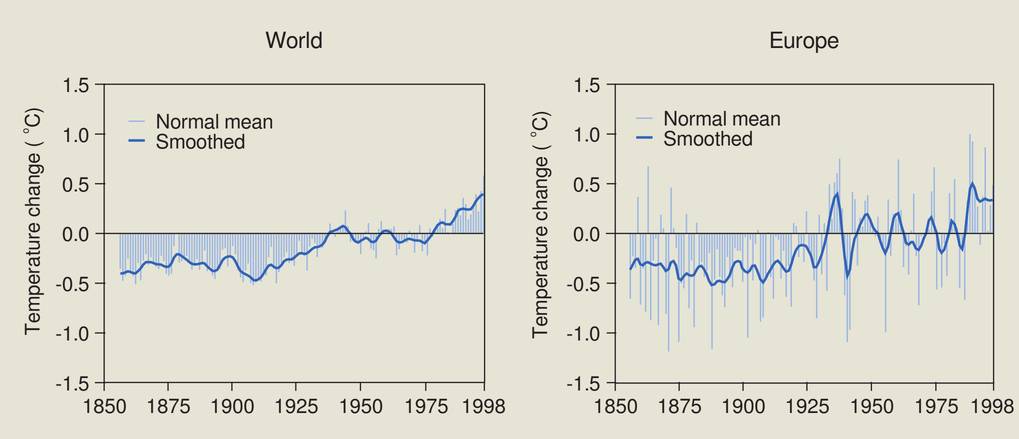
There is no scientific consensus on sustainable target values for the main indicators of the impact of climate change. The EU has adopted a provisional 'sustainable' target of a global average temperature increase of 2 °C above the pre-industrial level (European Community, 1996). This is below the IPCC projections of a temperature increase of 2 °C by 2100 compared to 1990. Another proposed provisional 'sustainable' target is a 0.1 °C temperature rise per decade (Leemans & Hootsman, 1998). However, the IPCC projected rate of warming is more than double this provisional 'sustainable' target. Under the IPCC's baseline emission scenario prepared in 1996, stable potentially 'sustainable' atmospheric concentrations of the main greenhouse gases are unlikely to be realised by 2100. A reduction in global carbon dioxide emissions of 50-70 % would be needed to stabilise carbon dioxide concentrations in the atmosphere at 1990 levels by 2100.

Estimating the future of climate change using scenarios has various sources of uncertainty. These include: assumptions about socio-economic and sectoral developments; anticipated potential reductions in greenhouse gas emissions; the process of transforming emissions into climate change; and poorly understood processes in current climate models. The latest scientific knowledge on climate change will be described in the IPCC's Third Assessment Report, which is expected to be published in 2000/2001.

8.4. Current policies and measures

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

Observed global and European annual mean temperature deviations, 1856-1998 Figure 8.6.



Notes: Temperature plotted as the variation from the 1960-1990 mean. The bars show the annual average as the variation from the 1960-1990 mean and the line the 10-year smoothed trend.
Source: CRU, 1998

☹ Global mean temperature has increased by about 0.3-0.6 °C over the past 100 years. Climate models estimate temperature increases, above 1990 levels, of about 2 °C by the year 2100, thus exceeding the EU's provisional sustainability target.

These include:

- energy/carbon dioxide taxes in various Member States (no agreement has been reached on a comprehensive EU-wide energy products tax);
- a negotiated agreement between the European Commission and the car industry to reduce carbon dioxide emissions from new passenger cars by 25% between 1995 and 2008;
- 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.

8.5. Possible future responses

According to the latest estimates, the additional effort required to meet the EU's Kyoto Protocol target is some 600 million tonnes of carbon dioxide equivalents (see Section 8.2.1; EEA, 1999a; European Commission, 1999b). An important element of EU climate-change policy will be the cost-effectiveness of different policies and measures. Other important criteria for the selection and implementation of measures include political acceptability, fairness (e.g. between sectors), social barriers and industrial competitiveness.

As noted in the Communication on the preparations for implementing the Kyoto Protocol, common and coordinated policies and measures at Community level are expected to be necessary to complement national initiatives (European Commission, 1999b). Possible new policies and measures, additional to those already agreed, are summarised in Table 8.3. Some of these are already being planned or implemented by various Member States.

The potential reduction from national and Community measures could be more than sufficient to achieve the EU's Kyoto target (European Commission, 1999b). Over half the required reductions could be achieved at low cost (less that EUR 5 per tonne of carbon dioxide equivalents). However, the distribution of costs will vary significantly between economic sectors and Member States.

According to a preliminary analysis (EEA, 1999b; EEA, 1999c), the total forest carbon sink for EU Member States is 1-10 million tonnes of carbon per year (0.1-1 % of total

EU carbon dioxide emissions). Forest carbon sinks can therefore only form a minor part of the policies and measures needed to achieve Kyoto Protocol commitments. However, the potential for carbon sequestration by forests is more significant in some countries than in others.

8.6. Indicator development

The main requirement is to improve the reliability of time series and to reduce uncertainty in estimates of greenhouse gas emissions. Current knowledge suggests an order of uncertainty of: ±5 % for carbon dioxide from fossil fuels; ±10 % for total carbon dioxide emissions (including the very uncertain emissions from land-use change and forestry); ±20 % for fluorocarbons; ±20-50 % for methane; and ±50-100 % for nitrous oxide. However, there is less uncertainty associated with emission trends and these are considered reasonably robust.

National efforts are also required to improve the completeness of the time series for their greenhouse gas emission estimates and to achieve consistency by applying the same methodology to all years.

For the future, more and improved climate change impact indicators with particular relevance for Europe will be considered.

Table 8.3. **Possible future EU policies and measures to reduce greenhouse gas emissions**

Greenhouse gas	Sector	Policies and measures	Linked with indicator
Carbon dioxide	Transport	Passenger cars: negotiate agreements with manufacturers in Japan and Korea, and companies not members of the European Automobile Manufacturers Association (ACEA)	Fig.5.3.
		Freight transport by road: intermodal freight transport; fair and efficient pricing	Fig. 5.4, 5.5.
		Aircraft: taxation of fuel; operational measures	
	Industry	Improved energy efficiency in industry through environmental agreements	Fig. 7.1.
		More use of combined heat and power (CHP) generation	Fig. 4.6.
	Energy	Reduce/remove fossil fuel subsidies	
		More fuel switching	Fig. 3.3.
		Greater energy efficiency	Fig. 3.2.
		More use of combined heat and power (CHP) generation	Fig. 4.6.
		Greater share of renewables in primary energy consumption (i.e. 12 % in 2010)	Fig. 3.4.
	Household	Extend energy efficiency standards to other equipment	
Methane	Agriculture	Improved manure management and feed conversion efficiency	Fig. 6.1.
	Waste	Recover energy from landfill gas energy recovery. Reduce amounts of biodegradable waste going to landfill (already a requirement of the Landfill Directive)	Fig. 11.3.
	Energy	Reduce natural gas leakage	Fig 3.1.
Nitrous oxide	Agriculture	Reduce fertiliser application and improve manure management	Fig. 6.3.
	Industry	Install Best Available Technology (BAT) for adipic acid and nitric acid production	
	Transport	Reduce emissions from passenger car	
Fluorocarbons	Industry	Reduce HFC formation as a by-product of HCFC-22 production	
		Specific measures to reduce other fluorocarbon emissions	

Such indicators, to be selected on the basis of ongoing European research and IPCC activities, could include temperature increase, radiative forcing, precipitation, sea-level rise and water resources.

Analysis of the impact of energy taxes, of subsidies to encourage more environment-friendly fuels and reduce emissions, and of other aspects of emission-reduction programmes is needed in the future to evaluate the effectiveness of response measures.

8.7. References and further reading

AEA (1998a). *Options to reduce methane emissions.* Report prepared for the Commission (DG Environment). UK.

AEA (1998b). *Options to reduce nitrous oxide emissions.* Report prepared for the Commission (DG Environment). UK.

CRU (1998). Climate Research Unit University of East Anglia, UK. www.cru.uea.ac.uk/cru/data/temperat.htm.

DETR (1999), *Climate change and its impact: stabilisation of carbon dioxide in the atmosphere.* Prepared by the Hadley Centre, The Meteorological Office, UK for the Department of the Environment, Transport and the Regions, UK.

Ecofys (1998a). *Reduction of the emissions of HFCs, PFCs and sulphur hexafluoride in the EU.* Report prepared for the European Commission by Ecofys, the Netherlands.

Ecofys (1998b). *Emission reduction potential and costs for methane and nitrous oxide emissions in the EU.* Report prepared for the European Commission by Ecofys, the Netherlands.

EEA (1999a). *Environment in the European Union at the turn of the century.* European Environment Agency, Copenhagen.

EEA (1999b). *Overview of national programmes to reduce greenhouse gas emissions*. Topic report no 8. European Environment Agency, Copenhagen.

EEA (1999c). *Case study on carbon dioxide sinks of forests*, European Forest Institute. Technical Report no 35. European Environment Agency, Copenhagen.

European Commission (1998). *Communication on implementing the Community strategy to reduce carbon dioxide emissions from cars: an environmental agreement with the European automobile industry*. COM(1998)495. European Commission, Brussels.

European Commission (1999a). *Communication on climate change – preparing for implementation of the Kyoto Protocol.* COM(99)230. European Commission, Brussels.

European Commission, (1999b). *Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste*. Official Journal L 182 , 16.07.1999. European Commission, Brussels.

European Community (1996). *Council conclusions on climate change*, June 1996. European Commission, Brussels.

European Community (1998). *Council conclusions on climate change*. June 1998. European Commission, Brussels.

European Community (1999). *Council conclusions on climate change*. May 1999. European Commission, Brussels.

IPCC (1996). *Second assessment climate change 1995, report of the Intergovernmental Panel on Climate Change. 'The Science of Climate Change', Contribution of Working Group 1. 'Impacts, Adaptations and Mitigation of Climate Change', Contribution of Working Group 2. 'Economic and Social Dimensions of Climate Change', Contribution of Working Group 3.* World Meteorological Organisation. United Nations Environment Programme. Cambridge University Press.

IPCC (1999). *Aviation and the global atmosphere, a special report of working groups 1 and 3 of the Intergovernmental Panel on Climate Change,* World Meteorological Organisation. United Nations Environment Programme. Geneva.

IPCC/OECD/IEA (1999). *Programme for national greenhouse gas inventories: good practice in inventory management.* Intergovernmental Panel on Climate Change. Organisation for Economic Co-operation and Development. International Energy Agency. Paris.

Leemans, R. and Hootsman, R. (1998). *Ecosystem vulnerability and climate protection goals.* Report no. 481508004. RIVM, the Netherlands.

March Consulting Group (1998). *Opportunities to minimise emissions of hydrofluorocarbons from the EU*. Draft report prepared for the Commission. UK.

UNFCCC (1998). *Second compilation and synthesis of second national communications from Annex I Parties*, 6 October 1998, FCCC/CP/1998/11/Add.1 and Add.2) and *Summary compilation of annual greenhouse gas emissions inventory data from Annex 1 Parties,* 31 October 1998, FCCC/CP/1998/INF.9, UNFCCC Secretariat, Bonn.

UNFCCC (1999a). *Report on national greenhouse gas inventory data from Annex 1 Parties for 1990 to 1997*, UNFCCC Secretariat, Bonn.

UNFCCC (1999b). *Report of the Conference of Parties on its fourth session, held at Buenos Aires 2-14 November 1998, part 2: Action taken by the conference of Parties*, FCCC/CP/1998/16/Add.1., UNFCCC Secretariat, Bonn.

9. Stratospheric ozone depletion

indicator	policy issue	DPSIR	assessment
average ozone column in March	any improvements already?	state	☹
total potential chlorine and bromine concentrations in the troposphere	any improvements already?	state	😐
increase in UV radiation	public interest indicator: how serious is the problem?	state	☹
radiative forcing of ozone-depleting substances	what is the remaining effect of ozone-depleting substances on climate change?	driving force	😐
production of ozone-depleting substances	are ozone-depleting substances phased out according to the schedule? is discouraging the use of HCFCs successful?	driving force	☺
contribution to multilateral fund to assist developing countries to implement the Montreal Protocol	can we ensure that developing countries meet their targets?	response	☺

The thickness of the ozone layer above Europe has decreased significantly since the beginning of the 1980s and is declining at a rate of up to 8 % per decade. The gradual fall in chlorine concentrations in the troposphere (on their way to the stratosphere) shows that international policies to control ozone-depleting substances are having success. Production and sales of ozone-depleting substances in EEA member countries have fallen significantly since 1989. However, the long life of these substances in the atmosphere means that recovery of the ozone layer may not be complete until after 2050. The remaining policy challenges for European countries are to tighten control measures, to reduce the production and use of HCFCs and methyl bromide, to manage banks of existing ozone-depleting substances, and to support developing countries in their efforts to reduce their use and subsequent emissions of ozone-depleting substances.

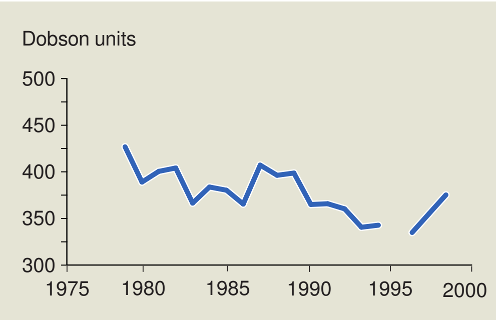
Stratospheric ozone protects the earth's surface from damaging short-wave ultraviolet (UV) radiation. Ozone is produced in the upper stratosphere by short-wave sunlight, which together with chemical reactions dissociates the ozone again to create a dynamic balance between production and loss. Anthropogenic emissions of inert compounds containing chlorine and bromine affect this balance. A single chlorine or bromine atom can destroy thousands of ozone molecules before being removed from the atmosphere.

Compounds causing significant ozone depletion include chlorofluorocarbons (CFCs), carbon tetrachloride, methyl chloroform, halons, hydrochlorofluorocarbons (HCFCs), hydrobromofluorocarbons (HBFCs) and methylbromide. They are used as solvents, refrigerants, foam blowing agents, degreasing agents and aerosol propellants, fire extinguishers (halons) and as agricultural pesticides (methyl bromide). The extent to which an ozone-depleting substance affects the ozone layer (i.e. its ozone-depleting potential) depends on the compound's chemical characteristics. Other factors that affect the ozone layer include natural emissions, large volcanic eruptions, climate change and the greenhouse gases, methane and nitrous oxide.

The dramatic depletion of stratospheric ozone in polar regions is caused by a combination of anthropogenic emissions of ozone-depleting substances, stable circulation patterns, extremely low temperatures and solar radiation. Reactions on the surface of polar stratospheric cloud particles, which form at low temperatures, start a series of chemical reactions that destroy large numbers of ozone molecules in the polar spring, i.e. March/April in the Arctic and September/October in Antarctica.

The total amount of ozone over Europe is the main indicator of the state of the ozone layer above EEA member countries. The ozone column (a measure of the thickness of the ozone layer) has decreased significantly since the beginning of the 1980s (Figure 9.1); the observed trend in March is approximately -8 % per decade. The global trend in the whole winter/spring period at northern mid-latitudes is -5.4 % per decade (WMO, 1999).

Figure 9.1. **Average ozone column over Europe in March**



Notes: The ozone column is the amount of ozone in a column that reaches from the ground to the top of the atmosphere. Monthly average ozone data derived from satellite instruments (Nimbus 7 TOMS, Meteor3 TOMS and GOME) averaged from 35ºN to 70ºN and from 11.2ºW to 21.2ºE. Different instruments used in different years. 1 Dobson unit = 0.01 mm ozone column thickness at standard earth surface temperature and pressure.
Source: RIVM

☹ The thickness of the ozone layer over Europe (March averages) has decreased significantly since the beginning of the 1980s by up to 8 % per decade.

The first international agreement aimed at protecting the ozone layer was the 1985 Vienna Convention. The Montreal Protocol of 1987 (and subsequent Amendments and Adjustments) aims to eliminate the production and use of ozone-depleting substances worldwide. EU measures and policies to protect the ozone layer include Council Regulation 3093/94/EC, which is in the process of being revised and strengthened (European Commission, 1999a). Current challenges in the EU include:

- ensuring full compliance with the Protocol by developing countries, as well as in Russia and other countries with economies in transition;
- reducing remaining production of ozone-depleting compounds for essential uses and to supply developing countries;
- stopping the 'dumping' of second-hand equipment CFC-using in developing countries;
- taking action against CFC and halon smuggling;
- reducing emissions of halons and CFCs from existing equipment, especially in developed countries;
- discouraging the use of HCFCs as re placements for CFCs;
- preventing the increased use of methyl bromide in developing countries;
- preventing the production and marketing of new ozone-depleting substances.

9.1. Total potential chlorine and bromine concentrations in the troposphere

The effect of the measures taken is noticed first in the lower part of the earth's atmosphere: the troposphere. The relevant indicator showing this effect is expressed in terms of 'potential chlorine or bromine concentration' and is derived from the concentrations of individual substances (taking into account the number of halogen atoms in each compound) in the troposphere. This gives a direct indication of the potential impact of these compounds on the ozone layer.

As a result of international policies, the total potential chlorine concentration in the *troposphere* has fallen since 1994 (Figure 9.2). The main reason for this decline is a large decrease in the concentration of methyl chloroform. The concentration of some CFCs is decreasing, while the increase in concentration of other CFCs is levelling off. However, concentrations of HCFCs (used as an alternative to CFCs) are increasing.

The concentration of potential chlorine in the *stratosphere* is expected to reach its maximum level by about 2000. Contrary to earlier expectations, the total potential bromine concentration is still rising due to increased concentrations of halons.

Because ozone-depleting substances have a very long lifetime in the stratosphere, detectable recovery of the ozone layer due to the Montreal Protocol is not expected before 2020. Complete recovery is not expected to occur until after 2050 (WMO, 1999). Over the polar regions, extensive ozone depletion will continue to be observed in spring in the coming decades.

Ground-based measuring stations have recorded increases in the amount of UV radiation in recent years. Modelled estimates (Figure 9.3) show the percentage increase in UV radiation at wavelengths that cause human skin to turn red. These satellite-derived UV data and ground measurements generally agree.

Increased levels of UV radiation will continue until ozone recovery is complete, but the damaging effects of UV on human health and ecosystems are likely to persist even longer. Skin cancers, for example, only appear many years after exposure to UV. However, the general increase in cases of skin cancer in Europe over the past 50 years is most likely due to changes in lifestyle leading to more exposure to the sun. The anticipated effect of an increase in UV radiation will be superimposed on this effect. Public health campaigns encouraging people to reduce their exposure to the sun may offset the adverse effects of ozone depletion (United Kingdom Stratospheric Ozone Review Group, 1999).

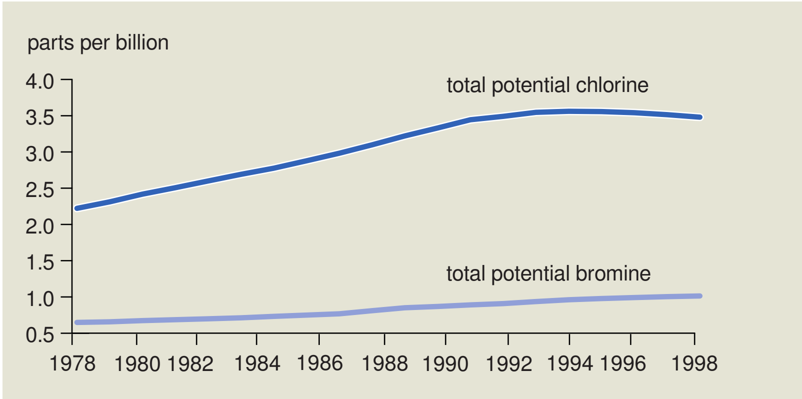
9.2. The interaction between climate change and ozone depletion

Some ozone-depleting substances, e.g. CFCs and HCFCs, are also potent greenhouse gases. Stratospheric ozone depletion and climate change (see Chapter 8) therefore have common sources. Ozone is also a greenhouse gas, but most of the warming effect comes from troposheric ozone.

CFCs, HCFCs and related compounds contribute about 13 % to the total radiative forcing (the net extra radiation giving rise to global warming) from all greenhouse gases (Figure 9.4). However, their emissions are not regulated under the Kyoto Protocol (see Sections 8.2 and 8.3) because they are already controlled under the Montreal Protocol. HFCs, which are increasingly used as substitutes for ozone-depleting substances, are also potent greenhouse gases. HFCs are covered by the Kyoto Protocol rather than the earlier Montreal Protocol.

The radiative forcing of ozone-depleting substances is still increasing, but less than in the 1980s. There are a number of reasons for this. The phasing-out of methyl chloroform under the Montreal Protocol is largely responsible for the decrease in total potential chlorine. However, methyl chloroform contributes less to radiative forcing than CFCs and HCFCs. In addition, the contribution from CFCs is levelling off as a direct result of the Montreal Protocol and the radiative forcing of HCFCs is increasing as their concentration in the troposphere increases.

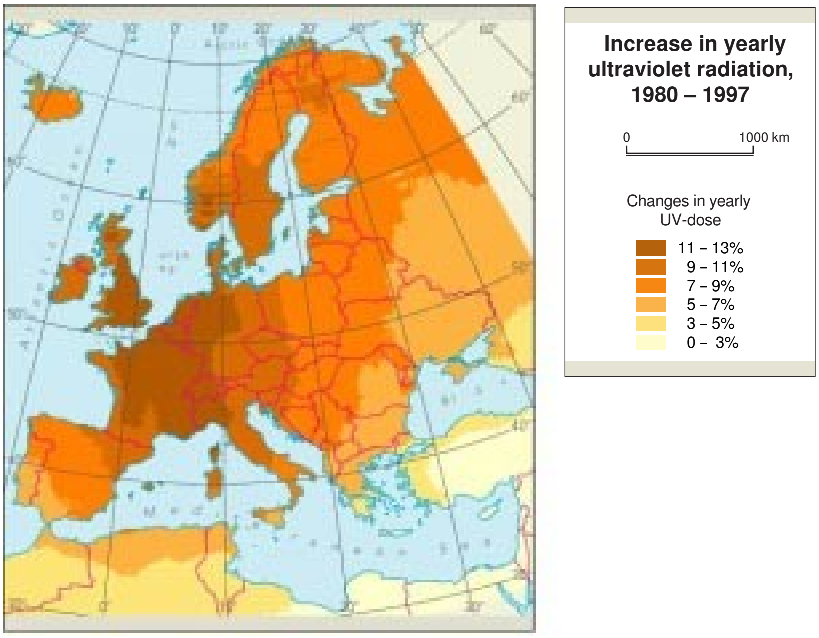
Total potential chlorine and bromine concentrations in the troposphere Figure 9.2.



Notes: Total potential chlorine/bromine is defined as the sum of the concentrations of all chlorine/bromine species in the troposphere, multiplied by the number of chlorine/bromine atoms per molecule. The sum of the bromine compounds is multiplied by the bromine efficiency factor of 60 for total potential bromine to account for the different ozone-depleting efficiency of bromine.
Source: RIVM; ALE/GAGE/AGAGE network; NOAA/CMDL network

Although total potential chlorine concentrations in the troposphere reached their maximum around 1994, total potential bromine concentrations in the troposphere are still increasing.

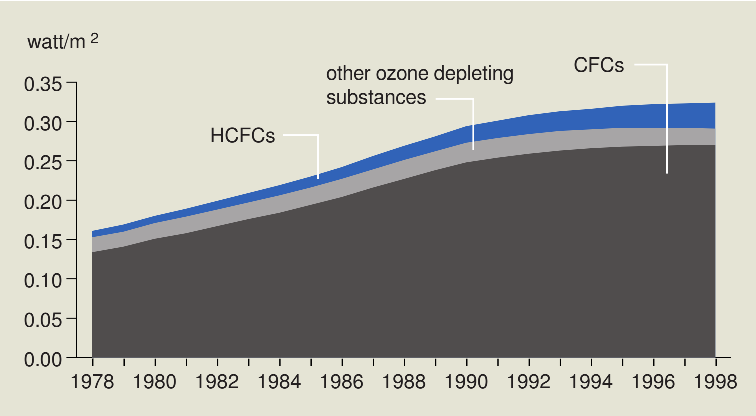
Increase in UV radiation in Europe, 1980-1997 Figure 9.3.



Note: The map shows the increase in the yearly dose of UV radiation during the 17 year period, calculated using observed total ozone values from TOMS satellite instruments and assuming clear sky conditions.
Source: EEA, 1999; RIVM

Observations suggest that UV radiation has increased above Europe.

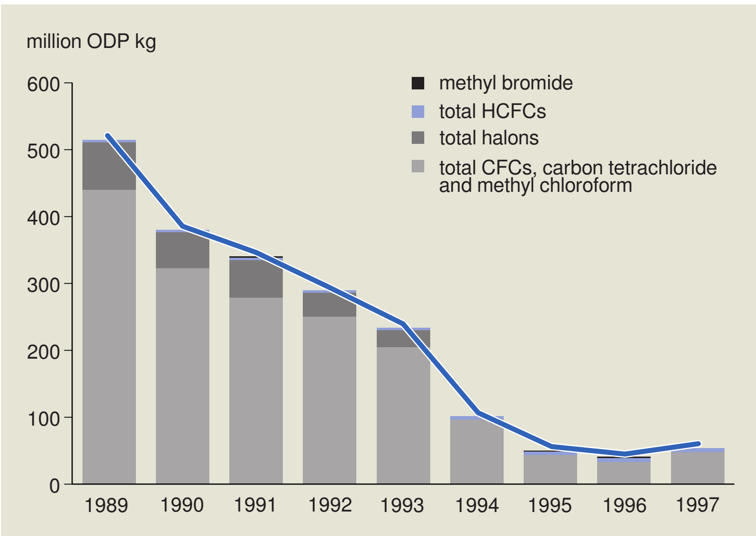
Figure 9.4. **Radiative forcing of ozone-depleting substances at a global level**



Note: Radiative forcing is based on global average tropospheric concentrations (Figure 9.2) and WMO radiative forcing parameters.
Source: RIVM

The radiative forcing of ozone-depleting substances is still increasing. This is because the radiative forcing of HCFCs is increasing, while that of CFCs is levelling off.

Figure 9.5. **Production of ozone-depleting substances in EEA member countries**



Notes: Production is defined as actual manufacture in the EU for dispersive uses, but excluding: imports; production for use as a raw material for the production of other chemicals; and used material recovered, recycled or reclaimed. Production data is weighted according to ozone-depleting potential (ODP).
Source: European Commission 1999b; UNEP, 1998

9.3 European production of ozone-depleting substances

The production of CFCs, carbon tetrachloride, methyl chloroform and halons in Europe fell substantially between 1989 and 1997, while production of HCFCs increased (Figures 9.5 and 9.6). The sale of ozone-depleting substances shows a similar pattern. This overall decline in the production and sale of ozone-depleting substances in EEA member countries is a direct result of the Montreal Protocol and EU regulations. Halon production in the EU has been banned since 1994 and production of CFCs, carbon tetrachloride and methyl chloroform since 1995. Limited production and use of certain compounds (mainly CFCs) is still allowed for designated essential uses (e.g. metered dose inhalers for medical purposes) and for use to meet the basic needs of developing countries. Production for sale to developing countries accounts for the increase in 1997. HCFCs and methyl bromide may still be produced and sold in the EU subject to mandatory limits.

The production of ozone-depleting substances in EEA member countries was about 32 % of global production in 1989 and about 25 % in 1996. In all member countries, use of ozone-depleting substances has fallen faster than required under the Montreal Protocol.

Global production and emissions of ozone-depleting substances have also decreased significantly. However, existing equipment and products still contain large amounts of CFC and halons – generating emissions when these are released. Emissions of ozone-depleting substances can occur within a few months of production (e.g. during the manufacture of open cell foams) or after several years (e.g. from refrigerators, closed-cell foams and fire extinguishers).

Smuggling and illegal production of ozone-depleting substances is estimated at 10 % of 1995 global production. These illegal activities will delay the recovery of the ozone layer by several years.

☺ Production of ozone-depleting substances in EEA member countries has decreased by almost 90 %. However, production of HCFCs – with low ozone-depleting potential but high global warming potential – is increasing.

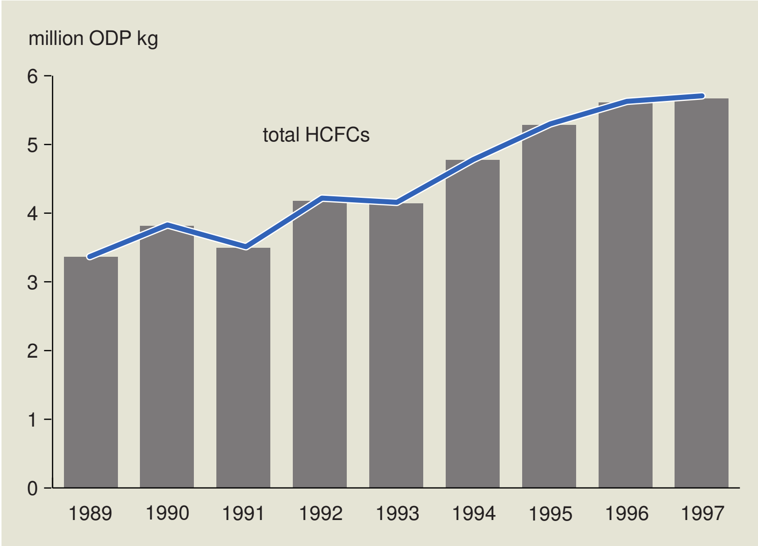
9.4. Technology transfer to developing countries

Europe's successes and the recovery of the ozone layer will be jeopardised unless developing countries also meet their commitments under the Montreal Protocol. These came into effect in 1999.

In 1990, a multilateral fund was established by the Parties to the Montreal Protocol to help developing countries implement the Protocol. Developed countries contribute to this fund, while developing countries can apply for financial assistance for particular projects.

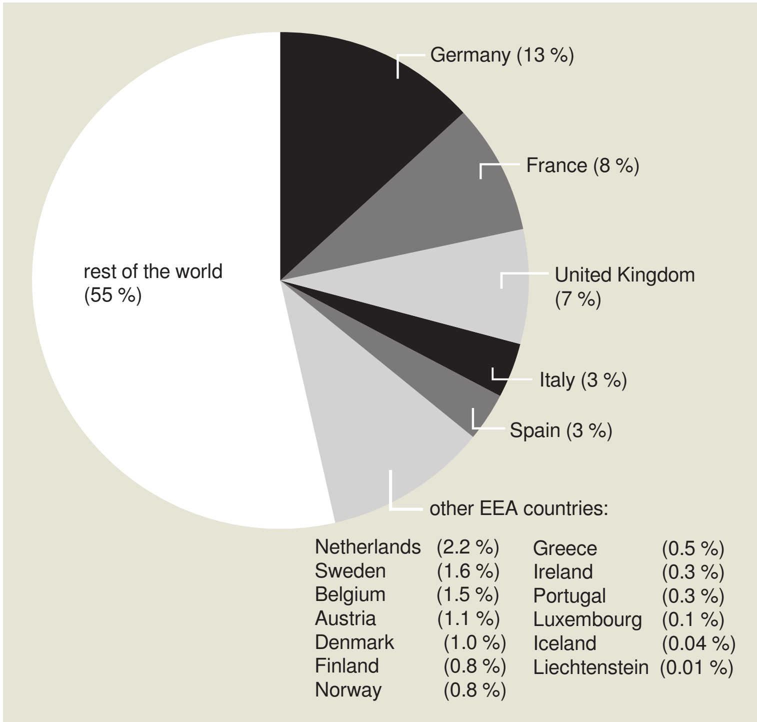
EEA member countries contributed US $371.6 million to the multilateral fund between 1991 and 1998. This amount is about 45 % of total global payments to the fund (Figure 9.8). The total amount spent so far by the fund (US $936 million) is expected to result in the phasing out of the use of 122 million ODP kg (more than twice the 1997 production in EEA member countries) and the phasing-out of the production of about 42 million ODP kg of ozone-depleting substances.

Production of HCFCs in EEA member countries Figure 9.6.



Source: European Commission, 1999b; UNEP, 1998

Relative contribution of EEA member countries to multilateral fund to assist developing countries implement the Montreal Protocol, 1991-1998 Figure 9.7.



Source: UNEP, 1999

☺ EEA member countries have together contributed around 45 % of the total multilateral fund to help developing countries reduce their emissions of ozone-depleting substances.

Methyl bromide: supporting developing countries

Twelve years after being signed, the Montreal Protocol is viewed as a success. Methyl bromide, which has an ozone-depleting potential of 0.6 compared to CFCs, was added to the list of controlled substances in 1992. The Copenhagen Amendment requires the phasing out of methyl bromide in developed countries by 2005 and in developing countries by 2015.

Methyl bromide is still used throughout the developing world as a fumigant to control pests in soils, structures and commodities. However, alternatives for 90 % of methyl bromide applications have been found - often as part of integrated pest management, but few have yet been implemented.

GTZ, the German Agency for Technical Co-operation, is advising developing countries on possible substitutes for methyl bromide. GTZ emphasises non-chemical alternatives such as crop rotation and biocontrol. GTZ is also helping with the disposal of old stocks of methyl bromide; for example, it recently helped the Sudanese government dispose of over eight tonnes of methyl bromide.
Source: UNEP

9.5 Indicator improvement

Harmonisation of data reporting on current production and sale of ozone-depleting substances to both the European Commission and the United Nations Environment Programme (UNEP) would remove some inconsistencies from the indicators. Data on individual EU Member States is not available.

For the future, improved breakdowns for contributions by European countries to the multi-lateral fund to help developing countries implement the Montreal Protocol would be desirable. Analysis of the effectiveness of this policy instrument in helping to reduce the production and consumption of ozone-depleting substances in developing countries would also be useful.

For the future, improved indicators and analysis of the interactions between climate change and ozone depletion should be developed. Radiative forcing, which is presented here, is just one example of such an indicator. Another interesting interaction is the temperature fall in the stratosphere due to greenhouse gas emissions and its effect on the ozone layer at mid-latitudes and polar regions. However, this interaction is more difficult to assess.

9.6. References and further reading

EEA (1999). *Environment in the European Union at the turn of the century.* European Environment Agency, Copenhagen.

European Commission, DG Research (1997). *European research in the stratosphere*. EUR 169986 EN. European Commission, Brussels.

European Commission (1999a). ‘A Common Position for a revised Council Regulation on substances that deplete the ozone layer 5748/99.’ *Official Journal* C123/03.

European Commission (1999b). *Statistical factsheet – ozone-depleting substances*. European Commission, Brussels.

WMO (1999). *Scientific assessment of ozone depletion: 1998*. World Meteorological Organisation Global Ozone Research and Monitoring Project – Report 44. World Meteorological Organisation, Geneva.

UNEP (1998). *Production and consumption of ozone-depleting substances 1986-1996*. United Nations Environment Programme, Nairobi, Kenya.

UNEP (1999), UNEP/OzL.Pro/ExCom/27/48 (Annex I, Page 5). United Nations Environment Programme, Nairobi, Kenya (http://www.unmfs.org).

United Kingdom Stratospheric Ozone Review Group (1999). *Stratospheric ozone 1999*. Department of the Environment, Transport and the Regions, London, UK.

10. Air pollution

indicator	policy issue	DPSIR	assessment
Multiple effects: area with exceedance of critical loads for acidity and eutrophication	how much have we protected the environment against acid precipitation?	state	☺ / ☹
limit value exceedance days for atmospheric ozone	are we protecting the population effectively against exposure to photochemical substances?	state	☹
exposure of crops and forests to atmospheric ozone	how much have we protected the environment against the effect of photochemical substances?	state	☹
limit value exceedance days for particulate matter	are we protecting the population effectively against exposure to particulate matter?	state	☹
Multiple pollutants: emissions of acidifying gases	will policy targets be reached?	pressure	☺
emissions of ozone precursors	- „ -	pressure	😐
emissions of sulphur dioxide	- „ -	pressure	☺
emissions of nitrogen oxide	- „ -	pressure	😐
emissions of ammonia	- „ -	pressure	😐
emissions of non-methane volatile organic compounds	- „ -	pressure	😐

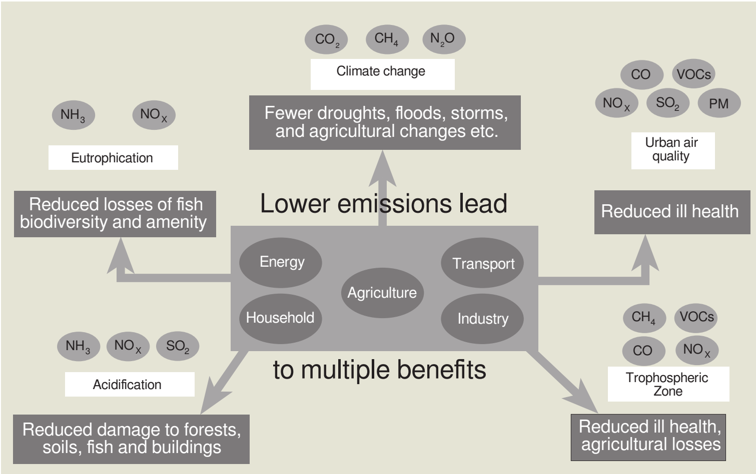
Despite a decline in emissions of general air pollutants, the ultimate goal of avoiding all harmful effects on health, vegetation, water and soil has still to be achieved. The area where the critical load of acidifying emissions is exceeded has fallen significantly, but substantial parts of the population in EEA member countries are exposed to unacceptable concentrations of ground-level ozone and fine particles. The fifth environmental action programme emission reduction targets for 2000 will be achieved for sulphur dioxide, but are unlikely to be met for nitrogen oxides and volatile organic compounds (VOCs). The proposed EU and national 2010 targets for sulphur dioxide appear achievable, but reaching those for nitrogen oxide, ammonia and VOC emissions will require substantial further reductions and additional policies and measures in most Member States.

The main environmental problems associated with air emissions are harm to human health, the acidification and eutrophication of water and soils, and damage to natural ecosystems, cultural heritage and crops. Often these are transboundary effects, as pollutants in the air can travel a considerable distance away from their source. In addition, emissions from sources in urban areas can have a significant local impact on human health. Local and transboundary air pollution are considered as one environmental issue in this report, since the effects of air pollution are interrelated through common causes and common impacts. Policies to reduce emissions are increasingly considering various pollution problems together in a multi-pollutant, multi-effect approach (Figure 10.1).

10.1. Policy update

The first international treaty with strategies for reducing transboundary air pollution was the UNECE Convention on Long Range Transboundary Air Pollution (CLRTAP). Several CLRTAP Protocols are in force for its European parties, including the EU and its Member States. The substances covered and the required reductions are listed in Table 10.1. The Second Sulphur Protocol (UNECE, 1994) used the approach, for the first time, of setting emission targets to reduce the exceedance of critical deposition levels for ecosystems (‘gap closure’). This Protocol thus resulted in national emission-

Figure 10.1. **Multi-pollutants, multi-effects**



Source: EEA

Table 10.1. **Air emissions reduction targets for the EU and its 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

reduction commitments that varied according to the ecosystems' sensitivity.

In May 1999, the European Commission presented a proposal for a Directive on national emission ceilings (NECD) (European Commission, 1999a) for the same pollutants as CLRTAP and, for the first time, for ammonia. The proposed Directive uses a similar approach as the Second Sulphur Protocol, but extends it to include reduction in exceedance of critical limit values for ozone for human health and ecosystems. These targets in the NECD proposal, which has not yet been adopted, are much stricter than currently agreed targets.

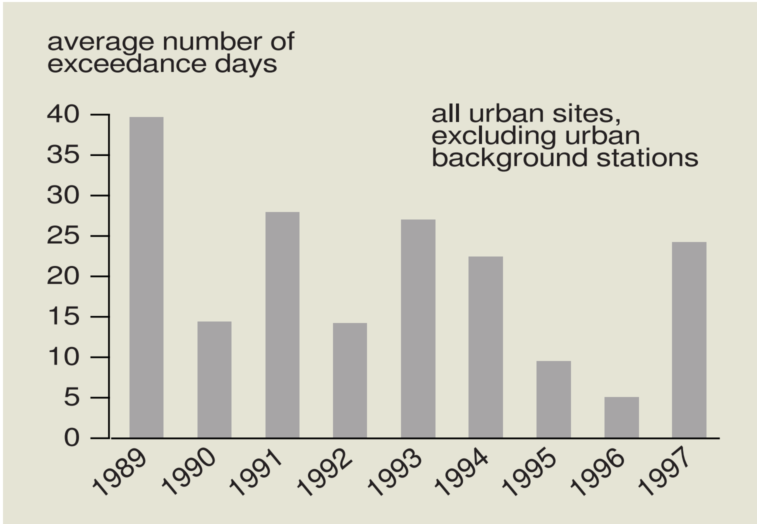
In a parallel process, on 1 December 1999 the CLRTAP agreed on national emission ceilings for many European countries (including EU Member States) in a new multi-pollutant Protocol for the same four pollutants as NECD. For a number of Member States, however, the targets are less strict than those in the proposed Directive.

Table 10.1 summarises the main current and proposed targets for the EU.

To help reach these targets, current European Community legislation aimed at reducing acidifying pollutants and ozone precursors includes a Directive on the reduction of emissions from large combustion plants and various recent Directives on vehicle emissions, the quality of petrol and diesel fuels and the sulphur content of certain liquid fuels. A Directive on the storage and distribution of petrol and the Solvents Directive on the reduction of emissions from the industrial use of organic solvents both aim to limit emissions of volatile organic compounds (VOCs). By the end of 1999, new proposals are expected

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 NOx 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 that corresponds with different emission ceilings for each Member State is shown.
[5] Targets from the European Commission's 1999 proposal for a national emission ceilings directive (NECD). The emission reduction target for the EU that corresponds with different emission ceilings for each Member State is shown.
Source: EEA

Percentage area where critical loads for acidity and eutrophication are exceeded in EEA member countries Figure 10.2.



Note: Figure shows area where 5th percentile critical loads for acidity and eutrophication are exceeded.
Source: CCE for critical loads and EMEP/MSC-W for deposition estimates

☺ Since 1985, there has been about a 40 % reduction in the area where critical loads for acidity are exceeded.

☹ The ecosystem area exposed to eutrophication has notchanged much and is still high.

from the second Auto-Oil Programme for emission limits on new cars, other technical measures and non-technical measures to encourage more environment-friendly modes of transport. There is currently no EU legislation aimed at reducing ammonia emissions. Legislation and targets for abatement of direct emissions of fine particles are also still lacking.

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.

The proposed national emission ceilings for 2010 should be regarded only as interim as they will not provide full protection to ecosystems and human health. Assuming a baseline scenario (EEA, 1999), some ecosystems in 2010 will still be receiving deposition above critical loads, and threshold values for ozone will continue to be exceeded. Future development of policies and measures in the coming years are likely be performed in parallel by UNECE/CLRTAP and the EU, following the same approach as for the recently proposed emission ceilings.

This chapter begins by using four indicators to evaluate developments in meeting critical limit values. These indicators equate approximately to the major impacts of air pollutants, i.e. acidification and eutrophication of water, soil and ecosystems; human-health effects of ground-level ozone; ecosystem effects of ozone; and human health impacts of particulate matter. This concise overview of progress in limiting multiple effects is followed by two indicators summarising the reduction in most of the pollutants involved. The distance to the various emission targets listed in Table 10.1 gives an indication of the amount of policy effort still required. The chapter concludes with a number of indicators on emissions and the gap between the target and actual reductions for the individual pollutants.

10.2. Multiple effects

10.2.1. Impact 1: Acidification and eutrophication of water, soils and ecosystems

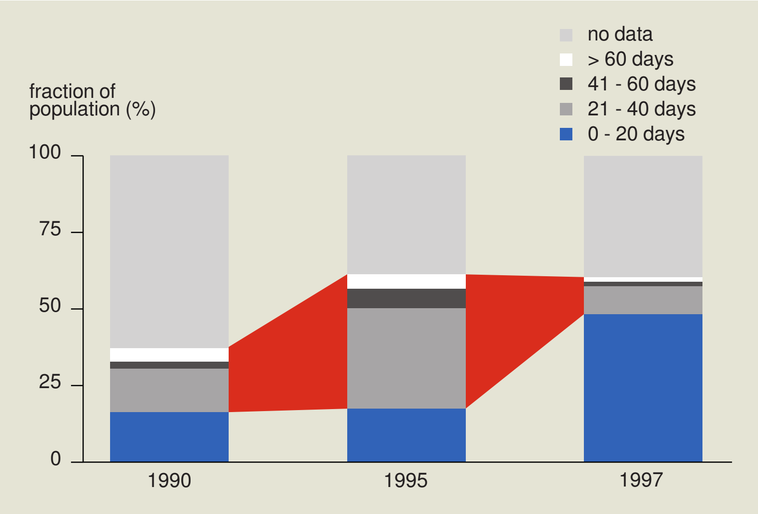
The area where critical loads are exceeded due to emissions of sulphur and nitrogen oxides falling on water and soils (deposition) has decreased substantially since 1985 (Figure 10.2). Both sulphur and nitrogen deposition contribute to the acidification of water and soils; the lines in Figure 10.2 for the exceedance in critical loads for acidifying sulphur and acidifying nitrogen therefore run in parallel. However, the decrease in areas exposed to acidification appears to be due mainly to the decrease in sulphur oxide emissions (see Figure 10.6). Much of the deposited nitrogen accumulates in the soil or is taken up by vegetation and thus will contribute at some stage to eutrophication. The area where depositions of nitrogen exceed the critical load has remained high, reflecting insufficient reduction of nitrogen oxide and ammonia emissions (see Figures 10.10 and 10.12).

10.2.2. Impact 2: Human-health impacts due to exposure to ozone

Large numbers of people living in EEA member countries are exposed to ground-level ozone concentrations above the proposed EC threshold value (Figure 10.3).

Ozone concentrations at ground level are far higher than they would be naturally because additional ozone is formed by photochemi-

Figure 10.3. **Population exposure in EEA member countries to ozone levels above EC targets**



Notes: Number of days per year with 8-hour rolling average concentration greater than 120 µg/m 3. Based on data from rural monitoring stations. Ozone concentrations in urban areas are often lower than rural concentrations, due to local reactions with nitrogen oxides from traffic emissions. The population exposure may therefore be somewhat overestimated.
Source: AIRBASE

☹ A substantial part of the population in EEA member countries is exposed to ozone concentrations above the proposed EC target. Monitoring data suggests that ozone peak values are decreasing.

cal reactions in the atmosphere. The main substances with a role in ground-level ozone formation (i.e. ozone precursors) are nitrogen oxides, non-methane volatile organic compounds (NMVOCs), carbon monoxide and methane.

Ozone is an oxidant that can induce damage to human health (European Commission,1999b). Epidemiological and toxicological evidence indicates that exceedances of threshold values during summer smog episodes have led to associated health problems, particularly inflammatory responses and impaired lung function. Multiannual exposure to high concentrations of ozone may lead to decrements in the lung function of young children (Frischer *et al.*, 1999).

Insufficient data and strong year-on-year fluctuations owing to episodes of high ozone concentrations prevent clear conclusions on time trends. However, the limited monitoring data suggests that peak concentrations are decreasing.

The reduction in emissions of ozone precursors achieved in the EU (see Figure 10.7) has not yet been sufficient to make a significant difference to health risk. Increased background concentrations – caused by emissions in the whole northern hemisphere – are partially responsible for continued high concentrations in EEA member countries.

Despite projected further emission reductions, ozone concentrations are expected to exceed EC threshold values over all EEA member countries in the next decade (EMEP, 1999). By 2010, north-western European areas are expected to comply with the proposed EU target value of only 20 exceedance days per year in the long-term air quality objective (European Commission 1999b).

10.2.3. Impact 3: Damage of forest and crops due to exposure to ozone

Exposure to ozone can induce foliar injury in plants and thus reduce crop and forest yields. The forested area where critical ozone concentrations have been exceeded is smaller than the affected area of arable land (Figure 10.4). However, the proposed long-term critical level for forests is less stringent than the proposed EC guideline for crops. Significant fluctuations between years and lack of data for over 50 % of the relevant area prevent definitive conclusions on trends being drawn.

Despite the expected reductions in the emissions of ozone precursors following the implementation of the CLRTAP protocol and EU legislation, ozone concentrations are forecast to remain well above the critical levels for the next decade. By 2010, the gap between current concentrations and critical values is expected to have halved (EMEP, 1999).

10.2.4. Impact 4: Human-health problems from exposure to particulates

Recent research has shown that exposure to fine particles in the air is associated with a significant impact on human health (UNECE/WHO, 1999). The health effects attributed to fine particulates range from increased frequency and severity of respiratory problems to increased risk of premature death.

In preparation for implementing the EC Air Quality Daughter Directive, most countries have only recently introduced monitoring of particulate matter less than 10 mm in diameter (PM10). Data on PM10 concentrations is currently insufficient to draw firm conclu-

☹ A substantial proportion of forests and crops in EEA member countries are exposed to ozone levels greater than proposed EC critical levels.

sions about emission trends. However, concentrations of total suspended particulates (TSP) and black smoke are generally decreasing (Figure 10.5).

Particulate matter originates both from direct air emissions (primary particles) and from atmospheric reactions between sulphur and nitrogen oxides, and ammonia and organic compounds (secondary particles). Emissions of precursors of secondary particles are limited by existing environmental legislation, but there is no EU legislation directly governing primary particle emissions.

Air-pollution control techniques designed to reduce precursor emissions often reduce primary particulate emissions. However, PM10 concentrations are expected to remain well above limit values in most urban areas of EEA member countries in the coming decade. This suggests that more measures need to be taken to reduce human-health risks significantly (European Commission, 1999c).

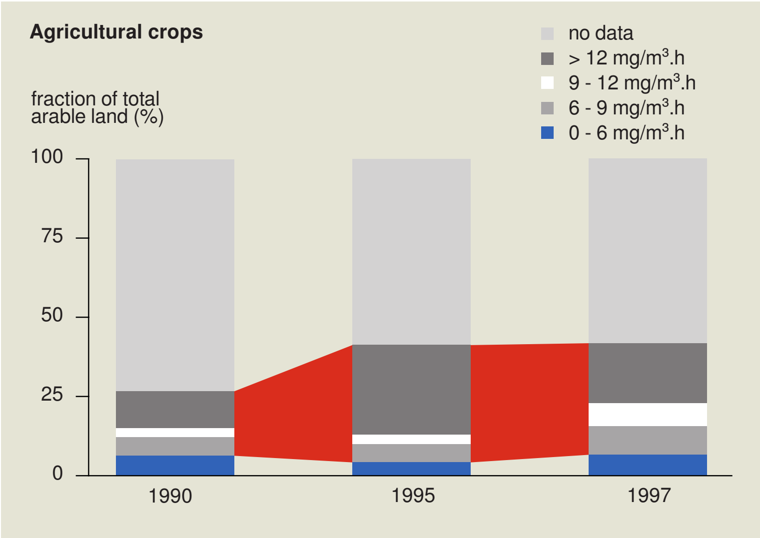
10.3. Multiple pollutants

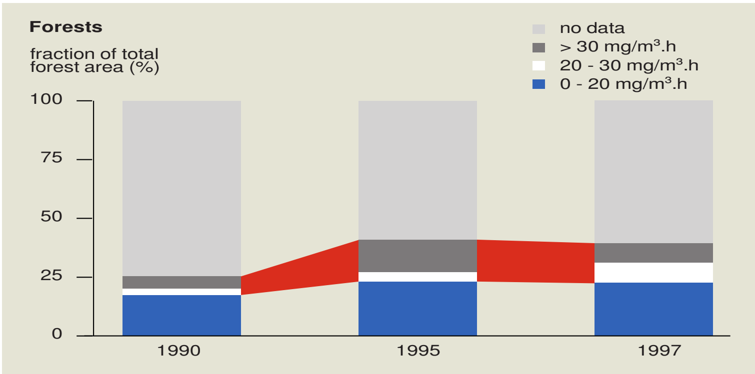
Emissions of gases causing acidification and eutrophication (sulphur dioxide, nitrogen oxides and ammonia) have decreased significantly in most EU Member States. Sulphur dioxide and nitrogen oxides also have health impacts. In the EU as a whole, emissions decreased by 27 % between 1990 and 1996 (Figure 10.6), despite an increase in gross domestic product (GDP).

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 (see Figure 10.8). However, nitrogen oxide emissions decreased much less and are unlikely to meet the fifth environment action programme (5EAP) target for 2000. Ammonia

☹ Many people living in towns and cities in EEA member countries are exposed to higher concentrations of fine particulate matter than EC limit values.

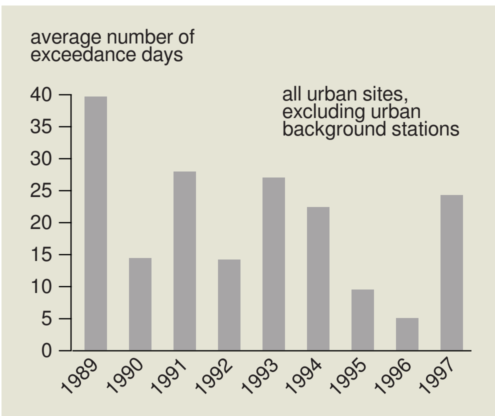
Exposure of agricultural crops and forests in EEA member countries to atmospheric ozone — Figure 10.4.





Note: Proposed EC long-term critical level is 20 mg/m³h (AOT40) for forests and 6 mg/m³h (AOT40) for agricultural crops.
Source: EEA-ETC/AQ and EMEP/CCC

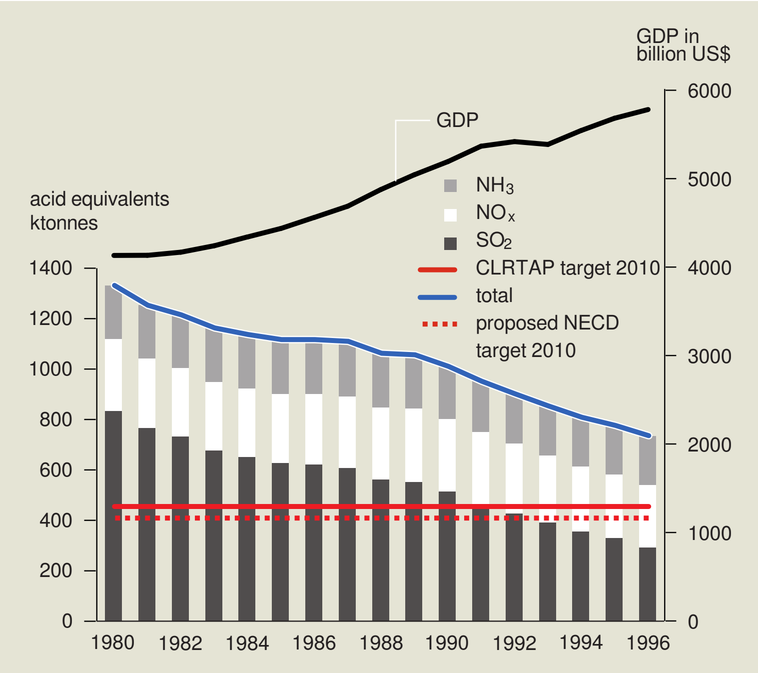
Exposure to particulate matter in urban areas of EEA member countries — Figure 10.5.



Source: AIRBASE

Notes: Shows number of days when 24-hour average particulates threshold value is exceeded, averaged over all monitoring stations. The threshold value taken depends on the type of particulates measured: for PM10 (fine particulate matter) 50 µg/m³, for total suspended particulates (TSP) 120 µg/m³ and for black smoke 125 µg/m³. The implicit assumption is that an exceedance day for TSP is just as bad as an exceedance day for black smoke or PM10. Only a small proportion of the population is covered by the monitoring network.

Figure 10.6. **Total EU emissions of acidifying gases**



Notes: Emission reduction targets are for the EU and combined for the three gases using weighting factors. Acidifying equivalents per kg used for weighting are: sulphur dioxide 31.2; nitrogen oxides 21.7; ammonia 58.8. Table 10.1 gives more information on the targets .
Source: EEA-ETC/AE and UNECE/EMEP

☺ Emissions of acidifying gases in EU Member States have decreased significantly, showing a clear de-coupling from GDP growth. This decrease was mainly due to reductions in sulphur dioxide emissions. Further reductions in nitrogen oxide and ammonia emissions will be necessary to achieve the targets for 2010.

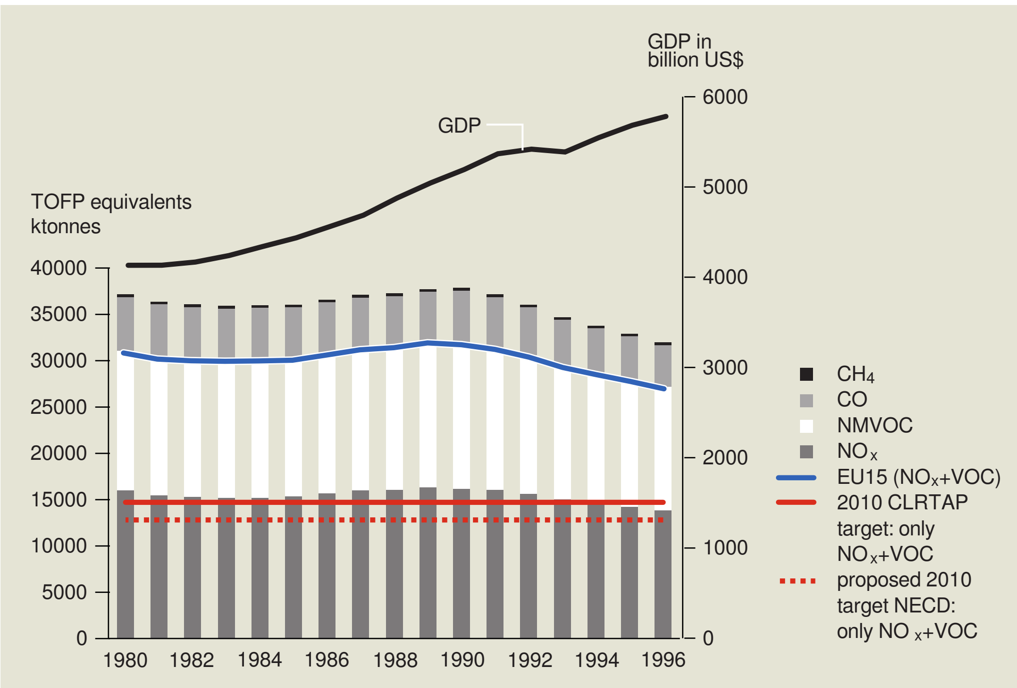
emissions are stabilising (see Figures 10.12 and 10.13). The slower reduction in nitrogen oxide and ammonia emissions is reflected in a less significant reduction in deposited nitrogen and in the area in which the critical load for eutrophication is exceeded (see Figure 10.2).

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

😐 Emissions of ozone precursors in EU Member States have decreased, showing a de-coupling from GDP. However, substantial further reductions in emissions are required to achieve the targets for 2010.

Figure 10.7. **Total EU emissions of ozone precursors**

Notes: This indicator is a first attempt at weighting total EU ozone precursor emissions, but of course it is an oversimplification. In many regions, nitrogen oxide emissions enhance ozone formation, but in urban areas, they can deplete ozone. A decrease in aggregated emissions does not therefore imply a similar decrease in ozone concentrations. Emissions are combined for four ozone precursors, but reduction targets exist only for the two main precursors (nitrogen oxides and non-methane VOCs). Weighting factors (tropospheric ozone precursor potentials) used: nitrogen oxides 1.22; non-methane VOCs 1.00; carbon monoxide 0.11, methane 0.014. Table 10.1 gives more information on the targets.
Source: EEA-ETC/AE and UNECE/EMEP



Emissions of gases that can lead to ground-level ozone fell in most EU Member States and by 15 % in the EU as a whole between 1990 and 1996 (Figure 10.7). These results were achieved despite an increase in gross domestic product. The reduction is mainly due to fewer VOC emissions, which fell by 13% between 1990 and 1996 mainly due to limits on industrial emissions and measures to reduce emissions from road vehicles (see Figure 10.14). Although these reductions appear to have decreased peak concentrations of ozone, they have not been enough to limit human health and ecosystem risks significantly (see Figures 10.3 and 10.4). Further initiatives are needed to meet the 5EAP targets for 2000.

Substantial further reductions of emissions of ozone precursor pollutants are required to achieve the proposed NECD targets or even the less strict CLRTAP targets for 2010.

10.4. Achievement of policy targets: individual substances

This section presents an overview of the development in emissions compared with the various targets for each of the four pollutants that contribute to acidification, eutrophication and ground-level ozone.

10.4.1. Sulphur dioxide

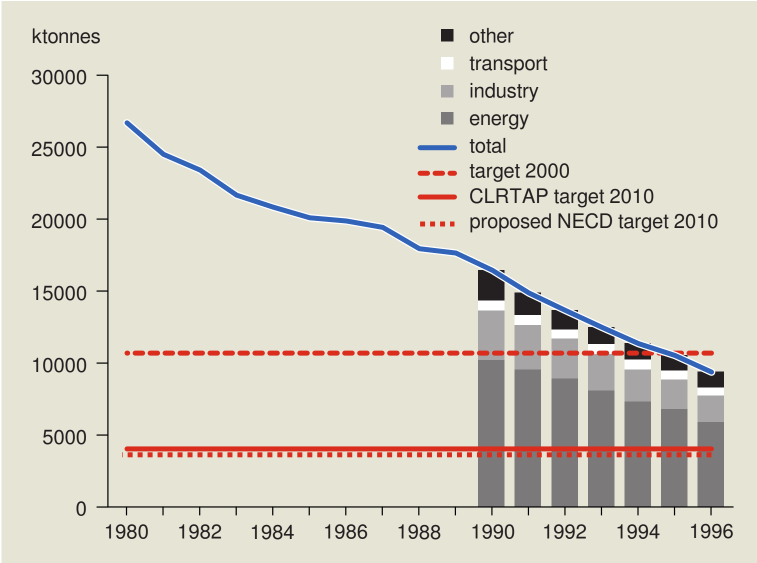
Main sources: energy (60 %), industry (25 %), transport (6 %) and household (1 %) sectors (Figure 10.8).

Development in emissions: a decrease of over 60 % from 1980 (over 40 % since 1990) in the EU. Largest reduction 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.

Distance to target: EC's 5EAP target (-35 % of 1985 emissions by 2000) reached by EEA member countries in 1992. By 1996, 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 (Figure 10.9).

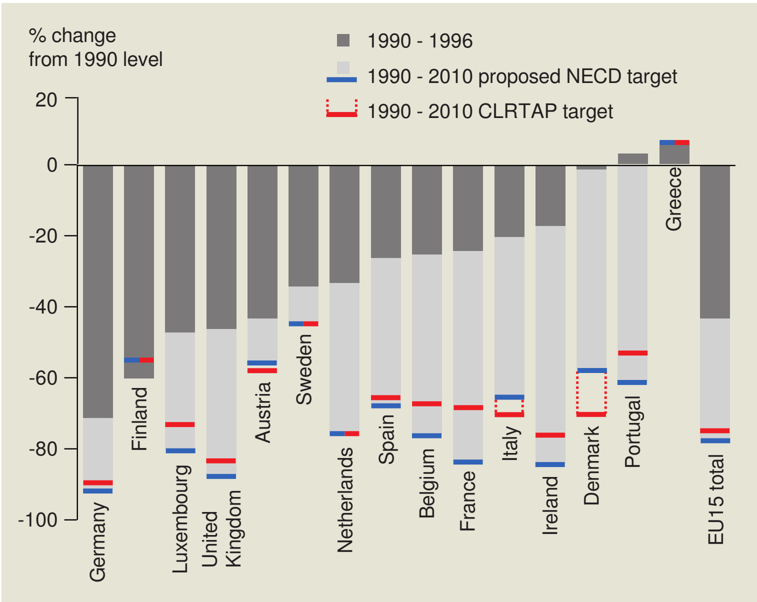
Outlook: EU baseline scenario (EEA, 1999) projection: -70 % in 2010 from 1990 levels. For some countries, additional measures will

Total EU sulphur dioxide emissions from major sources compared to EU and CLRTAP targets Figure 10.8.



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.
Source: EEA-ETC/AE and UNECE/EMEP

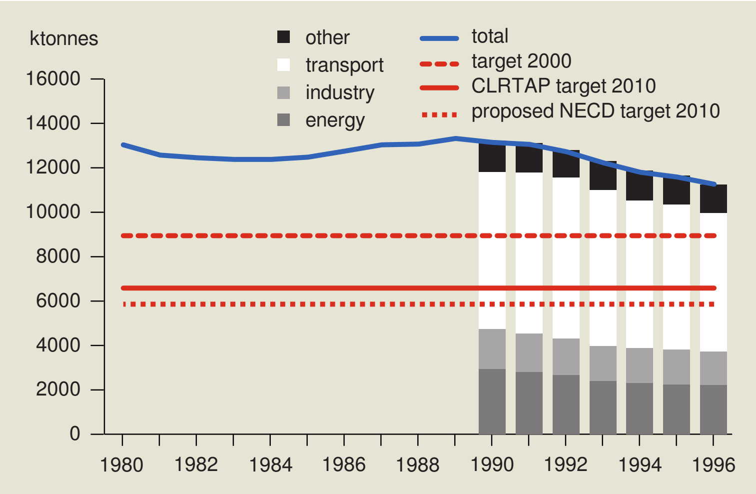
Percentage change in national sulphur dioxide emissions in EU Member States, 1990-1996 Figure 10.9.



Notes: A reduction in emissions from 1990 is shown by a negative percentage.
Source: EEA and UNECE/EMEP

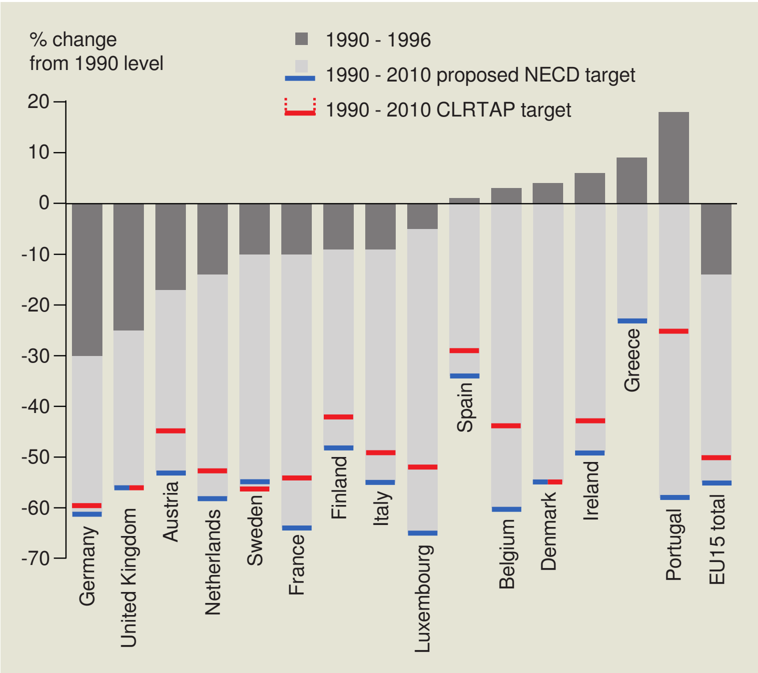
☺ Since 1980, EEA member countries have reduced their sulphur dioxide emissions by over 60 %. Reduction targets for 2000 have already been achieved for the EU as a whole. The targets for 2010 appear to be attainable for the EU, although additional measures will be required in some countries.

Figure 10.10. **Total EU nitrogen oxide emissions from major sources compared to EU and CLRTAP 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.
Source: EEA and UNECE/EMEP

Figure 10.11. **Percentage change in national nitrogen oxide emissions in EU Member States, 1990-1996**



Note: A reduction in emissions from 1990 is shown by a negative percentage.
Source: EEA and UNECE/EMEP

The CLRTAP target of stabilising nitrogen oxide emissions at 1987 levels was achieved by the EU as a whole. However, the EC's 5EAP target is unlikely to be reached by 2000. The targets for 2010 will also be difficult to achieve for the EU and additional measures will be required for various countries.

be required to achieve the proposed NECD and agreed CLRTAP Protocol targets.

10.4.2. Nitrogen oxide

Main sources: transport (55 %) energy (19 %) and industry (14 %) sectors (Figure 10.10).

Development in emissions: a decrease of 14 % since 1990 in EU Member States, mainly due to the introduction of catalysts on new cars and improved abatement in the energy and industry sectors. Increasing road travel has partly offset reductions achieved by emission abatement. Emissions increased in some countries (Figure 10.11).

Distance to target: First CLRTAP Nitrogen Oxide Protocol target (stabilising to 1987 emissions by 1994) achieved by the EU as a whole and by most Member States. However, the fifth environment action programme target of a 30 % reduction by 2000 with respect to 1990 will not be achieved.

Outlook: EU baseline scenario (EEA, 1999) projection: -45 % in 2010 from 1990 emissions. It will be difficult to achieve the proposed NECD and agreed CLRTAP Protocol targets. Additional policies and measures will be required in various EU Member States.

10.4.3. Ammonia

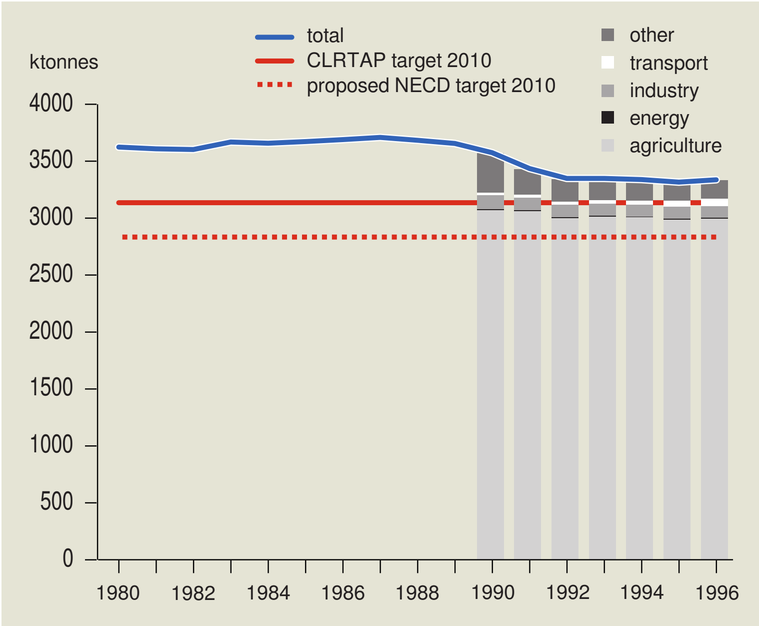
Main sources: agriculture, particularly livestock (pigs, cattle, sheep and poultry) (Figure 10.12).

Development in emissions: Slight decrease between 1990 and 1996, due to reduced agricultural activity and measures taken by a few Member States. A reduction in Denmark, Germany and the Netherlands of over 10 % achieved. Emissions from some Member States increased (Figure 10.13). Estimates of ammonia emissions are more uncertain than those for sulphur dioxide and nitrogen oxide.

Distance to target: Until recently no 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.

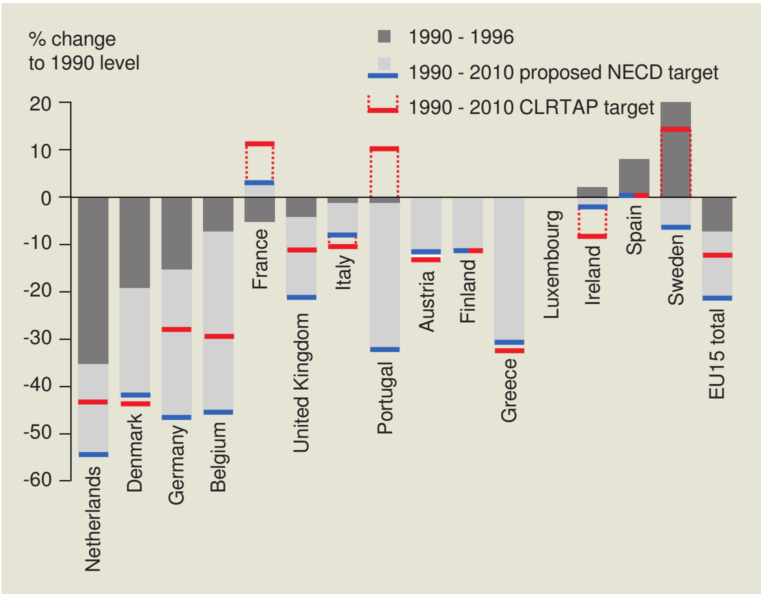
Outlook: EU baseline scenario (EEA, 1999) projection: -14 % in 2010 from 1990 emissions. Changes in agricultural practice to promote better manure management (e.g. ploughing in manure spread onto fields) and fewer animal numbers are expected to help reduce ammonia emissions. For the countries mentioned above and some other EU Member States, additional policies and measures will be required to meet the proposed NECD and agreed CLRTAP targets.

EU total ammonia emissions from major sources compared to EU and CLRTAP targets Figure 10.12.



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.
Source: EEA and UNECE/EMEP

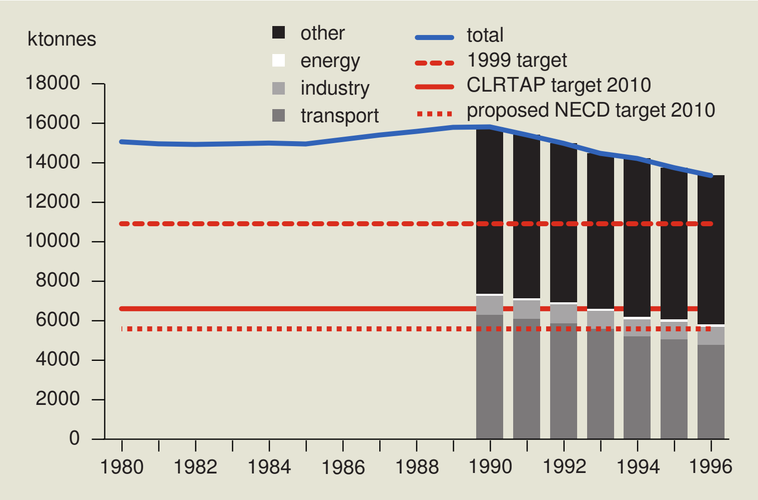
Percentage change in national ammonia emissions in EU Member States, 1990-1996 Figure 10.13.



Notes: A reduction in emissions from 1990 is shown by a negative percentage.
Source: EEA and UNECE/EMEP

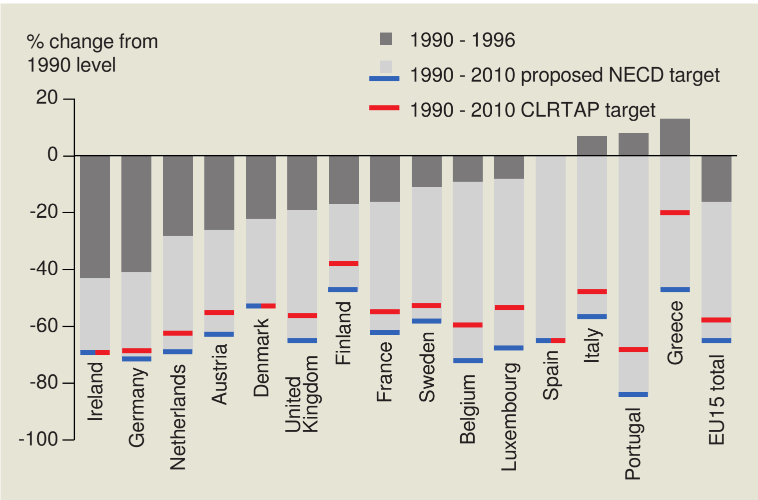
Reduction targets have been defined for the first time for ammonia emissions. The targets for 2010 will be difficult to reach for the EU and additional measures will be required for various countries.

Figure 10.14. **Non-methane volatile organic compound emissions in EU Member States from major sources compared to EU and CLRTAP targets**



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.
Source EEA-ETC/AE and UNECE/EMEP

Figure 10.15. **Percentage change in national NMVOC emissions in EU Member States, 1990-1996**



Note: A reduction in emissions from 1990 is shown by a negative percentage.
Source: EEA-ETC/AE and UNECE/EMEP

Total EU emissions of non-methane volatile organic compounds fell by 13% between 1990 and 1996. However, the EC's 5EAP target for 2000 will be difficult to achieve and reaching the targets for 2010 will require substantial further reductions in emissions. Additional measures will be required for various countries.

10.4.4. Non-methane volatile organic compounds (NMVOCs)

Main sources: transport sector (Figure 10.14). The category 'other' in Figure 10.14 comprises emissions from solvent use and the storage and distribution of fossil fuels.

Development in emissions: decrease by 14 % in EU and decreases in most Member States (Figure 10.15) due to the introduction of catalytic converters in vehicle exhausts. 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.

Distance to target: 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.

Outlook: EU baseline scenario (EEA, 1999) projection: -49 % in 2010 from 1990 emissions. Current policies are not enough to reach the proposed NECD (-62 %) and the agreed CLRTAP Protocol (-59 %) targets. Additional policies and measures will be required in various EU Member States.

10.5. Indicator development

The spatial coverage requires improvement for current exposure indicators. A greater consistency between years is necessary to properly assess exposure to air pollutants and especially population exposure to particulates. A combination of modelling and monitoring data could provide a better estimate of environmental indicators in areas with unsatisfactory data coverage. Information from different indicators could be combined to produce simple indexes to monitor the state of the environment.

The main requirement for the emission indicators is improved reliability and completeness of the time series and a reduction in the uncertainty in the estimates. To achieve consistency, use of the same methodology for all years is required. There is also a need for further validation and checking within the framework of UNECE/CLRTAP, in particular by the Task Force on Emission Inventories and related EEA (ETC/AE) activities.

Separate indicators for urban emissions, including PM10 emissions, should be developed because such emissions have a major impact on urban air quality and related health effects, while trends may differ significantly from national totals.

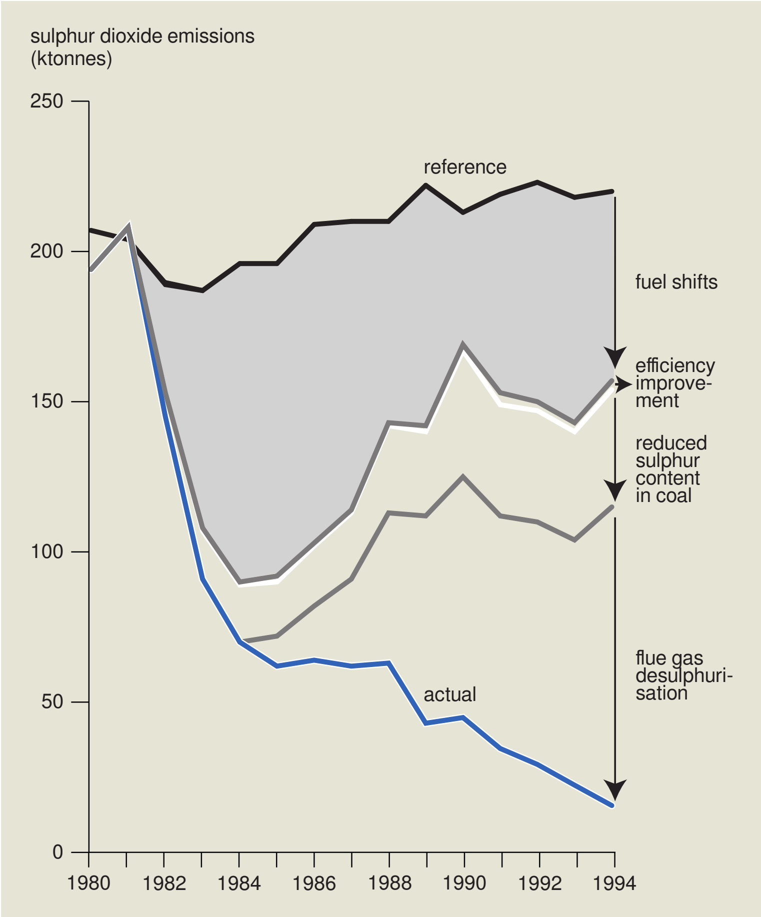
Emission indicators for other pollutants, e.g. heavy metals and persistent organic compounds, are still missing. Future developments could also include indicators on other environmental effects (including ecosystems and material corrosion) and an indication of the cost-effectiveness of measures and policies to reduce emissions.

Indicators could also be developed to visualise the effects of policy responses to trends in air emissions and air quality. Emission reductions resulting from policy and technical measures could be presented together with the actual emissions and in relation to a 'reference' emission – a hypothetical emission level for the situation where no policies/measures are implemented.

Two examples from the Netherlands are presented below. The first example is for sulphur dioxide emissions from power plants (Figure 10.16). A shift in fuel from oil to natural gas produced a net downward effect on emissions until the mid-1980s, when greater use of coal reversed the trend. Flue-gas desulphurisation units began to be fitted to Dutch power plants in 1986 and, by 1996, 96 % were equipped.

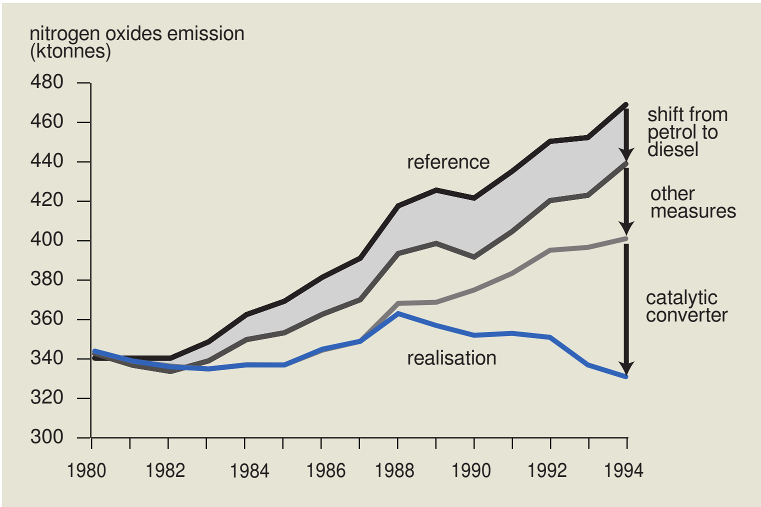
The second example deals with the effectiveness of measures to reduce nitrogen oxide emissions from motor vehicles in the Netherlands (Figure 10.17). Emissions fell substantially following the introduction of catalytic converters in 1988. Until 1993, use of catalytic converters was stimulated by a lower sales tax on new cars. In 1993, new emission standards came into force that could only be met with a three-way converter. In 1994, 33 % of all passenger cars were equipped with a catalytic converter. While most of the recent decrease in nitrogen oxide emissions is due to the use of catalytic converters, the shift from petrol to diesel has also contributed (diesel cars tended until recently to have lower emissions per kilometre than petrol cars).

Sulphur dioxide emissions from power plants in the Netherlands, 1980-1994 — Figure 10.16.



Note: The reference line is based on electricity produced.
Source: RIVM

Nitrogen oxide emissions from traffic in the Netherlands, 1980-1994 — Figure 10.17.



Note: The reference line is based on the distance driven by road and for goods transport on tonne-kilometres.
Source: RIVM

10.6. References and further reading

EMEP (1999) *Transboundary Photo-oxidants in Europe*, EMEP Summary Report 2/99. EMEP/Meteorological Synthesising Centre-West, Oslo.

European Commission (1999a). *Proposal for a Directive setting national emission ceilings for certain atmospheric pollutants and for a Daughter Directive relating to ozone in ambient air.* COM (99)125. European Commission, Brussels.

European Commission (1999b). *Ozone position paper.* (to be published). European Commission DG Environment-D3, Brussels.

European Commission (1999c). *The Auto-Oil II Programme*, draft version 5.0 , November 1999. European Commission, Brussels.

European Environment Agency (1999). *Environment in the European Union at the turn of the century.* European Environment Agency, Copenhagen.

Frischer T., Studnicka M., Gartner C., Tauber E., Horak F., Veiter A., Spengler J., Kühr J., Urbanek R. (1999). *Lung function growth and ambient ozone. A three-year population study in schoolchildren*. Am. J. Respir. Crit. Care Med., 160, 390-396.

UNECE (1994). *Protocol to the convention on long-range transboundary air pollution on further reduction of sulphur emissions (1994 Sulphur Protocol).* UN Economic Commission on Europe, Geneva.

UNECE (1996). *1979 Convention on long-range transboundary air pollution.* UN Economic Commission on Europe, Geneva.

UNECE (1999). *Protocol to the 1979 convention on long-range transboundary air pollution (CLRTAP) to abate acidification, eutrophication and ground-level ozone*, Gothenburg, Sweden, 1 December 1999.

UNECE/EMEP (1999). *EMEP Emission data, status report 1999.* Report 1/1999, EMEP/MSC-W, Oslo.

UNECE/WHO (1999). *Health risk of particulate matter from long-range transboundary air pollution - preliminary assessment*. Task Force on Health Aspects of Long-Range Transboundary Air Pollution, Geneva.

11. Waste

indicator	policy issue	DPSIR	assessment
waste and economic activity	is de-linking occurring?	pressure	😐
municipal waste generation and disposal	is the 5EAP target being met?	pressure	☹
biogradable waste landfilled	is the Landfill Directive target being met?	pressure	☹
extra costs of incineration compared with landfill tax	are taxes being used to correct the relatively low price for landfilling?	response	😐
packaging waste management	is the treatment of packaging waste developing according to targets?	response	☺

Waste quantities are increasing, but de-linking of waste from economic activity has been achieved for some waste streams and countries. The amount of municipal waste generated is considerably higher than the target for 2000 in the EU's fifth environmental action programme target, and a large proportion of biodegradable waste is still disposed of in landfills. However, recycling initiatives are increasing. The use of waste taxes is increasing in Member States, but they are not yet fully integrated into waste-management strategies. Some EEA member countries have achieved higher recovery and recycling rates for packaging wastes than target values.

Waste represents the loss of both material and energy resources. Because excessive waste generation is a symptom of inefficient production processes, low durability of goods and unsustainable consumption patterns, waste quantities can be considered an indicator of how efficiently society uses raw materials.

The key environmental impacts of waste can be summarised as:

- use of land for landfills and leaching of harmful substances (nutrients, toxics, etc.) from landfills;
- air pollution and toxic residues from incinerators;
- air and water pollution and generation of secondary waste streams from recycling plants;
- increased road transport.

All data on waste is associated with major uncertainties, but it is estimated that a total of 1 300 million tonnes of waste is generated each year in the EU. The overall aim and priority of European waste-management policy is waste prevention – the most challenging task for waste management. For waste that is generated, the EU waste strategy calls for increased recycling and energy recovery to prevent disposal, such as landfill or incineration without energy recovery. In addition, specific Directives impose common rules for the separate collection and treatment of certain waste streams, such as packaging, batteries and accumulators, waste oils, sewage sludge and polychlorinated biphenyls (PCBs).

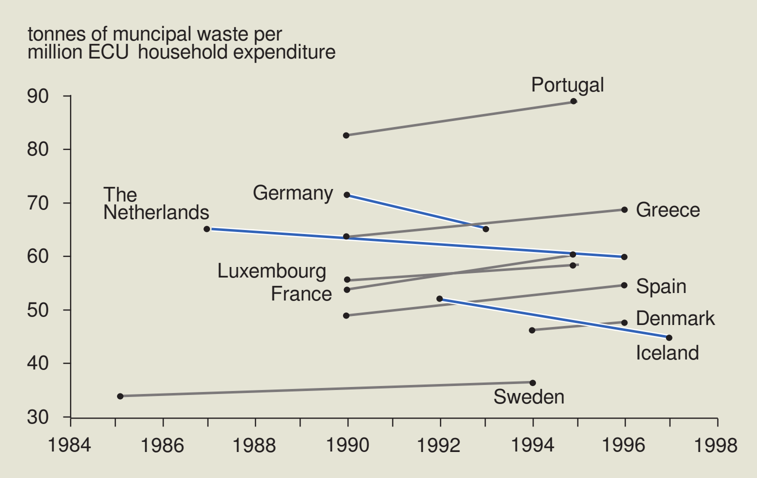
This chapter focuses on municipal waste and packaging waste, both priority waste streams in the EU waste strategy and for which policy targets have been set against which progress can be measured. Hazardous waste, industrial waste, construction and demolition waste, sewage sludge and waste transport will be covered in future editions of this report.

The transport of waste, for example, is an issue of growing concern; French studies suggest that 15% of all freight transport involves waste and that waste transport accounts for 5% of the transport sector's total energy consumption (Ripert, 1997). Transport distances for waste recycling are also much higher than those for disposal. The environmental pressures caused by the transport of waste are likely to increase in the future as waste is separated into more fractions for different treatment.

11.1. Is de-linking of waste generation from economic activity occurring?

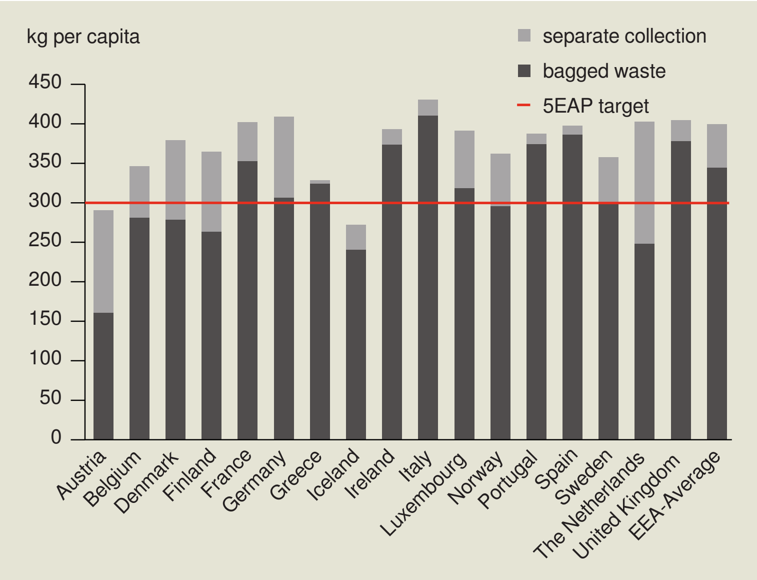
Removal of the link between waste generation and economic activity has a key role in

Figure 11.1. **Municipal waste generation compared with household expenditure in selected EEA member countries, 1984-1998**



Source: Eurostat and EEA-ETC/Waste

Figure 11.2. **Waste generation from daily household and commercial activities in EEA member countries, 1996**



Notes: Deviating reference years: France 1995; Germany 1993; Ireland 1995; and Sweden 1994. No data for Liechtenstein.
Source: EEA-ETC/W

☹ Waste generation per capita from household and commercial activities is much greater than the fifth environmental action programme target for 2000. There is a large potential for increased recycling.

helping to meet the objective of reduced waste generation. Waste generation appears to be increasing at a greater rate than economic growth: the amount of waste generated in European countries belonging to the Organisation for Economic Cooperation and Development (OECD) increased by an estimated 10 % between 1990 and 1995, while GDP increased by 6.5 % (EEA, 1999).

At Member State level, de-linking of municipal waste generation from household expenditure is occurring in some countries (Figure 11.1). In particular, Germany, the Netherlands and Iceland appear to show successful de-coupling of municipal waste generation from economic activity, while other countries such as Portugal, Greece, France, Spain, Denmark and Sweden appear not to be making as much progress. Household expenditure, however, is not an ideal parameter for comparison purposes as municipal waste also includes commercial waste.

11.2. Are we meeting policy targets for municipal waste generation and disposal?

Although some de-linking from economic activity occurred in the 1990s for municipal waste, all EEA member countries (except for Austria and Iceland) are some way away from meeting the EU fifth environmental action programme (5EAP) target of stabilising municipal waste generation per capita at 300 kg per capita by 2000 (Figure 11.2).

Waste from daily household and commercial activities (Figure 11.2 and Table 11.1) consists of certain well-defined fractions of municipal waste, which can be compared between all EEA member countries. These fractions include bagged wastes (i.e. mixed waste collected from households and other sources) and separately collected wastes such as paper, cardboard, glass, metal packaging and food/organic waste. Bulky waste is not included in this indicator. As waste from daily household and commercial activities does not constitute all municipal waste, the distance to the municipal waste target is even larger.

On the positive side, all EEA member countries have recycling schemes and, on average, 13 % of municipal waste is collected separately. However, wide variations exist between countries and regions. In northern European countries, an average 20 % of waste is collected separately but large differences exist between countries – the Netherlands leads with 38 %. In southern European countries, an average 5 % of municipal waste is collected separately. Overall, there is a large potential for increasing the total amount of waste recycled.

This potential is further illustrated and reinforced by Figure 11.3 which shows that, in 1995, too much biodegradable waste was still going to landfill in many countries despite the fact that such waste could be recovered as compost or incinerated.

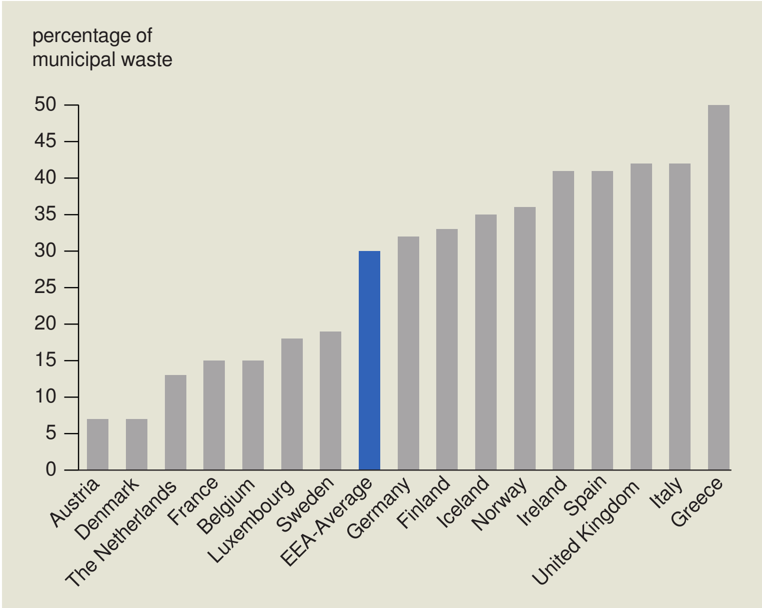
Landfilling of biodegradable waste results in greenhouse gas emissions and is a loss of resources. An estimated 55 million tonnes of paper, paperboard, food and organic garden waste was landfilled in 1995 in EU Member States (less Portugal but including Iceland and Norway). If plastics are classed as biodegradable, this figure rises to 66 million tonnes. The Landfill Directive sets a target of reducing the amount of biodegradable municipal waste landfilled to 35 % by 2016, i.e. a maximum of 19 million tonnes. Minimising waste to landfill is a central plank of the EU waste strategy and it will be important to see in future editions of this report whether progress is made towards meeting the Landfill Directive target for biodegradable waste.

The variation between countries in the amount of landfill waste may be linked to the way their tax systems favour disposal by incineration rather than landfill. A landfill tax is operational in a number of Member States (Figure 11.4). The aim is to improve the competitive position of recycling and incineration with energy recovery as treatment methods. The limited capacity of landfills is another factor which may motivate countries to impose a landfill tax.

Figure 11.4 compares the relative costs of the treatment and disposal of waste by landfilling and incineration for a number of EEA member countries. In countries that have implemented landfill taxes, less biodegradable waste than the EU average goes to landfill. Finland is an exception; this can be partly explained in that the price difference between incineration and landfilling still encourages disposal to landfill over incinera-

☹ Taxation of landfill disposal favours incineration only in Austria, Denmark and Sweden.

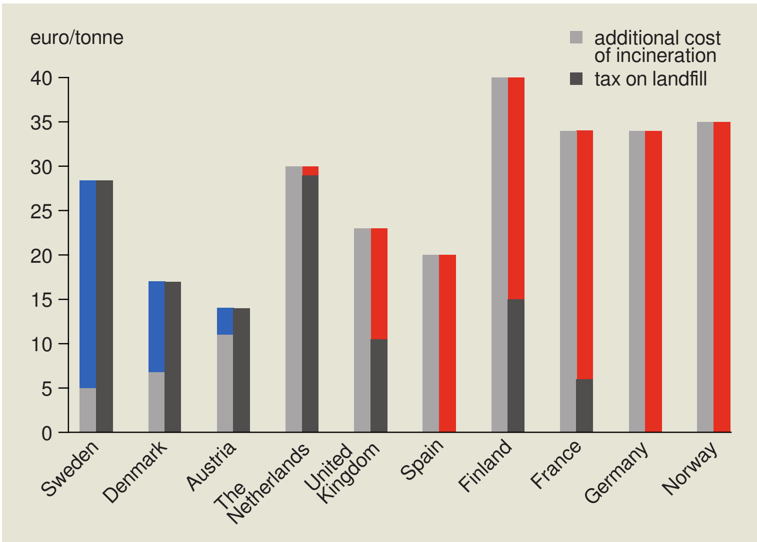
Biodegradable municipal waste landfilled in EEA member countries, 1995 Figure 11.3.



Notes: Deviating reference years: Belgium partly 1996; Germany 1993; Greece 1990; Italy 1996; the Netherlands 1994; and Sweden 1994. No data available for Liechtenstein and Portugal.

☹ Too much biodegradable waste ends up in landfills.

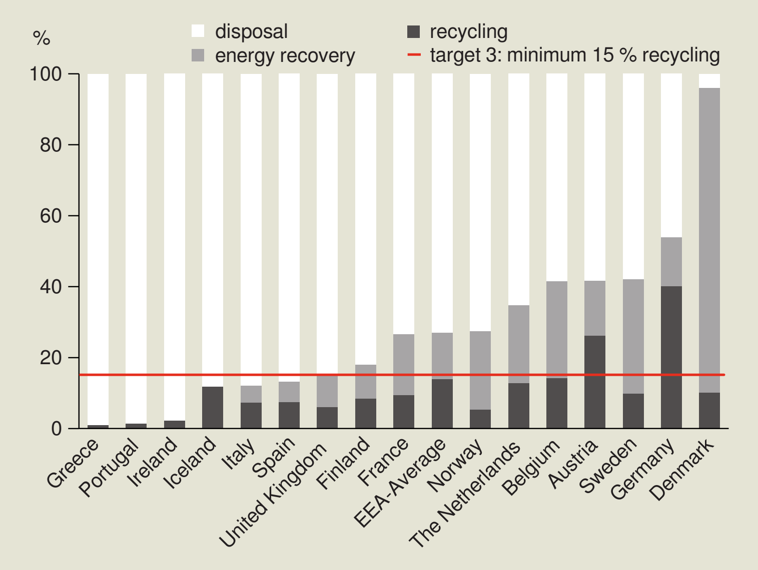
Landfill taxes in selected EEA member countries Figure 11.4.



Note: All prices are average observed prices and cover large variations between plants. Denmark and Norway also have a tax on incineration; the landfill tax shown for these two countries is the difference between the tax on landfill and the tax on incineration with energy recovery. The additional costs are before tax. Also Belgium has a landfill tax, but it could not be shown due to lack of data.
Source: EEA-ETC/W

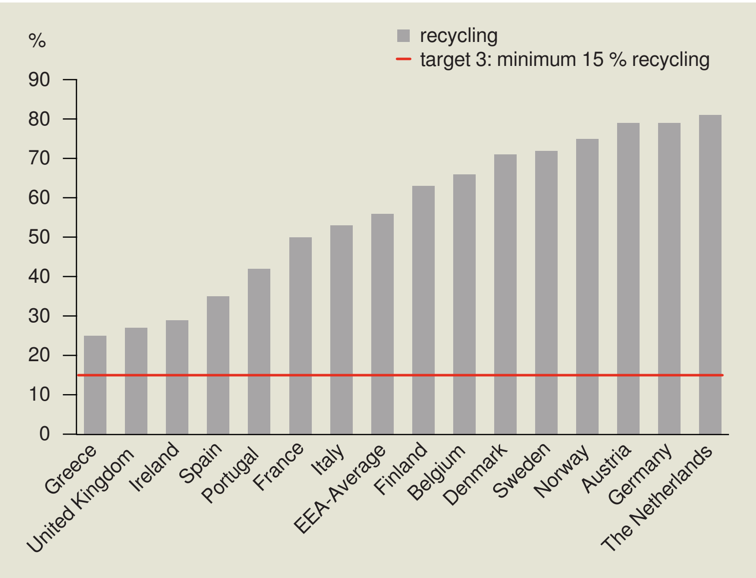
Figure 11.5. **Recycling/recovery of packaging waste**

Plastics, 1997



Source: Association of Plastics Manufacturers in Europe

Glass, 1996



Source: FEVE (European Container Glass Federation)

☺ Some EEA member countries have met the minimum requirements of the Packaging Directive. Not all countries meet all the Directive's targets.

Closing the loop

To help meet the requirements of the Landfill Directive, Sweden has implemented an ambitious scheme to compost 10 % of all Swedish municipal waste at a single site in the near future.

Swedish engineers have developed a way of converting cement kilns to giant composting facilities; cement kilns are capable of processing hundreds of tonnes of waste per day and have a large infrastructure of storage tanks, silos, docks, weighing stations and conveyor-belt production. Cement kilns in Sweden are not currently operating at full capacity and older plants are under pressure to close. Switching from manufacturing cement to producing compost is one solution to this problem.

Organic waste material for the kilns is provided by a collaboration of municipalities, supermarkets, airlines and fast-food chains. The waste will be converted at a pilot plant near Stockholm into compost pellets suitable for application to agricultural and forestry land. The fast-food chains 'close the loop' by asking their growers and suppliers to use the compost pellets in crop production.

Source: Restructuring inefficient and polluting industries, G.Pauli. www.zeri.org/1999/may/may_ind.htm

tion. The Finnish example shows that landfill taxes can be effective only as part of an integrated approach to waste management when economic instruments are used synergistically to promote the desired environmental outcome and do not act in opposition to each other.

11.3. Are the EU's objectives for packaging waste being met?

One of the waste streams given special attention by the EU is packaging. The Packaging Directive includes measures aimed at preventing waste generation and increasing the recovery and recycling of packaging waste. In 1997, 136 kg/capita of packaging waste was generated, i.e. almost a third of total waste from daily household and commercial activities. Paper/cardboard is by far the largest fraction of packaging waste, with 63 kg/capita, followed by glass (35 kg/capita) and plastics (29 kg/capita). Metals (9 kg/capita) make up the rest.

A number of targets have been set by the Packaging Directive. Target 1 requires Member States to reach a *recovery* level of between 50 % as a minimum and 65 % as a maximum by weight of *all* packaging wastes. In this case, recovery covers all kinds of recycling, energy recovery and composting.

To achieve Target 2, Member States must reach a *recycling* level of between 25 % as a minimum and 45 % as a maximum by weight of *all* packaging waste. The obligation for Target 3 is to reach a minimum *recycling* level of 15 % on *specific* packaging waste materials.

Good rates of paper and glass recycling have been reached, but progress with plastics has been poor (Figure 11.5). Municipal waste is the largest source of plastics waste, generating over 61 % of total plastics waste in 1996. Only Austria and Germany currently achieve a recycling rate of more than 15 % for plastics waste.

Paper and plastics recovery is high in countries where energy recovery is the predominant treatment method. The high rates achieved by some member countries indicate the potential for increased recycling and recovery throughout the EEA area. For example, variations between member countries include 6 % plastics recycling in Denmark compared with 45 % in Germany. The variation in recycling of glass is smaller.

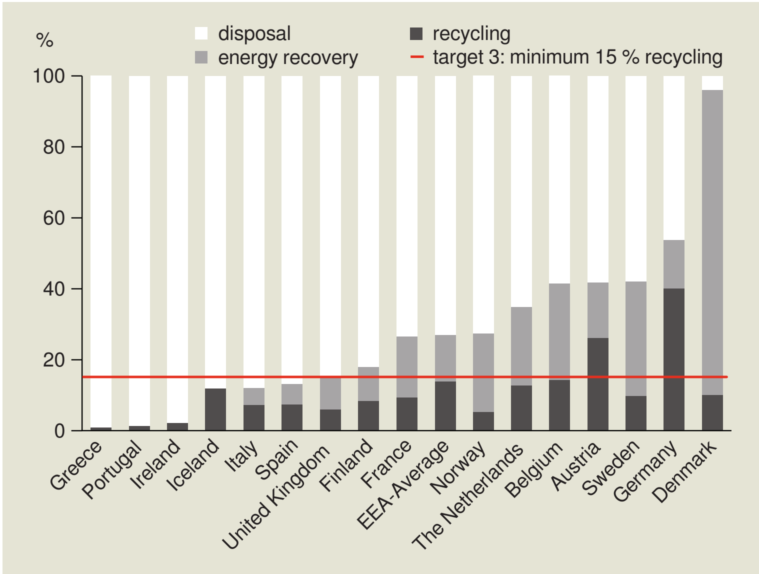
11.4. Indicator development

For existing indicators, improved estimates of generation, treatment and disposal are needed for all waste streams as well as greater methodological consistency between countries. Consistent and complete trends data are also lacking in many areas, but in particular there are gaps for the base years against which progress towards policy targets is measured. Improved information on the use of economic instruments such as taxes would also be useful.

For the future, priority needs to be given to construction and manufacturing waste streams, hazardous waste and waste transport. Analysis of the effectiveness of economic instruments and the synergies between them, in particular taxes and voluntary agreements for meeting policy objectives, would be desirable.

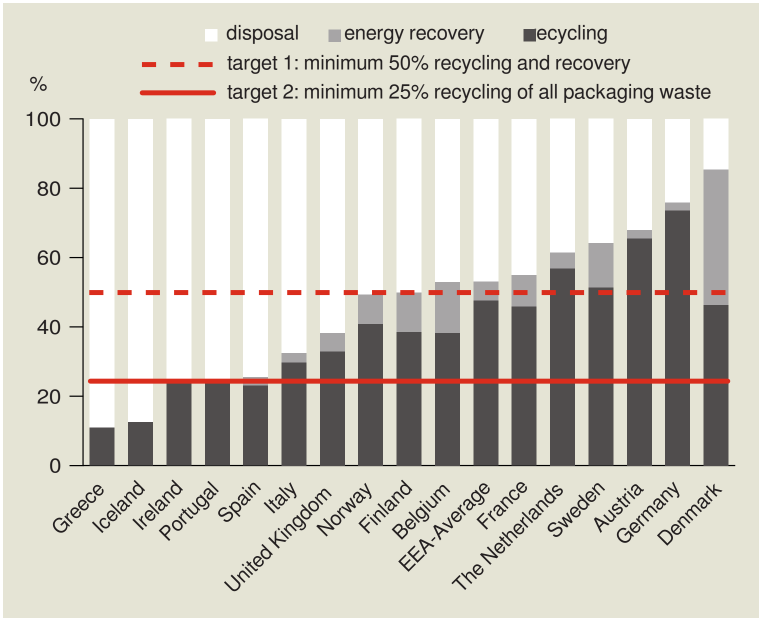
Recycling/recovery of packaging waste Figure 11.5.

Paper and cardboard, 1997



Note: Iceland and Ireland: 1995 data.
Source: Member States' reports to DG Environment under provisions of the Packaging Directive.

Four packaging materials, 1997



Note: (Energy) recovery includes composting and energy recovery (also biogas for Sweden). Disposal is assumed to account for all remaining waste which is not recovered or recycled. Waste imported for recycling has been excluded and waste exported for recycling has been included. The aggregated data has been weighted for amount of waste generated for each of glass, plastics, metals and paper.
Source: Member States' reports to DG Environment under the provisions of the Packaging Directive.

Waste prevention

An integrated Norwegian approach to reducing waste generation uses economic incentives, including a fixed levy on one-way packaging (EUR 0.1/ unit) and an environmental tax (EUR 0.4) on all packaging. The environmental tax is reduced if packaging (e.g. bottles) is returned for recovery or re-use. If returns within an approved system exceed 95 %, no environment tax is paid and consequently both producers (importers) and consumers have an economic incentive to achieve a high percentage of re-use and recovery. An example of an approved system is the recycling of bottles with a deposit system covering the whole of Norway. Bottles made from glass and the plastic, PET, are re-used in a closed loop as part of this system. Consumers pay a reasonable deposit for the bottle, and the deposit is refunded when the empty bottle is returned to the retailer. This recycling system leads to estimated annual savings of 83 000 tonnes of glass waste (20 kg per capita per year).

11.5. References and further reading

European Commission/DG Environment (1998). *Database on environmental taxes in the European Union Member States, plus Norway and Switzerland.* http://europa.eu.int/comm/dg11/enveco/database.htm.

EEA (1999). *Environment in the European Union at the turn of the century*, European Environment Agency, Copenhagen.

EEA-ETC/W (1999a). *Generation of household waste and municipal waste in member countries of the European Environment Agency. Comparability and non-comparability.* Draft report to the European Environment Agency, Copenhagen.

EEA-ETC/W (1999b). *Construction and demolition waste management practices and their economic impacts.* Report to the European Commission/DG Environment. European Environment Agency, Copenhagen.

Eurostat (1999). *Waste Generated in Europe.* (Draft). Luxembourg.

Ripert, C.(1997). *La logistique et le transport des déchets ménagers, agricoles et industriels.* ADEME, Agence de l'Environnement et de la Maîtrise de l'Energie. Ministère de l'Equipement des Transport et du Logement.

Table 11.1. **Waste generation from daily household and commercial activities, 1996**

Note: Data from Member States, plus Norway and Iceland. Data for France 1995, Germany 1993, Ireland 1995, and Sweden 1994.
Source: EEA-ETC/W

Unit: kg/capita

	bagged	organic/food	paper/cardboard	glass	metal	total
Austria	160	45	54	26	5	290
Belgium	281	6	32	22	5	346
Denmark	278	13	63	25	0	379
Finland	262	14	77	6	4	364
France	352	0	24	23	3	402
Germany	306	12	58	30	3	409
Greece	324	0	0	4	0	328
Iceland	240	0	21	11	0	272
Ireland	373	0	9	11	0	393
Italy	410	0	10	10	0	430
Luxembourg	318	0	39	34	0	391
Norway	295	11	45	9	2	362
Portugal	374	0	1	12	0	387
Spain	386	0	0	11	0	397
Sweden	300	0	46	11	0	357
Netherlands	248	75	54	22	3	402
UK	378	5	12	9	0	404
EEA	344	8	27	18	2	399

12. Water quantity

indicator	policy issue	DPSIR	assessment
exploitation index	how much of the available water do we consume anyway?	pressure	😐
water use by sector	how do various sectors contribute to water quantity problems?	driving force	-
irrigated area	how does agriculture contribute to water quantity problems?	driving force	☹
public water supply	how does public water supply contribute to water quantity problems?	driving force	☺

Water use by households and industry has decreased in many EEA member countries. However, water use for agriculture has increased, especially in southern Europe where it is a major contributor to water stress.

Water stress, which is pressure on the **quantity** and **quality** of water resources, has a profound influence on both human activities and the economy. Adequate water management to ensure reliable water supplies is essential to support all kinds of human activities and water-dependent ecosystems. Water abstraction is half the problem, the other half is related to pollution. This Chapter considers quantity issues, while quality problems due to nutrients are dealt with in Chapter 13.

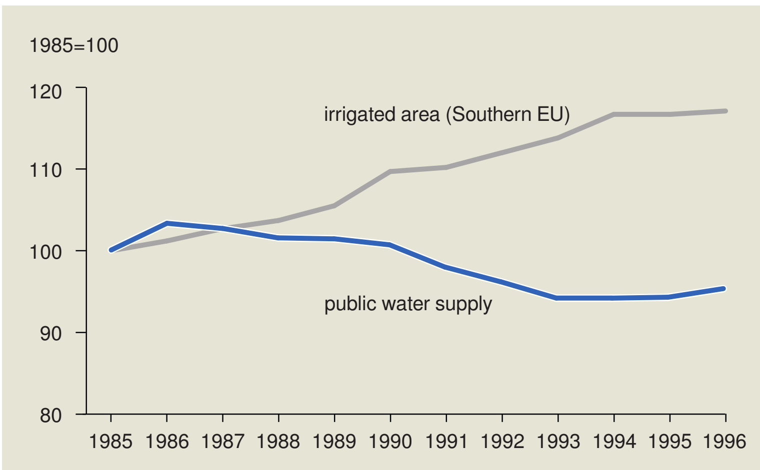
Water availability problems occur when the demand for water exceeds the amount available during a certain period. They occur frequently in areas with low rainfall and high population density (mainly around cities and in popular tourist areas along the Mediterranean coast), and in areas with intensive agricultural or industrial activity (e.g. the densely populated areas of north-western Europe). Apart from causing problems providing water to users, over-exploitation of water has lead to the drying-out of natural areas in western and southern Europe, and to salt-water intrusion in aquifers around the Mediterranean coast.

Over the past decade, the amount of water abstracted for public water supply has fallen by about 10 % (Figure 12.1). The amount of irrigated farmland in southern Europe has increased by nearly 20 % during the past 15 years, leading to a significant increase in water use by agriculture. Since 1994, however, this trend appears to have levelled off slightly.

☺ The amount of water abstracted for public water supply has fallen by about 10 % since 1985.

☹ Water use by agriculture in southern Europe has increased due to the marked increase in irrigation over the past 15 years.

Trends in public water supply and agricultural water use Figure 12.1.



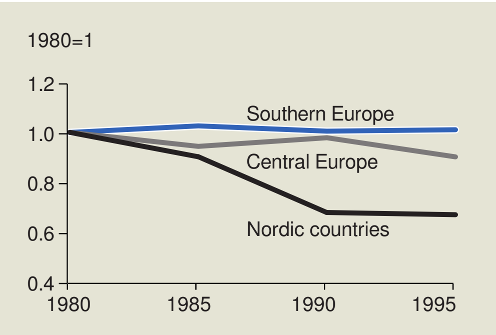
Note: Public water supply data from: Austria, Denmark, Finland, Germany, the Netherlands and the UK (England and Wales only). Irrigated area data from: France, Greece, Italy, Portugal and Spain.
Source: EEA-ETC/IW (public water supply); Eurostat/FAO (irrigated area)

12.1. Water resources in Europe

Water resources are unevenly distributed, with annual average run-off ranging from more than 3 000 mm in western Norway to 100-400 mm over much of central Europe and less than 25 mm in central and southern Spain. Some countries rely heavily on water flowing in from across their borders.

Figure 12.2. **Water exploitation in three European regions**

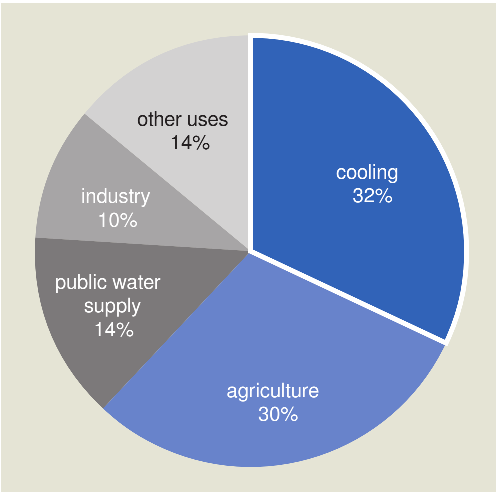
Note: The water exploitation index is the ratio between total water abstraction and total renewable resources in a region. Central Europe: Austria, Belgium, Denmark, Germany, the Netherlands and the UK. Southern Europe: France, Italy and Spain. Nordic countries include Sweden and Finland.
Source: EEA-ETC/IW



The water exploitation index has decreased in Nordic and central European countries over recent years. It has remained stable in southern Europe.

Figure 12.3. **Water use in EEA member countries by sector, latest available year**

Note: Public water supply is used by households and industry. Businesses with direct water abstraction, e.g. from boreholes, are included in the industry sector.
Source: EEA-ETC/IW



Cooling and agriculture account for nearly two-thirds of water use in the EEA area.

To meet their needs, the northern, central and southern regions abstract, on average, around 1 %, 25 % and 26 % respectively of their renewable freshwater resources each year. However, in central Europe, the main use of abstracted water is cooling water for energy production. Most of this water is returned virtually unchanged to the water body it was abstracted from and can be used again. In southern Europe, the main use of abstracted water is agricultural. Around 80 % of this water is consumed and is therefore not available for other uses.

The ratio between total water abstraction and total renewable water resources in a region, known as the exploitation index, provides a good indication of water quantity problems. Figure 12.2 shows that countries in the Nordic and central regions reduced their exploitation of water between 1980 and 1995 by 30 % and 10 % respectively. In southern Europe, however, exploitation has remained more or less constant. In 1995, more than 25 % of renewable water resources were exploited in Belgium, Germany, Italy and Spain. The exploitation index was between 10 % and 15 % in Denmark, France, the Netherlands and Portugal. Austria, Luxembourg and the Nordic countries do not have problems with exploitation (the index is less than 5 %).

The continued deterioration in the quality and quantity of water – particularly groundwater – led the European Council to call for a detailed EU action programme to be drawn up to protect and manage groundwater as part of an overall policy on water protection. The draft Groundwater Action and Water Management Programme (European Commission, 1996) required a programme of actions aimed at sustainable management and protection of freshwater resources to be implemented by 2000 at national and Community level. Many of the draft programme's recommendations are included in the proposed Water Framework Directive (European Commission, 1997).

12.2. Water use by sectors

The major uses of abstracted freshwater in the EEA area are cooling water for power generation and irrigation in agriculture (Figure 12.3).

Total abstraction varies from around 200 m^3/inhabitant/year in Denmark, Luxembourg and the UK to more than 800 m^3/

inhabitant/year in Italy, the Netherlands and Spain (Figure 12.4). This variation is due to: high water use by industry in northern countries; the large amounts used as cooling water in Belgium, France, Germany and the Netherlands (normally taken directly from large rivers and discharged back again after use); and high water use for agriculture in southern countries.

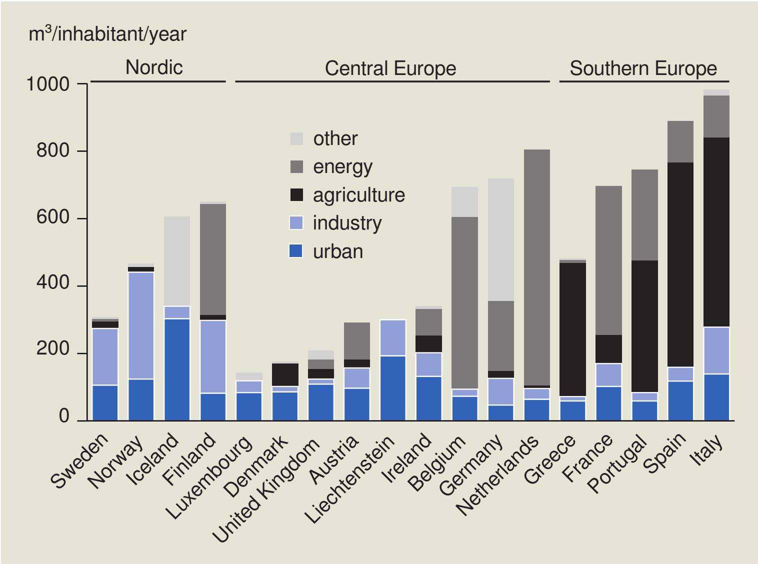
12.3. Water use by agriculture

Data on trends in the amount of water used for irrigation in Europe is not available. A substitute is to consider the land area subject to irrigation (Figure 12.5). This shows an increase of about 7 % in the irrigated area in southern Europe between 1990 and 1996. Figure 6.4 shows particularly rapid growth in Greece during this period, although Italy and Spain have experienced the largest absolute growth.

Around 94 % of water use for irrigation in the EU occurs in the south. The amount of water used for irrigation in Italy and Spain is about 10 times higher than in the central EU countries combined. France, Greece and Portugal each use about the same amount of water for irrigation as central EU countries. The role of irrigation in southern Europe is completely different from central and northern countries. Irrigation is essential to improve production in the dry summers of the south. However, reform of the Common Agricultural Policy should lead to planting of crops with lower water demands. Introduction of more efficient irrigation systems should also reduce water use.

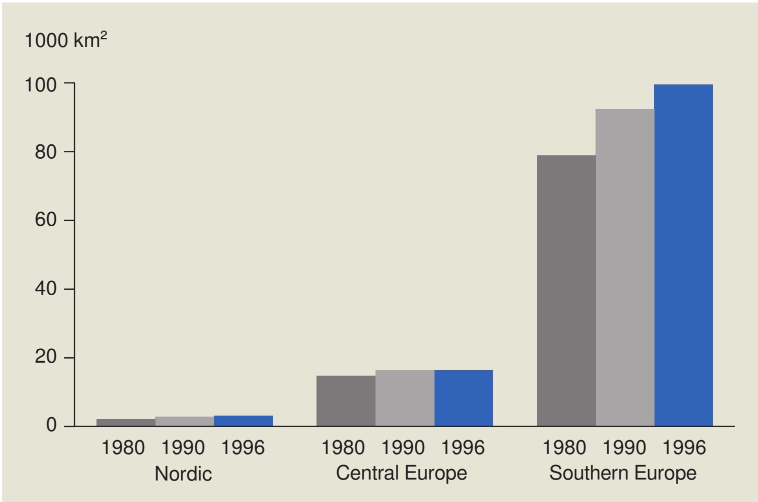
Water charges are not generally related to the true cost (including environmental impact) and are not the same for all users. This is particularly true for agricultural users, who are considered to pay very low charges that are related to neither the quantity used nor the real environmental impact. Economic instruments – in this case abstraction charges and pricing mechanisms – are widely regarded as valuable tools for achieving sustainable water management. Use of economic instruments for irrigation therefore deserves further attention. Water charges have been one reason for the decline in water use by households and industry.

Total water abstraction in EEA member countries by region and by major uses, latest available year Figure 12.4.



Source: EEA- ETC/IW

Development in irrigated area in Europe by region, 1980-1996 Figure 12.5.



Note: Nordic: Finland, Iceland, Norway and Sweden. Central: Austria, Belgium, Denmark, Germany, Ireland, Luxembourg, the Netherlands and the UK. South: France, Greece, Italy, Portugal and Spain.
Source: FAO/Eurostat

☹ Irrigated areas have increased during the past 15-20 years, especially in southern Europe.

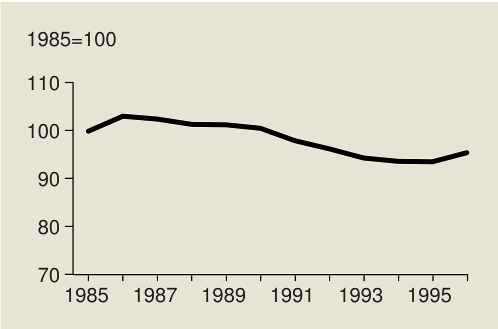
12.4. Water use by households and industry

Public water supply in selected European countries has declined in the decade from 1985 (Figure 12.6). There are a number of reasons for this decline, including greater awareness of water use; water metering; increased water charges and taxes; restrictions on garden watering; fewer leaks; and widespread use of more efficient appliances such as low- or dual-flush toilets.

Groundwater is the source of over 75 % of the water for public water supply in Austria, Denmark, Iceland and Portugal. In Belgium (Flanders), Finland, France, Germany, Luxembourg and the Netherlands between 50 % and 75 % of the public water supply is abstracted from groundwater (Eurostat, 1997). Groundwater is increasingly preferred for public water supply because it is generally higher quality than surface water and requires less treatment. This has led to over-abstraction and a lowering of the groundwater table in many parts of Europe. Consequences include: the drying-up of spring-fed rivers, such as in Denmark; destruction of many wetlands (with examples from 'dry' countries like Spain and 'wet' countries like the Netherlands); and salt-water inflow to aquifers along the Mediterranean coast.

Figure 12.6. **Public water supply in selected European countries**

Note: Based on information from Austria, Denmark, Germany, Finland, the Netherlands and the UK (England and Wales only).
Source: EEA-ETC/IW



☺ Public water supply fell by 8-10 % in a number of European countries between 1987 and 1995.

12.5. Indicator improvement

Many of the indicators in this Chapter are not yet available as time series. For existing indicators, improved harmonisation is needed of data and methodologies for estimating and reporting water abstractions and water use (particularly focusing on the treatment of cooling water and water use for irrigation), including sectoral breakdowns.

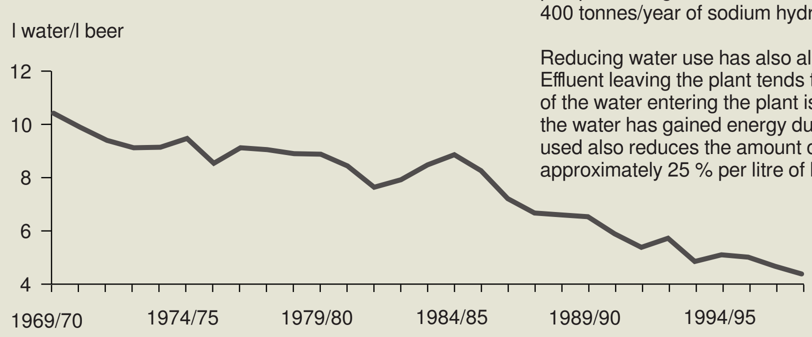
For the future, indicators are needed on the intensity and efficiency of water use (leakage) by countries, including sectoral breakdowns. Response indicators would be desirable on the costs of producing water fit for human consumption and the use of pricing mechanisms (charges) to assure Cost Recovery Principle which is a cornerstone of European water policy. Positive indicators on the elimination of subsidies and the

Brewery water savings cut energy bill

The water-saving target set by Carlsberg in 1977 has resulted in a 50 % reduction in the amount of water used per litre of beer produced at its Copenhagen brewery. Washing, pasteurisation and bottling machines were modified to recycle water, while processes were systematically revised and modified to encourage water saving. These changes to machinery and processes saved a total of 200 000 m^3/year of water. A similar approach was applied to the brewing area, where cleaning water is now collected in a tank, pumped through a filter and re-used. This saves 35 000 m^3/year of water and 400 tonnes/year of sodium hydroxide.

Reducing water use has also allowed Carlsberg to reduce energy consumption. Effluent leaving the plant tends to be at around 30-35°C, but the temperature of the water entering the plant is 10°C. This temperature difference shows that the water has gained energy during the process. Reducing the amount of water used also reduces the amount of effluent, leading to energy savings of approximately 25 % per litre of beer produced.

Source: Carlsberg, Denmark



internalisation of pollution costs in prices would also be desirable.

Analysis of the effectiveness of demand side vs supply side strategies for alleviating water stress should be considered, as well as of the effectiveness of the Groundwater Action Programme and the Drinking Water Directive for improving the quality of drinking waters.

12.6. References and further reading

EEA (1998). *Europe's Environment: The second assessment.* European Environment Agency, Copenhagen.

EEA (1999a). *Groundwater quality and quantity in Europe.* Environmental assessment report No 3. European Environment Agency, Copenhagen.

EEA (1999b). *Environment in the European Union at the turn of the century*. Chapter 3.5 Water Stress. European Environment Agency, Copenhagen.

EEA (1999c). *Sustainable water use in Europe - sectoral use of water*. Environmental assessment report No 1. European Environment Agency, Copenhagen.

European Commission (1996). *Proposal for a European Parliament and Council Decision on an action programme for integrated groundwater protection and management*. COM(96)315 final. European Commission, Brussels.

European Commission (1997). *Proposal for a Council Directive establishing a framework for Community action in the field of water policy*. COM(97)49 final. European Commission, Brussels.

Eurostat (1997). *Estimation of renewable water resources in the European Union*. Luxembourg.

Total water abstraction per inhabitant in EEA member countries Table 12.1.

Unit: m^3 per inhabitant per year

	1980	1985	1990	1991	1992	1993	1994	1995	1996
Austria	290	280			299	281			
Belgium	917								
Denmark	235		228					170	
Finland	774	816	471					479	
France	651	631	675				702		
Germany	686	804		591					
Greece	523								
Iceland	439	427			626			607	
Ireland	315						328		
Italy	996	918							
Liechtenstein									
Luxembourg			183	154	Average for 1990-95 is 143.				
Netherlands	650	638		518					
Norway	496								
Portugal			735						
Spain	1068	1204		948				849	
Sweden	494	356	345					308	
UK	270	231	211	206	216	194	182	212	198

Note: Denmark: 1977 data given for 1980. France: 1981 data given for 1980. Germany: 1981 and 1983 data given for 1980 and 1985 data respectively and for former West Germany only. The Netherlands: 1981 and 1985 data given for 1980 and 1985 respectively. Portugal: 1989 data given for 1990. UK data is for England and Wales only and excludes water abstraction for power generation.
Source: OECD

13. Eutrophication

indicator	policy issue	DPSIR	assessment
nitrogen and phosphorus concentrations in rivers	do we see the results of nutrient policies in rivers?	state	😐 / 🙂
nitrogen run-off	what have been the main contributions to the total load of nitrogen?	pressure	☹
nitrogen balance	has agriculture balanced its inputs and outputs of nutrients?	pressure	☹
phosphorus load	what have been the main contributions to the total load of phosphorous?	pressure	😐
discharge of phosphorus from urban wastewater treatment plants	what has been the result of the urban wastewater directive and national measures?	pressure	🙂
wastewater treated	- „ -	response	🙂
nitrate concentrations in groundwater	how often are groundwater quality aims for nitrogen exceeded?	state	☹
phosphorus concentrations in lakes	do we see the results of a decrease in phosphorus emissions?	state	🙂
phosphate concentrations in coastal water	do we see the results of nutrient policies in coastal waters?	state	😐
nitrate concentrations in coastal water	- „ -	state	😐

Measures to reduce nutrient pollution of water bodies have been implemented with varying degrees of success. The Urban Waste Water Directive and investment by EEA member countries in nutrient removal have reduced phosphorus discharges. Nitrogen pollution has been reduced to a far lesser extent, with the nitrogen surplus from agriculture staying at the same concentration as in 1990. Phosphorus concentrations in major rivers have fallen significantly over the last 15 years, but nitrate concentrations have remained constant and high. Nitrate concentrations in many groundwater supplies exceed limits set by the Drinking Water Directive. Phosphorus concentrations in severely affected lakes have fallen significantly. Nutrient concentrations in coastal waters show little overall improvement.

13.1. What is eutrophication?

The overloading of seas, lakes, rivers and streams with nutrients (nitrogen and phosphorus) can result in a series of adverse effects known as eutrophication. Phosphorus is the key nutrient for eutrophication in fresh waters and nitrate is the key substance for salt waters.

In severe cases of eutrophication, massive blooms of algae (sessile and planktonic) occur. Some blooms are toxic. As dead algae decompose, the oxygen in the water is used up; bottom-dwelling animals die and fish either die or leave the affected area. Increased nutrient concentrations can also lead to changes in the aquatic vegetation. The unbalanced ecosystem and changed chemical composition make the water body unsuitable for recreational and other uses, and the water becomes unacceptable for human consumption. High concentrations of nitrate in drinking water are considered a human-health problem because in the stomach nitrate is converted rapidly to nitrite, which can cause a reduction in the blood's oxygen-carrying capacity.

The main source of nitrogen pollution is run-off from agricultural land, whereas most phosphorus pollution comes from households and industry. The rapid increase in industrial production and household consumption during the 20th century has resulted in greater volumes of nutrient-rich wastewater. Nutrient removal during wastewater treatment in sewage-treatment plants is vital to minimise the impact of nitrogen and phosphorus pollution on Europe's water bodies.

Since 1980, nitrate concentrations in major EU rivers have been about constant (Figure 13.1). There is no evidence that reduced application of nitrogen fertilisers to agricultural land has resulted in lower nitrate concentrations in rivers. The decline in phosphorus concentrations in major EU rivers is due to improved wastewater treatment and less phosphorus in household detergents.

13.2. Controls of nutrient discharges

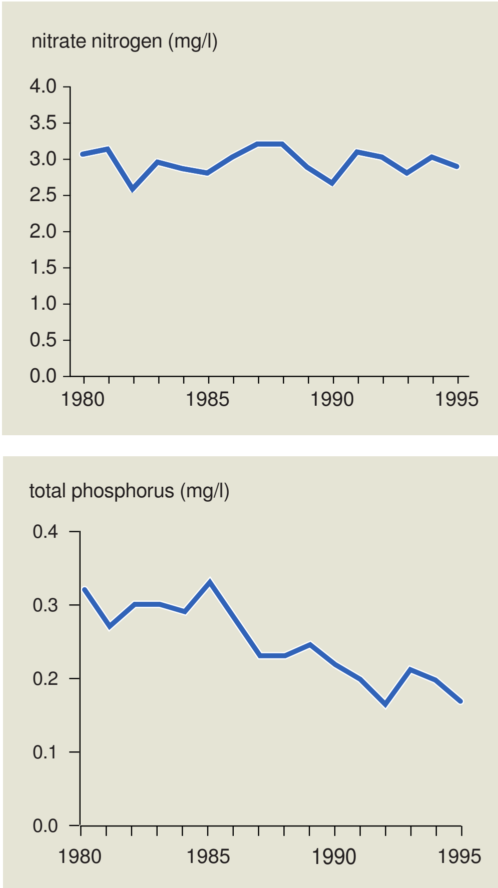
Control of point-source discharges varies between EU Member States. However, some improvement is likely as Member States invest in new infrastructure in order to comply with the Urban Waste Water Treatment Directive. This requires Member States to provide urban areas with sewage collection and wastewater treatment systems. In sensitive areas, nutrient removal is required as part of a more advanced treatment programme. Since May 1999 all Members States have fully or partly transposed this Directive into their national laws and developed implementation plans – in most cases with considerable delay. There are indications that it will be possible to reach the deadlines for achieving the environmental objectives of the Directive, although for Brussels and Milan much remains to be done.

Controls have been most effective for major point sources, such as urban wastewater and industrial effluents, and where nutrient use has been restricted or banned, e.g. phosphate in detergents. However, many small point sources are not covered effectively by current legislation and are likely to discharge into small rivers where they can have a significant negative impact.

Efficient control of diffuse sources such as nitrate run-off from agriculture has rarely been achieved. Fertiliser use and nutrient loads from manure have fallen since the 1980s, mainly due to the effects of CAP reforms. Nutrient inputs to water bodies from agriculture are still too high. Implementation of the Nitrate Directive has been unsatisfactory in most Member States and the Commission has begun legal action against those Member States that have not yet complied.

Although phosphorus pollution from point sources has fallen, it may be necessary to take measures to reduce diffuse loads from agricultural areas – particularly in areas where the soil's absorption capacity for phosphorus is exceeded.

Nitrogen and phosphorus in major EU rivers Figure 13.1.



Note: Median of indexed values of concentrations of nitrate nitrogen and total phosphorus at 92 locations. **Source**: EEA-ETC/IW based on country returns under EC Exchange of Information Decision (77/795/EEC)

😐 Nitrate concentrations have been largely unchanged since 1980.

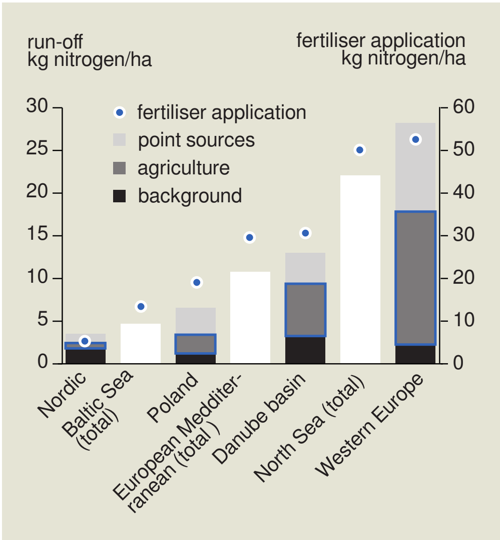
🙂 Phosphorus concentrations in some EU rivers have fallen since the mid-1980s, particularly in the largest and most polluted rivers.

13.3. Nitrogen flows

Comparison of nitrogen run-off with the application of fertiliser shows that diffuse sources – particularly agriculture – dominate (Figure 13.2). Human activities account for less than half the nitrogen discharged in the Nordic countries, where about 7 % of the land is cultivated and population density is low. Most comes from run-off from forested and uncultivated areas.

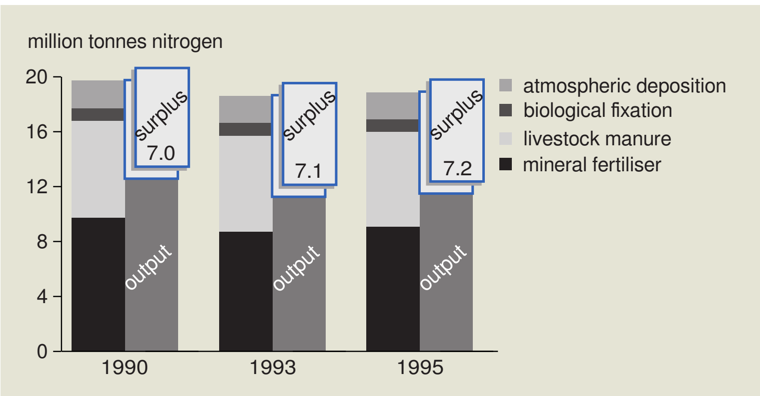
Figure 13.2.	Nitrogen run-off and fertiliser application in selected European areas, latest available year between 1988 and 1996

Note: All areas greater than 300 000 km². Run-off and fertiliser application per hectare of total land area.
Source: EEA-ETC/IW



Agriculture is the main source of nitrate pollution. Nitrogen run-off in areas with intensive agriculture is over 5, and often more than 10 times higher, than that from forested areas.

Figure 13.3.	Nitrogen balance for agricultural soil in EU Member States, 1990-1995



Note: Based on data from the first 12 EU Member States.
Source: Eurostat

About a third of nitrogen applied to agricultural land is not removed with the harvest.

Those areas with the five highest amounts of nitrogen run-off in Figure 13.2 have similar amounts (40-50 %) of arable land. The marked increase in run-off from 6.5 kg/hectare in Poland to 28 kg/hectare in western Europe is due to more intensive agriculture – as shown by the higher rates of fertiliser application.

The two main nitrogen inputs to agricultural land are mineral fertilisers and manure. Between 1990 and 1995, the total input in the first 12 EU Member States fell by around 5 % (Figure 13.3). However, there was a similar decrease in nitrogen removal by harvested crops (i.e. output). Surplus nitrogen – a source of pollution – remained almost constant at 7.2-7.4 million tonnes. Nitrogen surpluses in EU Member States for 1990, 1993 and 1995 are shown in Table 13.1. The nitrogen balance in the 15 EU Member States is only available for 1995, but is almost identical to that for the 12 Member States included in Figure 13.3.

13.4. Phosphorus flows

Figure 13.4 shows that the annual phosphorus load per hectare area increases with population density. In relatively sparsely populated areas with low agricultural activity, such as the Nordic countries, only half the phosphorus loading is due to human activities. The other half comes from diffuse run-off from forested and uncultivated land. For example, in the Baltic Sea catchment area where the population density is less than 50 inhabitants/km², the phosphorus load is 0.23 kg/hectare. In the North Sea catchment area, the population density is about 200 inhabitants/km² and the phosphorus load is 2.7 kg/hectare.

Over the past 15 years, phosphorus discharges from urban wastewater treatment plants in many countries in north-west Europe have fallen by 50-80 % (Figure 13.5). The main reason for this reduction is the upgrading of wastewater treatment plants to include phosphorus removal. The shift to phosphate-free detergents has also contributed.

During the same period, marked changes have occurred both in the proportion of the population connected to the sewerage system and in wastewater treatment technologies (Figure 13.6). In northern and central European countries, most of the population was connected to the sewerage system and a wastewater treatment plant by

Households and industry are the biggest contributors of phosphorus to the environment. However, in those parts of Europe with intensive agriculture, the contribution from agriculture approaches 50% of the total.

the early 1980s. In southern countries, the population connected to sewers has increased significantly – but by 1995 only about half had their wastewater treated.

In the 1980s, secondary treatment (i.e. biological removal of oxygen-consuming substances) became common in western countries. However, countries like Finland and Sweden were already using tertiary treatment (i.e. nutrient removal) as well. Many western European countries built treatment plants with nutrient removal in the late 1980s and the 1990s.

Total phosphorus discharges from urban wastewater treatment plants in north-west European countries have fallen significantly during the past 15 years.

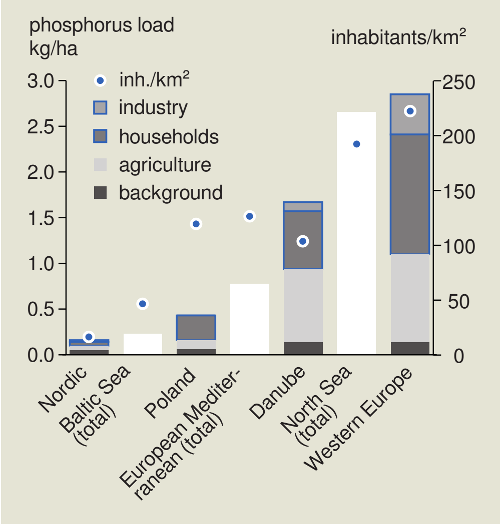
13.5. Nutrients in ground and surface waters

13.5.1. Nitrate in groundwater

When nitrate is washed out of agricultural soil, it first contaminates shallow groundwater. At a later stage, deeper groundwater in vulnerable positions is affected, e.g. parts of the UK with fractured limestone with thin soil cover and the eastern Netherlands with its sandy soils and severe nitrogen loading. Most groundwater supplies in the EU are from deep wells and are therefore not immediately affected by high nitrate concentrations. In areas where the nitrogen concentrations in groundwater are high and the water is obtained from shallow groundwater sources (the usual

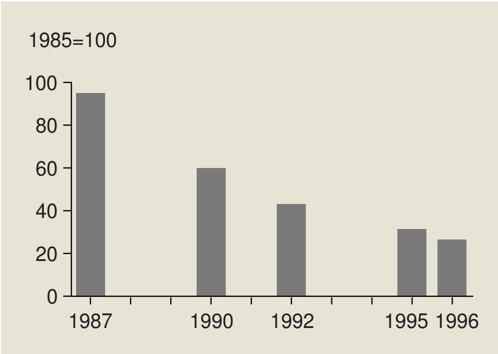
Nordic and central European countries have the highest percentage of wastewater subject to tertiary treatment (particularly phosphorus removal).

Sources of phosphorus in selected European countries and catchment areas, latest available year between 1988 and 1996 Figure 13.4.



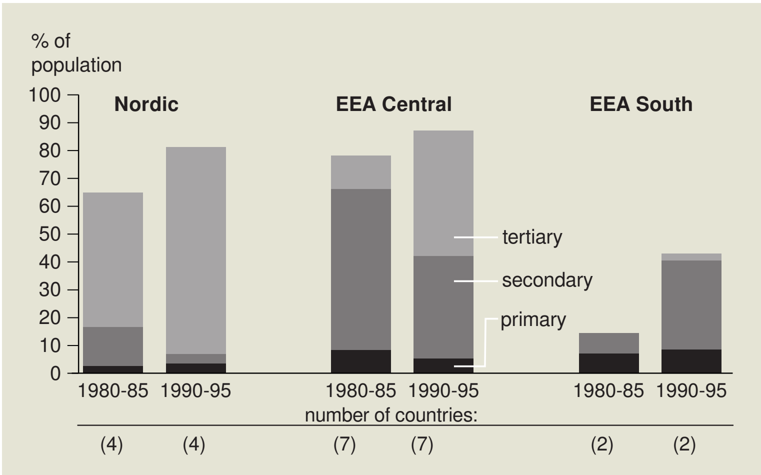
Note: All areas greater than 300 000 km ².
Source: EEA-ETC/IW

Discharge of phosphorus from urban wastewater treatment plants in north-west Europe Figure 13.5.



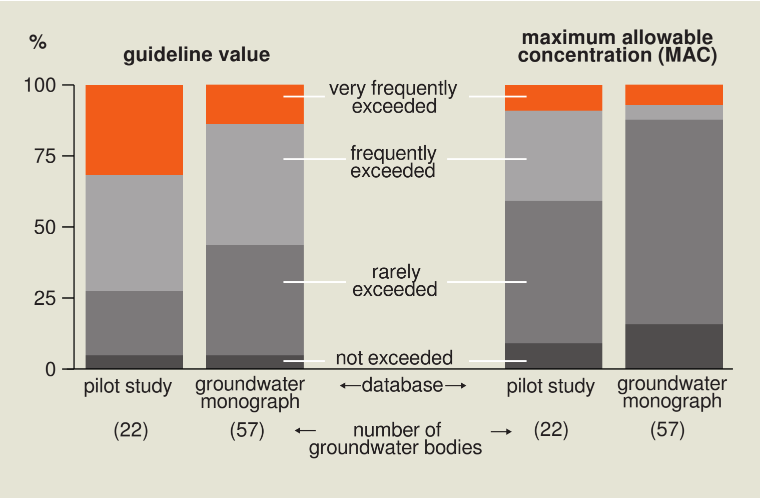
Note: Data from Denmark, Finland, the Netherlands, Norway, Sweden and North Rhine–Westphalia (Germany).
Source: EEA-ETC/IW

Developments in wastewater treatment in European regions between 1980-85 and 1990-95 Figure 13.6.



Notes: Nordic: Finland, Iceland, Norway and Sweden. EEA Central: Austria, Denmark, Germany, Ireland, Luxembourg, the Netherlands and the UK. EEA South: Greece and Spain.
Source: Eurostat and national information

Figure 13.7.	Nitrate concentrations in groundwater, latest available year between 1990 and 1996

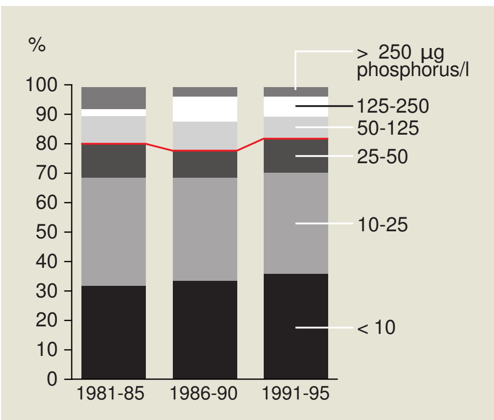


Notes: Percentage of groundwater bodies where the guide value and the MAC are exceeded: very frequently (>50 % of sites); frequently (>25 %); rarely (0–25 %); and not at all. Numbers in brackets indicate the number of administrative authorities responsible for the groundwater bodies in the database.
Source: EEA-ETC/IW

> ☹ The Drinking Water Directive guideline value and the maximum allowable concentration for nitrate in drinking water are exceeded in many EU groundwater supplies.

Figure 13.8.	Phosphorus in lakes

Note: Number of lakes: Finland 71; Denmark 13; Ireland 6; Sweden 6; Austria 5; Germany 5; France 4; Norway 4; the Netherlands 2.
Source: EEA- ETC/IW



> ☺ Lakes that had high phosphorus concentrations (>50 µg/litre) in the early 1980s have lower concentrations today. However, only slight changes in phosphorus concentrations have been observed in less-affected lakes.

practice for private and small communal supplies), the population can be at risk.

Figure 13.7 shows that the Drinking Water Directive guideline value of 25 mg nitrate/litre for drinking water is exceeded at over half the groundwater sampling sites used in the compilation of two EEA databases. The maximum allowable concentration (MAC) is exceeded at around a quarter of the sampling sites.

13.5.2. Phosphorus in lakes

Like rivers (Figure 13.1), phosphorus concentrations in many lakes have fallen (Figure 13.8). This is particularly true for lakes that had high concentration in the early 1980s. The improvement is due to better wastewater treatment and use of phosphate-free detergents. Diverting wastewater away from the lake is another frequently used method of reducing external loading.

Despite considerable reduction in phosphorus inputs from point sources, many lakes have not yet shown the expected environmental improvement. The main reason for this is accumulation and release of phosphorus from the lake bottom or continued contamination from scattered dwellings and agricultural sources.

13.6. Phosphorus in coastal waters

All signatories to the Third International Conferences on the Protection of the North Sea achieved the Conferences' objective of reducing phosphorus inputs to surface waters by 50 % between 1985 and 1995 (Andersen and Niilonen, 1995). However, this reduction is not yet reflected in overall phosphate concentrations in coastal waters.

In most coastal waters, there has been zero or limited change in phosphate concentration (Figure 13.9, 13.10). However, the reduced phosphate content of detergents and other measures in the catchment area have resulted in a fall in phosphate concentrations in parts of the coastal zones in some regions, e.g. the Skagerrak, Kattegat, the German Bight and the Dutch coastal zone. The average decrease in phosphate concentration of 46 % in these areas reflects the reduction in inputs. Reduced phosphorus loads in the River Rhine have resulted in an average 50 % reduction in concentrations in the Dutch coastal zone since 1985 and less phytoplankton biomass. Present phosphate concentrations in the area are still 2-3 times higher than marine background concentrations (De Vries *et al*, 1998). In the Gulf of Finland, leaching from sediment has caused phosphate concentrations to increase recently. In general, the presence of a large buffer of phosphorus in coastal sediments is the main reason why the reduction in phosphate inputs has not been reflected immediately by a reduction in phosphate concentrations.

13.7. Nitrogen in coastal waters

No signatory state to the Third International Conferences on the Protection of the North Sea achieved the Conferences' objective of reducing nitrogen inputs to surface waters by 50 % between 1985 and 1995. However, all North Sea States are expected to have reached a substantial reduction of nitrogen inputs to surface waters of around 25 % (Andersen and Niilonen, 1995).

Figure 13.11 shows a gradual reduction in nitrate concentrations in coastal waters for 48 % of the 10 km ^{2} squares in each sub-region. A 100 % decrease was found only in sub-regions with up to three squares per sub-region; this might therefore be due to the limited data available. The mean decrease in nitrate concentration is around 25 %. Part of the decrease appears to be due to very low run-off into rivers in 1996 and 1997.

Fishing for clean water

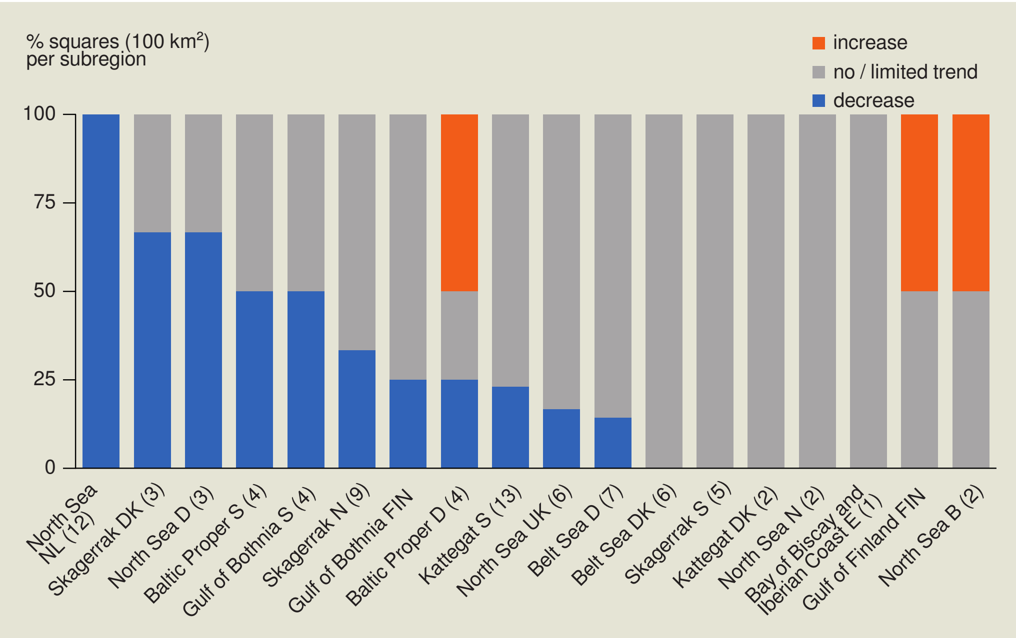
In cases of eutrophication, depth of visibility is one of the best indicators of lake condition. Shallow healthy lakes should have plants growing on the lake bottom, providing refuge for animal plankton from fish. The animal plankton keep plant plankton under control, thus preventing the harmful algal blooms characteristic of eutrophication. To become established and survive, however, underwater plants need high water clarity.

In Denmark, Lake Væng still showed the symptoms of severe eutrophication in 1986 despite a 63 % reduction in phosphorus inputs from 1982. Between 1986 and 1988, half the population of fish feeding on animal plankton were caught. This manipulation of the food chain resulted in an increase in the numbers of animal plankton grazing on the plant plankton and a corresponding decrease in plant plankton. Water visibility improved as the plant plankton were kept under control, leading to the establishment of underwater plants. The amount of plant plankton in the lake has remained low and stable, indicating a sustainable and clean lake environment with fewer signs of eutrophication than before the fish were removed.

Source: EEA, 1999c

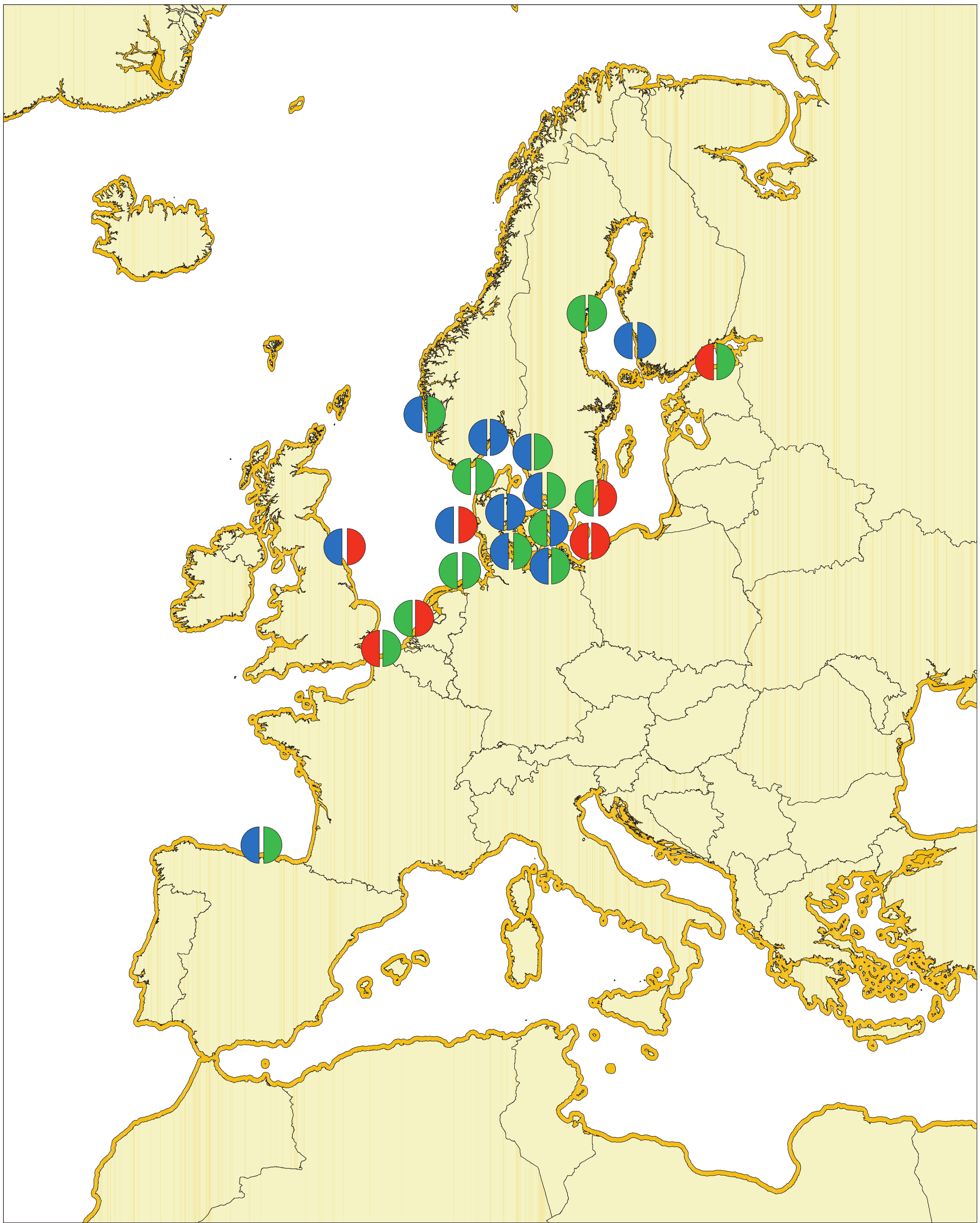
Most coastal waters show little or no change in phosphate concentrations. However, there is a substantial decrease in 35 % of OSPAR and HELCOM coastal waters within the EU and Norway.

Changes in phosphate concentration in OSPAR and HELCOM coastal waters, 1985-1998 Figure 13.9.



Notes: Trend in winter phosphate concentrations expressed as a percentage of squares (10 ´10 km) in coastal waters of OSPAR and HELCOM countries within the EU and Norway. The total number of squares in each area is given in brackets. The category 'no/ limited trend' indicates a trend between +10 % and -10 %. The methodology for the aggregation of squares in each region in given by Van Buuren et al. (draft)
Source: ICES; Finnish National Focal Point

Figure 13.10 **Nitrate and phosphate concentrations in Atlantic, North Sea and Baltic coastal waters, 1985-1996**



Source data: ICES

N = trend in nitrate

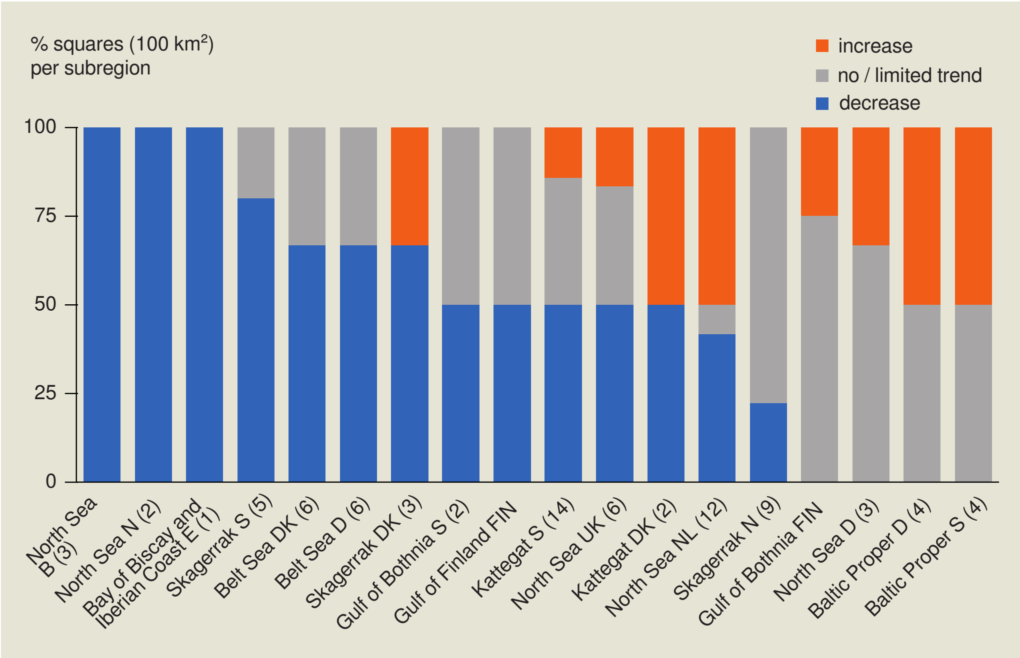
P = trend in phosphate

decrease

increase

no/limited trend or equal increase and decrease

Changes in nitrate concentration in OSPAR and HELCOM coastal waters, 1985-1998 Figure 13.11.



Notes: Trend in winter nitrate concentrations expressed as a percentage of squares (10 ´10 km) in coastal waters of OSPAR and HELCOM countries within the EU and Norway. The total number of squares in each area is given in brackets. The category 'no/ limited trend' indicates a trend between +10 % and -10 %. The methodology for the aggregation of squares in each region in given by Van Buuren et al. (draft).
Source: ICES; Finnish National Focal Point

About 20 % of the squares in each sub-region show an increase in nitrogen concentration. These are mainly sub-regions of the Baltic Sea, Kattegat and Skagerrak, where the increased nitrate concentrations are probably related to internal fluxes (remineralisation of nitrogen).

Nitrate concentrations in coastal waters fell in nearly half OSPAR and HELCOM coastal waters within the EU and Norway between 1985 and 1998. However, there were also some increases.

13.8. Indicator improvement

An ideal pressure indicator for eutrophication would be the total emissions of nutrients to waters and to the atmosphere by country and by source (point and diffuse). OSPARCOM is developing guidelines for the measurement and calculation of such emission data for nutrients.

When fully implemented, the EEA's water information and monitoring network, Eurowaternet, will provide information on water quality and quantity issues for different types of water bodies. Information will also be gathered on the status and trends in the quality and quantity of Europe's inland water resources and how these relate and respond to driving forces and pressures on the environment.

For the future, impact indicators on eutrophication (e.g. algae blooms, oxygen deficiency, changes in macrophyte and bottom animal communities) should be developed. Also indicators and analysis of the effectiveness of response measures such as the Urban Waste Water Treatment Directive and the Nitrates Directive against the costs of implementation, will be needed.

13.9. References and further reading

Andersen, J. and Niilonen, T. Eds. 1995. *Progress report. Fourth international conference on the protection of the North Sea*. Ministry of the Environment and Energy, Danish Environmental Protection Agency, Copenhagen.

Borum, J. 1996. 'Shallow waters and land/ sea boundaries' in *Eutrophication in Coastal Marine Ecosystems*. Eds: B.Børgensen and K. Richardson. American Geophysical Union. pp. 179-205.

De Vries, I., Duin, R.N.M., Peeters, J.C.H., Los, F.J., Bokhorst, M. and Laane. R.W.P.M. 1998. 'Patterns and trends in nutrients and phytoplankton in Dutch coastal waters:

Table 13.1. **Nitrogen surplus in agricultural areas of EU Member States, 1990-1995**

Unit: kg nitrogen/ha of utilised agricultural area (UAA)

	1990	1993	1995
Austria			16
Belgium	106	109	103
Denmark	93	92	72
Finland			51
France	47	54	57
Germany	105	101	102
Greece	84	61	58
Ireland	47	60	62
Italy	62	83	76
Luxembourg	124	124	121
Netherlands	229	212	213
Portugal	27	23	22
Spain	40	37	37
Sweden			38
UK	40	39	40
EU 12/15	**60**	**60**	**60**

Note: Surplus calculated as balance of inputs (mineral fertilisers, manure, biological fixation and atmospheric deposition) and outputs (harvested crops). Total average in EU 12 given for 1990 and 1993, and for EU 15 for 1995.
Source: Eurostat

comparison of time-series analysis, ecological model simulation and mesocosm experiments.' In *ICES Journal of Marine Science* Vol. 55, pp. 620-634.

EEA (1999a). *Groundwater quality and quantity in Europe. Environmental assessment report No 3*. European Environment Agency, Copenhagen.

EEA (1999b). *Environment in the European Union at the turn of the century. Environmental assessment report No 2.* European Environment Agency, Copenhagen.

EEA (1999c). *Nutrients in European ecosystems. Environmental assessment report No 4*. European Environment Agency, Copenhagen.

HELCOM (1996). *Third periodic assessment of the state of the marine environment of the Baltic Sea 1989-1993*. Balt. Sea Environ. Proc. No. 64 B.

HELCOM. *The state of the Baltic marine environment*http://www.helcom.fi/envst96.html/

Van Buuren, J., Smit, T., Poot. G., and van Elteren, A. (draft). *Testing of indicators for the marine and coastal environment in Europe. The development of the ETC/MCE indicator database*. European Environment Agency technical report, Copenhagen.

14. Wetlands

indicator	policy issue	DPSIR	assessment
designated area under the Ramsar convention	how much wetland is protected from damage or loss?	response	☺
land cover in and around Ramsar areas	what are the pressures on wetlands?	pressure	😐
proximity of transport infrastructure to Ramsar areas	- " -	pressure	☹
wintering waterbirds	how are pressures influencing the existence and distribution of flora and fauna?	state	☺

Despite global and national recognition of their importance, Europe's wetlands remain under severe pressure from land use and pollution. Many wetland areas border agricultural land and most are near transport infrastructure. One positive sign is the increase in the population of a number of wintering waterbirds, but this may be partly due to recent mild winters. All EEA member countries have now ratified the Ramsar Convention, but the process of designation to protect important wetlands takes many years to complete.

Wetlands are a characteristic feature of many landscapes, either as a major landform or as small and scattered areas. Their wide range covers marine, coastal and freshwater wetlands (lakes, rivers, bogs and marshes). Wetlands depend completely on the hydrological cycle (both natural and regulated by man) of the surrounding water catchment area. Because they receive and retain water from their surroundings, wetlands accumulate chemicals and sediments from these areas and are also subject to eutrophication (see Chapter 13).

Wetlands have a range of functions and are crucial for both chemical decomposition and as carbon sinks. They supply drinking and process water, provide fisheries and irrigation, act as a buffer against flooding, receive sewage water, support transport conduits, act as a source of hydroelectricity, and provide resources such as peat, game and berries. They also have enormous recreational value.

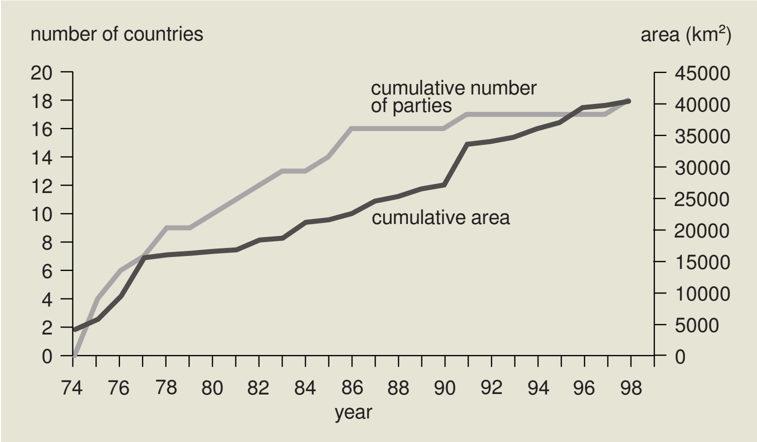
Although regulation and drainage of wetlands have been common practice in several areas of Europe for centuries, intervention has increased over the past 50-100 years. About two-thirds of the European wetlands that existed 100 years ago have been lost (European Commission, 1995) leading to a substantial decrease in the number, size and natural habitat of large bogs and marshes, and small or shallow lakes. This has changed both the visual landscape and environmental functions. The trend continues, albeit more slowly.

Although more wetlands are being restored, this does not make up for old or new losses. Restoration involves deregulation of rivers, closure of drainage systems, active pumping of water to wetlands and returning mineral quarries to wetlands. Use of the riparian zones of wetlands as nutrient traps and for sewage treatment is also becoming more widespread.

A large proportion of wetlands of international importance has been designated as Ramsar sites – after the *Convention on Wetlands of International Importance especially as Waterfowl Habitat*, adopted at Ramsar in Iran in 1971 (Figure 14.1). Other important legal instruments are the EU Birds Directive 1979 and the EU Flora, Fauna and Habitats Directive 1992. The Convention on Migratory Species (Bonn Convention) and the Bern Convention also promote wetland conservation. In addition, most European countries have specific national measures for wetland protection.

By 1986, 14 EU Member States and 2 EFTA countries had ratified the Ramsar Convention; by 1998, all 18 EEA member countries had signed. Table 14.1 shows the year of ratification, the number of areas and the total surface area designated. However, these figures give no indication of the quality of

Figure 14.1. **Contracting parties and total area designated under the Ramsar Convention by EEA member countries**



Source: Ramsar Bureau

Figure 14.2a. **Land cover in and around coastal and marine Ramsar areas in southern and north-western Europe**

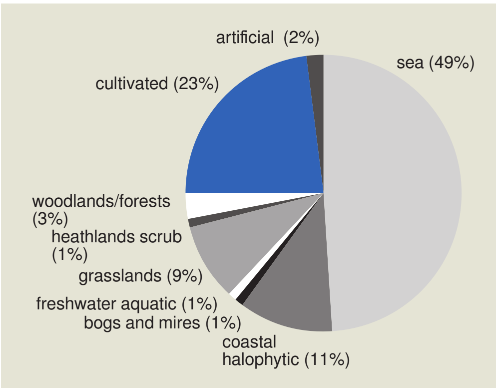
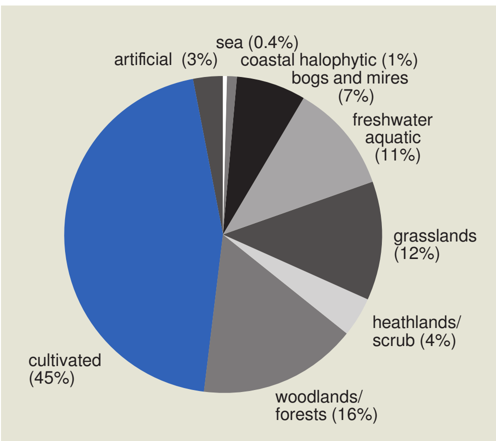


Figure 14.2b. **Land cover in and around inland Ramsar areas in southern and north-western Europe**



There is considerable national interest in global protection of wetlands, but national strategies vary and implementation takes time.

the designated areas and their subsequent management. Such evaluations have not yet been carried out. A comprehensive overview of the state of remaining unprotected valuable wetlands is also lacking.

14.1. Pressures on wetlands arising from land use

Pressures on wetlands arising from land use in and around the wetland are due to a combination of land management, fragmentation, drainage and regulation, chemical and sediment pollution.

Analysis of the land cover of important European wetlands (based on wetlands designated as Ramsar areas) gives a useful indicator of pressures from land use on wetlands (Figure 14.2). The known surface area of each Ramsar site has been used to define a circular area at the location of each site. Wetland habitats such as seas, rivers, lakes, bogs and marshes of course characterise these circular land and sea areas. However, a considerable amount of agricultural activity takes place in and close to Ramsar areas. Restriction of the analysis to Ramsar sites (due to lack of other data) means it does not necessarily reflect the full variety of important wetland types in each country.

About half the area in the coastal wetlands analysed in Figure 14.2a is classed as sea and

Many Ramsar wetland areas in southern, central and north-western Europe include or are surrounded by agricultural land. This makes them sensitive to farming practices.

Notes: Analysis covers Ramsar areas in Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. Sparsely vegetated areas in both coastal/marine and inland wetlands in these countries cover less than 1%. The analysis is based on circular areas of land with a radius corresponding to the surface area of the individual Ramsar areas concerned. Habitat information was derived from Corine Land Cover data. Due to limitations in land cover analysis, habitats covering less than 25 ha are not considered. Despite this, the results highlight a significant pattern. The data, which are for the 1990s, do not allow comparison with previous decades.
Source: Ramsar Bureau; Wetlands International; EEA Corine Land Cover; EEA-ETC/LC and EEA-ETC/NC

about half as terrestrial. Around half the terrestrial area is under cultivation and about a fifth is grasslands (used for grazing or under grass-harvesting management). Urban areas, harbours, roads, etc occupy about 5 % of the terrestrial area. Nearly two-thirds of the area of inland wetlands (Figure 14.2b) is either cultivated or wood-lands, while grasslands occupy just over one-tenth. The built-up area is slightly smaller than that for coastal and marine wetlands.

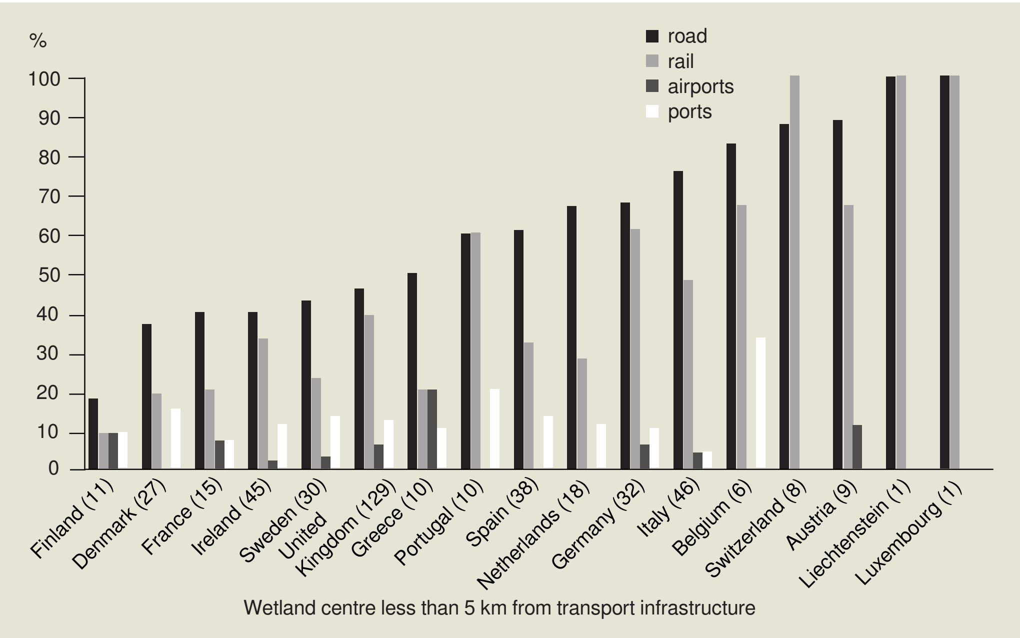
The high level of agricultural land in and around Ramsar areas means that maintaining the future value of wetland areas is closely connected with changes in agricultural practice and intensity, and with the maintenance of grasslands. In some cases, agricultural areas may be beneficial, for example in keeping the landscape open and allowing birds to feed, graze and rest on fields and grasslands. However, it is sometimes more profitable for the farmer to set aside land or to grow certain crops than to enter an agri-environmental scheme with payments for landscape management (see Chapter 6**).** The present analysis does not identify the nature and the benefits of agricultural land use around Ramsar areas.

14.2. Pressures on Ramsar areas from infrastructure

Analysis of the pressures on European wetlands arising from the fragmentation and disturbance created by roads, railways, airports and harbours either within or near wetlands shows that most Ramsar areas are near major infrastructure elements (Figure 14.3).

Roads have a major impact on wetlands in countries with a dense infrastructure, such as Austria, Belgium, Denmark, Germany, Luxembourg and the Netherlands. Railways tend to influence fewer areas, but many areas are under pressure from both roads and railways. Although airports give rise to fewer proximity problems, their large sealed surfaces can have significant local impacts. The pressure on existing Ramsar areas is expected to increase as transport networks expand. It will also become harder to designate new areas for protection that are not already influenced by infrastructure.

Proximity of transport infrastructure to Ramsar areas in selected European countries Figure 14.3.



Note: Number of Ramsar areas included in analysis is given in brackets.
Source: Ramsar Bureau; Wetlands International; EEA-ETC/LC

☹ Most Ramsar areas are near major infrastructure elements. Throughout Europe, roads and railways cause the greatest proximity problems. The possibility of designating new protected areas without proximity problems is becoming smaller.

Figure 14.4a. **Index of wintering waterbirds in four Mediterranean countries**

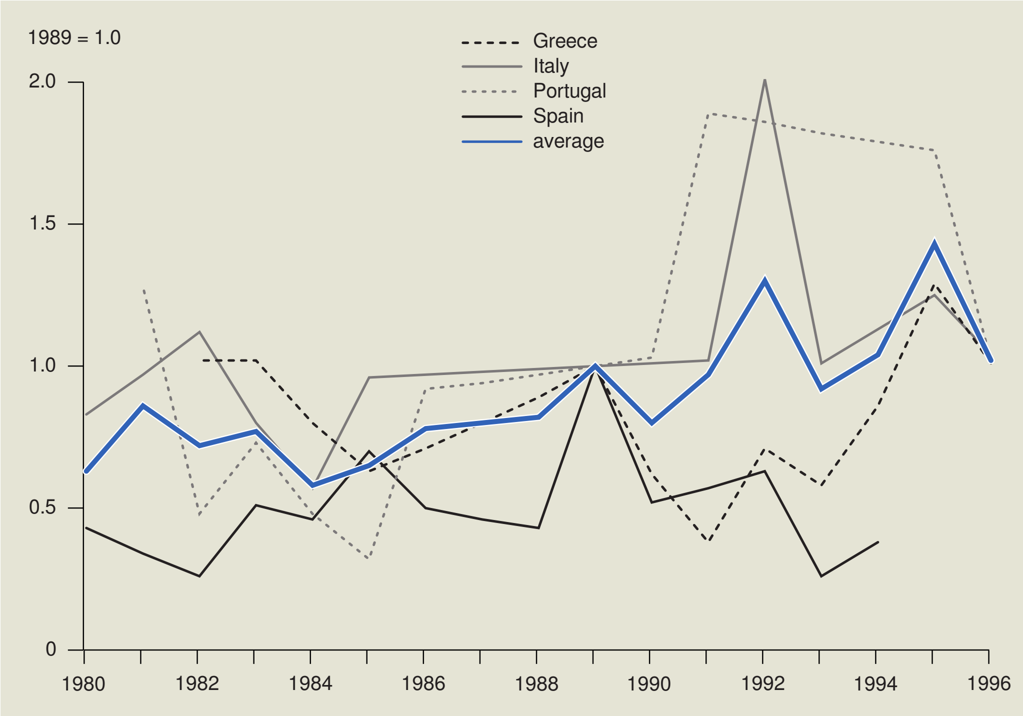
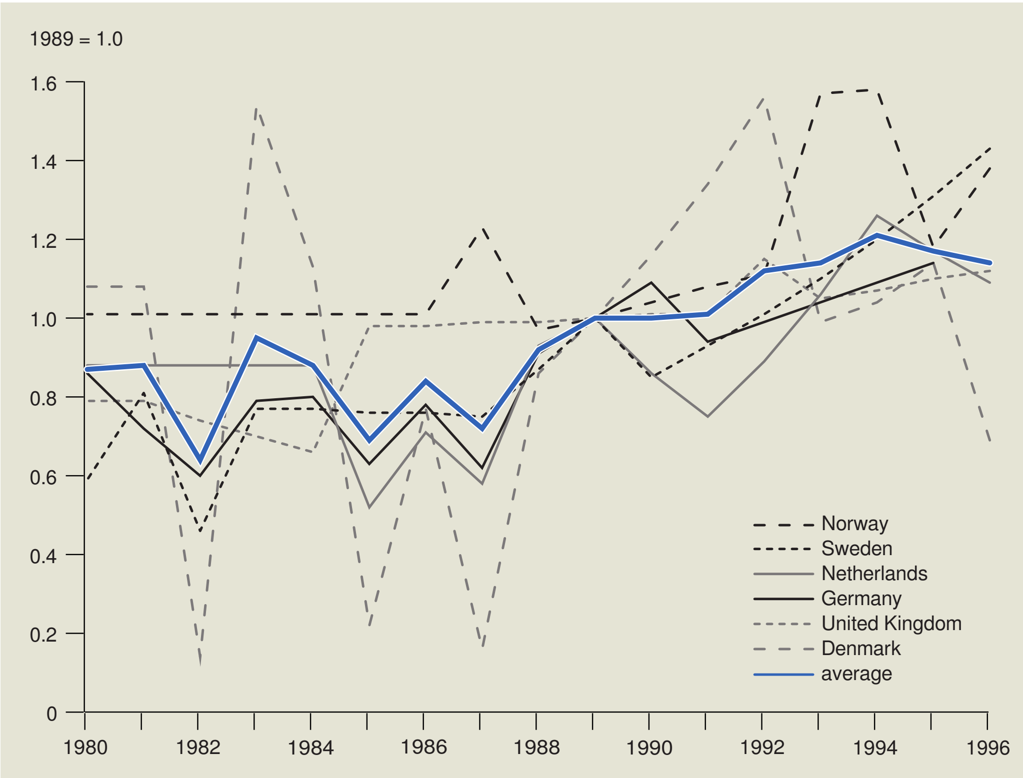


Figure 14.4b. **Index of wintering waterbirds in six north-western European countries**



Source: Ramsar Bureau, Wetlands International, EEA-ETC/NC

☺ The population of several wintering waterbirds has increased; mild winters seem to have helped.

14.3. Waterbirds in mild winters

European wetland habitats are home to a wide range of plant and animal species. They also play an important role for large numbers of migrating birds and fish. However, species composition has changed dramatically – with more widespread and robust species predominating – as a result of water pollution and eutrophication, regulation, invasion of new species and stocking with fish. An increasing number of specialised natural animal and plant communities now exist only in the upper reaches of unregulated rivers, in clean lakes, and in unpolluted bogs and marshes.

The quality and geographical distribution of wetlands are crucial to the survival of many of Europe's migrating bird populations. Changes in the number of bird species and bird population are often used as signals of general changes in the condition of and pressures on ecosystems.

Since 1967, field counts of wetland birds in their wintering wetland habitats have been undertaken as part of the International Waterbird Census (IWC) project. Data on 23 open-water species in 12 European countries (e.g. swans, ducks and the common coot) has been combined in an index. This index shows a slight overall increase, with the largest increase in north-western Europe (Figure 14.4). Increases in some bird populations are interpreted as being linked to the milder nature of the winters in these countries during this period. The effects of the very cold winters of 1982, 1985, 1987 and 1996 are reflected in the figures for several countries. For many species, however, the increases may only mean that numbers are recovering under favourable wintering conditions.

14.4. Indicator development

The indicators described in this chapter could be improved by including more types of wetlands; by using digitised boundary information to map the full extent of wetlands and overlay them with other spatially referenced data sets on human activities and environmental pressures that contribute to environmental impacts; and by updating land-cover information to allow comparisons with previous years. Information from more countries and on other species would improve the bird species indicator, as would analysis of the extent to

Tir Gwlyb I Gymru/Wetlands for Wales

Morfa Borth, an estuarine peatland complex in Wales, was drained in the 19th century by the re-routing of a nearby river, the Afon Leri. Morfa Borth is one of 19 Welsh wetlands that will be restored by Tir Gwlyb I Gymru/Wetlands for Wales, a collaborative project which recently obtained a £3.6 million grant from the UK Heritage Lottery Fund. The overgrown site will be restored by: raising the water table through the creation of four sluices; allowing brackish water to flow back into the area; and managing grazing to control the spread of scrub. The restored site should attract back wetland birds, plants and otters.

The loss of many natural Welsh wetlands through land drainage, peat extraction and agriculture has resulted in the disappearance of birds such as bitterns and marsh harriers, while numbers of other species, such as lapwing and snipe, have fallen significantly. Once restored, the 19 Welsh sites will form 26 % and 18 % of the UK's fenland and reed bed areas respectively.

Source: Environment Agency

Ramsar ratification, area and number of areas in EEA member countries Table 14.1.

Country	Total surface area of country, not including marine areas (km²) in 1994	Date of ratification	Total Ramsar surface area (including marine parts) (km²)	Total number of Ramsar areas in 1998
Austria	83 858	1983	1 028	9
Belgium	30 518	1986	79	6
Denmark	43 094	1978	7 390	27
Finland	338 145	1975	1 013	11
France	543 965	1986	5 791	15
Germany	356 970	1976	6 712	32
Greece	131 957	1975	1 635	10
Ireland	70 285	1985	697	45
Italy	301 323	1977	569	46
Iceland	103 000	1978	590	3
Liechtenstein	160	1991	1	1
Luxembourg	2 568	1998	3	1
Netherlands	41 526	1980	3 249	18
Norway	323 880	1975	697	18
Portugal	91 905	1981	658	10
Spain	505 990	1982	1 579	38
Sweden	449 964	1975	3 828	30
UK	244 101	1976	4 843	129
EU			**39 049**	**427**
EEA			**40 337**	**449**

Notes: Total country area does not include marine areas, but comprises estuaries and water lying on the land side of the normal baseline along the coast. A simple country comparison of the ratio between columns 2 and 4 is impossible because wetlands consist of both large marine and terrestrial areas. Ramsar areas in Denmark, for instance, consist of about 1 400 km² land area and 6 000 km² marine area.

Source: Wetlands International; Ramsar Bureau, EIONET; Eurostat (country area) which species numbers are changing as a result of factors other than environmental impacts (e.g. weather patterns).

For the future, indicators will be developed on the impacts of human activities (transport, agriculture, industry) and environmental pressures (emissions, resource extraction) on the quality wetlands and other protected areas. Indicators and analysis of the effectiveness of international conventions for protecting the extent and quality of protected areas and the species that rely on them will also be developed.

14.5. References and further reading

European Commission (1995). *Commission's communication to the Council and the Parliament: wise use and conservation of wetlands*. European Commission, Brussels, Belgium.

15. Environmental taxes

indicator	policy issue	DPSIR	assessment
environmental taxes compared with total tax revenue	any progress in the use of environmental taxes?	response	😐

Since 1980, revenues from environmental taxes have been increasing slowly. In 1997, they were slightly less than 7 % of total taxation and contributions paid by employees and employers to social security funds (social contributions). Taxes on polluting activities and products in the EU are small and have not increased significantly over the past 15 years. With the exception of Denmark and the Netherlands, energy taxes produce more than half of the revenue from environmental taxes in EU Member States. Energy and transport taxes provide more than 90 % of the total revenue from environmental taxes in most countries.

Environmental taxes are increasingly seen as efficient and effective instruments of environmental policy. These taxes take account of external environmental effects of economic activities and thus create fairer prices (i.e. 'getting the price right') for activities, products and services that consume natural resources and/or pollute the environment. Increasing the prices of such commodities through environmental taxes is generally expected to reduce consumption and thus relieve some of the pressures on the environment.

Ideally, progress in the use and impact of environmental taxes should be measured against their environmental effectiveness and economic efficiency. This requires advanced analysis and, as yet, not many results are available. A planned EEA report is expected to provide more information (EEA, in press).

The relative price increase of taxed products and activities can be taken as a first indication of the potential effect of taxes. For example, the real price of energy products (Figure 3.5) has decreased (as explained in Chapter 3), although revenue from energy taxes has increased (Figure 15.2). Chapter 5 gives information on fuel prices.

The indicators in this Chapter give an overview of the trend in environmental tax revenue.

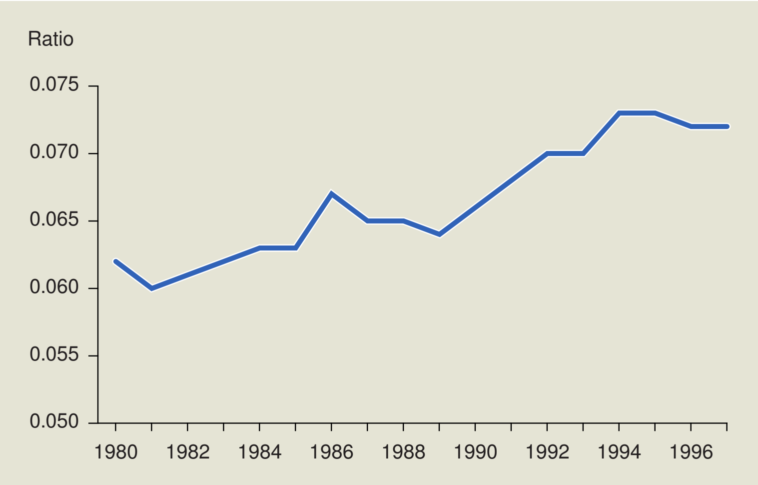
15.1. Tax revenues

New environmental taxes help to relieve some of the burden of other direct taxes such as income tax and social contributions in achieving a fixed amount of total tax revenue. 'Ecological tax reform' is generally assumed to have a positive economic impact; it reduces the cost of labour and may increase employment. The term 'double dividend' is used to describe this alleged positive economic impact in combination with better pricing of environmental effects.

Many EEA member countries apply environmental taxes to a wide range of activities, products and services, e.g. energy, transport, polluting substances, packaging, waste products and chemicals. Surveys and studies carried out during the past decade suggest that the use of taxes and charges is increasing (OECD, 1989, 1994, 1999; European Commission/DG Environment, 1998; EEA, in press).

However, the ratio of revenue from environmental taxes to revenue from other taxes and social contributions in EU Member States is still small (Figure 15.1). Environmental taxes are defined as energy taxes (including taxes on transport fuels), transport taxes and 'dedicated' pollution taxes. Between 1980 and 1997, this revenue ratio grew slowly from 6 % to slightly over 7 %. Although revenue from other taxes and social contributions also increased during this period, their growth was smaller than the growth of environmental taxes. This change indicates that the tax burden on economic activities is shifting slightly towards products and activities with a negative environmental impact and away from other tax bases such as labour. Progress can be detected, but it is marginal. However, the revenue data includes only fiscal taxes such as excise duty on petrol, and excludes environmental charges such as water pollution charges which can yield substantial revenues.

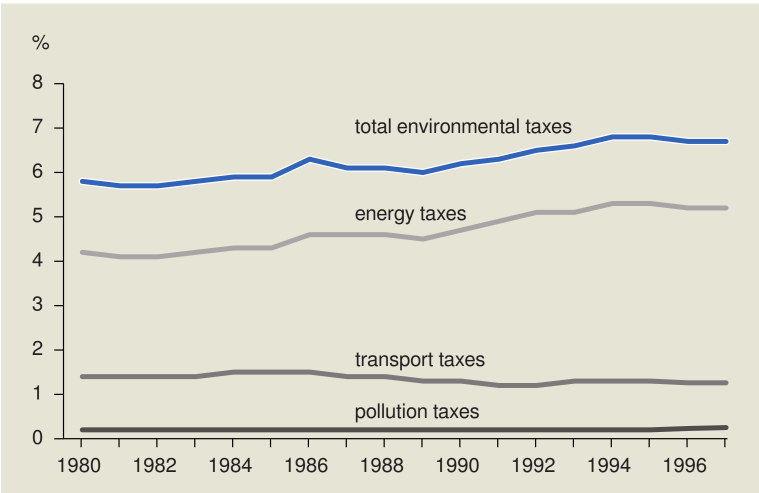
Figure 15.1. **Ratio of revenue from environmental taxes to revenue from other taxes and social contributions, 1980-1996**



Note: Environmental taxes are defined as energy taxes (including taxes on transport fuels), transport taxes and dedicated pollution taxes.
Source: Eurostat

The ratio of revenue from environmental taxes to revenue from other taxes and social contributions is small, but increasing slowly.

Figure 15.2. **Environmental taxes as a percentage of total taxes and social contributions, 1980-1997**



Note: Energy taxes include taxes on transport fuels. The latter make up more than three-quarters of energy taxes.
Source: Eurostat

The increase in revenue from environmental taxes is caused by a growth in energy taxes. The revenue from 'dedicated' pollution taxes is small and not increasing.

The increase in the share of environmental taxes in total tax revenue – in particular due to increasing energy taxes – could point to a growing role for environmental taxes as instruments of environmental policy. However, there are several possible reasons for the increased revenue. Revenue will generally increase when the number of taxes increases or if tax rates are higher – both are positive for the environment. Evidence for these developments is provided by OECD surveys (OECD, 1989, 1994, 1999). Revenue will also increase if the magnitude of taxed polluting activities increases or if more polluting products are sold – a negative development for the environment; these trends are also quite likely. During the period covered by Figure 15.1, there has been a general growth in the economy and in the two economic sectors – energy consumption and transport – which provide most (about 90 %) of total environmental tax revenue.

The question then is whether environmental taxes have an incentive impact. Despite the lack of information on the environmental effectiveness of taxes and charges, there is some evidence that environmental taxes do work (e.g. EEA, 1996, in press; OECD, 1999). If this is true, it means that in the absence of environmental taxation, polluting activities would have risen more than they actually did (assuming other policy measures affected the same actors equally).

The slight increase in the share of environmental taxes in total tax revenues and social contributions is mainly due to the increase in energy taxes from about 4 % to 5 % (see Figure 15.2). Transport taxes remained constant and pollution taxes made only a marginal contribution.

As shown in Figure 15.3, the contribution of environmental taxes to total tax revenues and social contributions varies widely between EU Member States: it ranges from 5 % in Austria to 10 % in Portugal. Energy taxes dominate, with pollution taxes significant only in Denmark, France and the Netherlands. Transport taxes are as important as energy taxes in Denmark, Ireland and the Netherlands, but much less important in France and Italy (where tolls are charged on major motorways) and in Sweden. Despite its lower tax levels, Luxembourg receives a large amount of revenue from fuel taxes due to 'fuel tourism' from neighbouring countries.

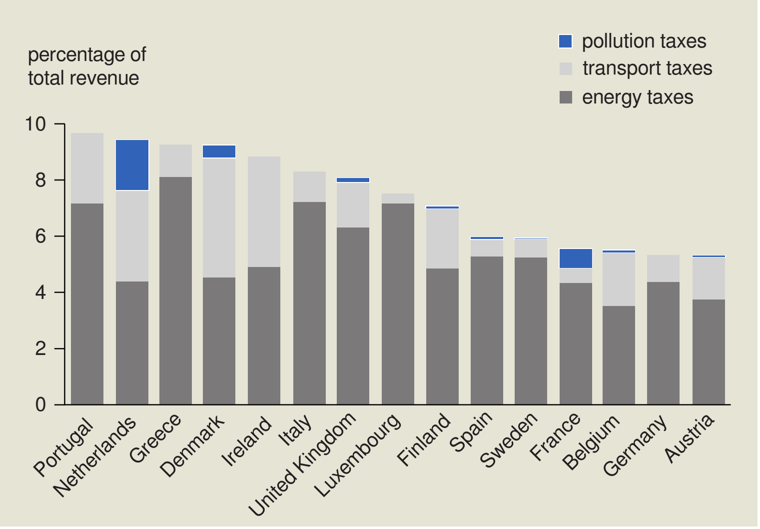
☹ ‘Dedicated’ pollution taxes are significant only in Denmark, France and the Netherlands.

15.2. Indicator improvement

A general evaluation of progress in environmental taxation cannot easily be achieved using indicators. Current data is insufficient for the advanced analysis required to measure effectiveness and efficiency in quantitative terms. However, some improvement in the indicators could be achieved in the near future. A breakdown of tax revenues according to number of taxes, tax rates and level of polluting activities and products would be helpful. More information on the relative price increases of taxed products and activities due to environmental taxes could provide a better indicator of the effectiveness of these taxes than their total revenues.

The indicators in this Chapter include only fiscal taxes (i.e. payments into the public purse). For a complete analysis, the significant environmental charges (i.e. payments for environmental services) imposed by many Member States should be included, but available data is incomplete and inconsistent.

Revenue from environmental taxes in EU Member States as a percentage of total revenue from taxes and social contributions, 1997 Figure 15.3.



Source: Eurostat

15.3. References and further reading

European Commission (1996). *Manual: statistics on environmental taxes*. European Commission, Brussels.

European Commission (1997b). *Communication on environmental taxes in the single market*. COM(97)9. European Commission, Brussels.

European Commission/DG Environment (1998). *Database on environmental taxes in the European Union Member States, plus Norway and Switzerland* http://europa.eu.int/comm/dg11/enveco/database.htm.

EEA (1996). *Environmental taxes: implementation and environmental effectiveness*. European Environment Agency, Copenhagen.

EEA (in press). *Environmental taxes and charges: tools for integration and environmental policy.* European Environment Agency, Copenhagen.

OECD (1989). *Economic instruments for environmental protection.* Organisation for Economic Co-operation and Development, Paris.

OECD (1994). *Managing the environment: the role of economic instruments.* Organisation for Economic Co-operation and Development, Paris.

OECD (1999). *Economic instruments for pollution control and natural resources management in OECD countries: a survey.* Organisation for Economic Co-operation and Development, Paris.

OECD (1999). *Consumption tax trends*. Organisation for Economic Co-operation and Development, Paris.

Ecological tax reform in the Netherlands

The Dutch government is preparing the new Income Tax Act, due to come into effect on 1 January 2001. One objective of the new taxation system is to promote sustainable economic development through greater emphasis on environmental levies.

Dutch consumers who buy energy-efficient appliances for their households or take energy-saving measures in their homes will be able to get a financial premium from energy companies and hence reduce their energy bills. The premium will be paid only to consumers who buy an appliance that meets the highest level of energy efficiency in the EU labelling system. These premiums are expected to be financed with revenue from increased energy taxes.

16. Developments in indicators: Total Material Requirement (TMR)

indicator	policy issue	DPSIR	assessment
Total Material Requirement (TMR)	decrease burden to global environment due to resource extraction	pressure	–
domestic TMR	decrease burden to domestic environment associated with resource extraction	pressure	☺
foreign TMR	decrease burden to environment in foreign countries	pressure	☹
Direct Material Input (DMI) versus GDP	improve materials productivity (processed materials only)	response	☺

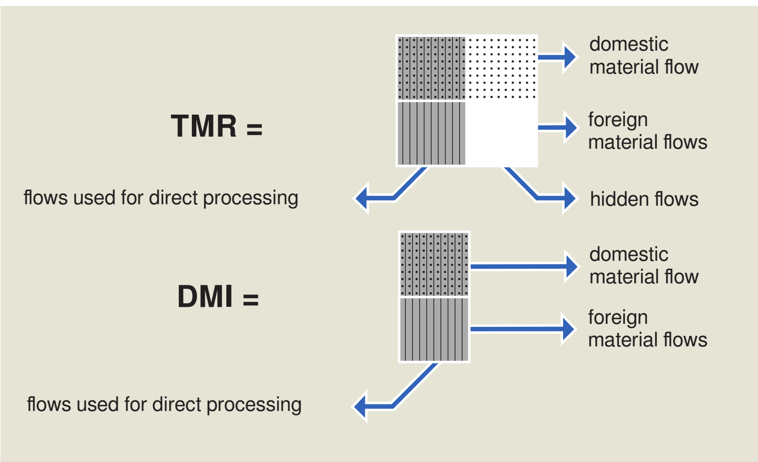
Extraction of natural resources in EU Member States declined by 12 % between 1985 and 1995, but imported resources increased by 8 % between 1995 and 1997. The Direct Material Input (DMI) in the economy fell by 8 % on a per capita basis at the beginning of the 1990s, but then increased slightly. In most Member States, economic growth has been associated with increased DMI. However, Finland, France, Italy and the UK have reduced their dependence on Direct Material Input.

The aim of this last chapter is to focus on new developments in environmental indicators. In past years, a number of aggregated physical measures have been proposed to show overall pressures on the environment. Examples include the 'human appropriation of net primary production' (indicating the share of biomass used by human activities in energy units) and the 'ecological footprint' (indicating the area of productive land utilised by a certain population and its activities). The new indicator, Total Material Requirement (TMR), expresses the total mass of primary materials extracted from nature to support human activities. Thus, TMR is a highly aggregated indicator for the material basis of an economy. This chapter presents the first calculation of the TMR for the EU. The reader is invited to study the outcomes and report back on the applications of this indicator.

The TMR indicator includes both materials used for further processing (Direct Material Input or DMI, see below) and hidden flows, i.e. extractions that are not used further, but have an environmental impact (e.g. overburden and extraction waste). TMR includes extraction both from domestic territory and of the resource requirements associated with imports. Changes in the balance between the foreign and the domestic amount of TMR indicate possible shifts in environmental impact between countries.

Similarly to energy requirements (see Figure 3.2) and total water abstraction (see Figure 12.2), TMR indicates a generic pressure on the environment. The volume of resource requirements determines the *scale* of local disturbances by extraction (e.g. devastation of mining sites, disruption of natural habitats, groundwater contamination and landscape changes at the extraction site), the throughput of the economy (DMI) and subsequent amounts of emissions and wastes. TMR, however, does not indicate the *severity* of these specific environmental pressures at the individual sites.

TMR consists of all resource extraction besides water and air. Statistics on industrial production, agriculture, forestry and fisher-



ies provide data on domestic material requirements, while foreign trade statistics give data on imports (grouped into raw materials, intermediate products and final products). Raw materials are traced back to the delivering countries using these statistics. This data is supplemented by specific information on hidden flows, e.g. overburden and extraction waste in mining and quarrying, excavation during construction and dredging, and erosion of agricultural fields. Intermediate products are classified according to their main constituent (e.g. steel or aluminium) and combined with data on cumulative resource requirements. Final products are accounted for only by their weight. The resulting values therefore represent minimum estimates for the Total Material Requirement.

TMR comprises all the primary resources needed for the production side of an economy, including trade and service activities. All inputs contributing to value added are considered, i.e. pure transit is not accounted for. Countries with a high dependence on either domestic resource extraction or imports exhibit high TMR values, irrespective of whether the resulting produce is exported or consumed within the own country.

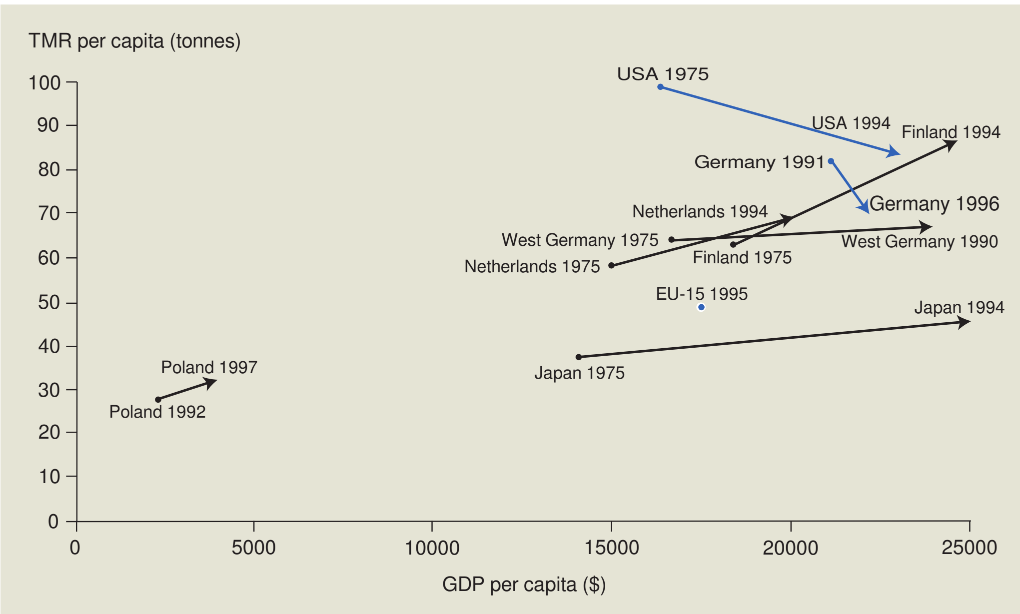
So far, TMR has been calculated only for a few European countries (Bringezu and Schütz, 1995; Bringezu, 1997; Adriaanse *et al*., 1997 and 1998; Juutinen and Mäenpää, 1999; Mündl *et al*.; 1999). The first calculation of TMR for the EU is presented and analysed below. Although the values are preliminary, the order of magnitude appears sufficiently valid for international comparisons.

16.1. Material resource requirements

In 1995, the EU's TMR amounted to 18.1 billion tonnes or 49 tonnes per capita (Figure 16.1). Due to the masses of materials involved and their hidden flows, the EU's TMR is dominated by energy, metals and mineral resources. It is significantly lower than that for the US in 1994 (84 tonnes/capita), but higher than that for Japan (45 tonnes/capita) in 1994. Both the US and Japan have a higher GDP per capita than the EU. By comparison, GDP per capita for Poland was a fifth of that for the EU in 1995, but the TMR per capita was almost 60 % of that for the EU.

A time series of TMR for the EU will be produced shortly. Until then two non-overlapping time series are presented – one for the domestic and one for the foreign components in TMR (Figures 16.3 and 16.4). In 1995, the domestic part was 63 % of total EU material requirements, having

TMR and GDP of the EU compared with selected Member States and other countries Figure 16.1.



Note: GDP given at constant prices and exchange rates for 1990.
Source: Wuppertal Institute, WRI, NIES, VROM, Thule Institute, INE, Warsaw University

fallen over the previous 10 years. The remaining 37 % of TMR was linked to imports; this value increased slightly between 1995 and 1997.

The main reason for the much lower total resource requirements in the EU compared with the US is the difference in material flows related to fossil fuels. Due to less use of energy in the EU and a reduced use of coal, Europe's fossil-fuel resource requirements are only 44 % of the US's (Figure 16.2).

Figure 16.2 also reveals differences in national patterns of material requirements:

- Because Germany still depends to a large extent on coal extraction, material flows related to fossil fuels are the same order of magnitude as in the US.
- Germany and Finland have the highest rate of minerals extraction due to sand and gravel production. The German value for minerals is twice the EU's due to significant housing and infrastructure construction.
- In Finland, where metal manufacturing is still a significant part of industrial production, resource requirements for metals are relatively high. The relatively high biomass values for Finland are due to forestry (timber is a significant Finnish export).
- The high material flows associated with erosion in the Netherlands reflect its significant agricultural imports from non-European countries.

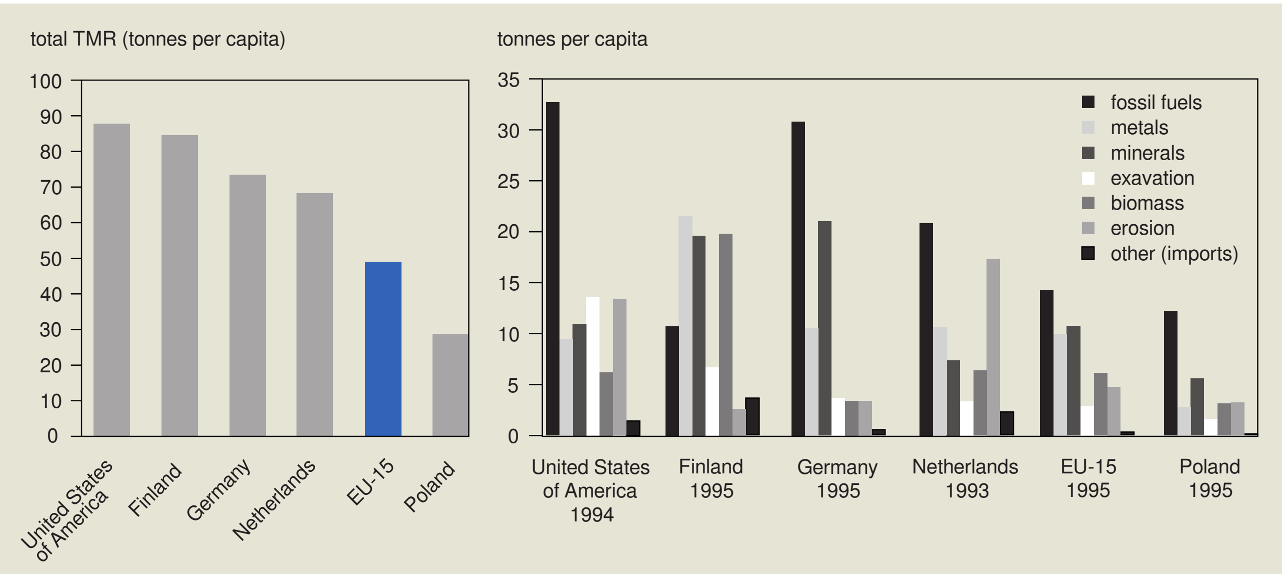
16.2. Domestic resource extraction

The domestic portion of TMR for the EU fell by 12 % between 1985 and 1995 to 63 %, mainly due to a decrease in the extraction of fossil-fuel resources (Figure 16.3).

The reduction was mainly due to a decline in lignite production following the closure of significant numbers of obsolete industrial facilities in eastern Germany since reunification. However, lignite production still represented 80 % of fossil-fuel-related domestic resource extraction in 1995 and was associated with 23 % of the domestic TMR of the EU. The main producers were Germany (74 % of EU lignite production), Greece (21 %), and Spain (4 %).

Extraction of hard-coal resources declined less rapidly but still significantly compared with lignite – by 35 % since 1985 to 135 million tonnes in 1995. In 1995, the main producers of solid hard coal were Germany, the UK and Spain with 44 %, 38 % and 13 % respectively. However, in terms of total extraction (including hidden flows), these

Figure 16.2. **Composition of TMR in the EU, selected Member States and other countries**



Note: Hidden flows are included in fossil fuels, metals and minerals or are represented by excavation and erosion.
Source: Wuppertal Institute, WRI, NIES, VROM, Thule Institute, INE and Warsaw University

countries accounted for 35 %, 24 % and 39 % respectively. Hard-coal production in Spain thus has much higher hidden flows than Germany and the UK.

The decline in energy-resource extraction was greatest for those energy carriers with the highest hidden material flows. For lignite, an average of nine tonnes of overburden has to be removed to extract one tonne of the energy carrier. This ratio, which highlights the poor resource efficiency of lignite production, has grown gradually. For hard coal, the ratio is much lower (around 1:1), but is also increasing slowly. The ratios for the other energy carriers are significantly lower. As lignite and coal production decline, these highly resource-intensive energy resources are being replaced by the less resource-intensive oil and gas.

Simultaneously with this decline in domestic material requirements for fossil fuels, the volume of mineral requirements has grown and, in recent years, has exceeded domestic energy resource extraction (Figure 16.3). Quarrying activities should therefore be taken as seriously as mining activities. The associated pressures on the environment associated with the overall extraction volume, e.g. hydrological changes, habitat disturbances, growth of built-up area and construction waste, have probably increased as well.

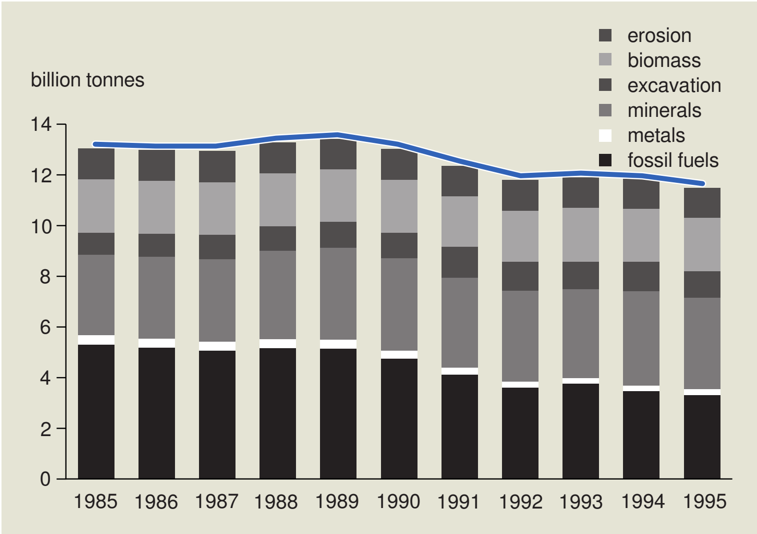
For mineral resources, the proportion of hidden flows is relatively low at 17.6 % of the total for mineral-resource extraction.

16.3. EU resource requirements in foreign countries

Imported metals, minerals and agricultural products are associated with higher hidden flows per commodity than domestic produce, indicating a relatively higher environmental impact in the exporting countries. In 1995, the resource extraction associated with EU imports was at least 37 % of TMR. Between 1995 and 1997, it increased by 8 % mainly due to the import of precious-metal ores (Figure 16.4). Renewable resources account for only 2.4 % of foreign TMR, compared with 18.3 % of domestic TMR. Foreign TMR thus contributes particularly to the depletion of non-renewable resources.

Imports of precious-metal ores into the EU increased by 51 % between 1995 and 1997 to 5 600 tonnes/year. In 1997, resource flows of

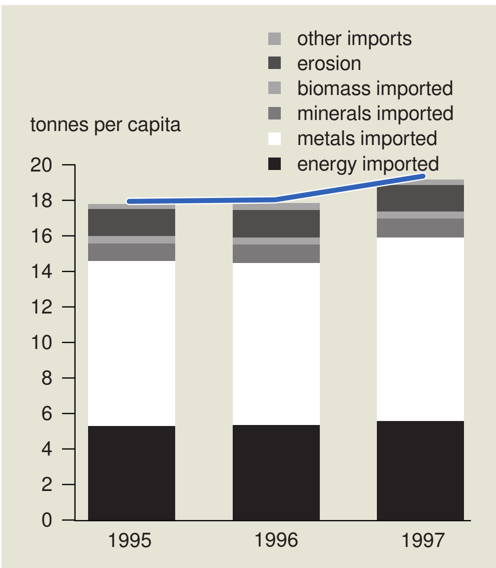
Domestic resource extraction in the EU between 1985 and 1995 — Figure 16.3.



Note: Before 1990, the values represent the combined extraction of the former West Germany and East Germany.
Source: Wuppertal Institute

Domestic resource extraction in the EU fell by 12 % between 1985 and 1995, mainly due to a decline in lignite production in eastern Germany.

TMR of the EU associated with imports — Figure 16.4.



Note: Foreign resource extraction as a basis for domestic activities.
Source: Wuppertal Institute

EU material requirements for foreign resources increased by 8 % between 1995 and 1997. Demand for luxury and precious commodities has a major influence on foreign TMR.

precious metals (an estimated 1.5 billion tonnes) contributed around 70 % to metal-resource extraction for imports to the EU while iron and copper ore, the second- and third-ranked metal imports, contributed only 18 % and 4 % respectively. Imports of finished products such as jewellery, plated ware, gold and silver goods also contribute to resource requirements. These have not yet been included in foreign TMR data for the EU, but are estimated to contribute an additional 1 tonne/capita.

Diamond imports dominate mineral requirements. Imports of only 44 000 kg in 1997 were linked to an estimated extraction of 232 million tonnes of material. This is more than half the mineral-resource requirements of the EU's foreign TMR. The hidden flows associated with the import of 2 450 tonnes of other precious stones in 1997 have not yet been quantified due to lack of data.

The inevitable conclusion from the data above is that much of the resource flows for EU imports are associated with luxury commodities.

There is a marked difference in the hidden flow to commodity ratios for domestic resource extraction and foreign resource extraction (Table 16.1).

Fossil-fuel imports (other than electricity) have a significantly lower hidden-flow ratio than domestic extraction of energy resources. Imports are mainly oil and natural gas, and have lower hidden flows than lignite and hard coal. Reducing energy use by industry, transport and households will mean less burden on the environment from resource extraction either domestically or in foreign countries.

Table 16.1. **Ratios of hidden flows to commodities for the EU in 1995**

	Domestic	Foreign	Total
Fossil fuels	3.48	1.63	2.55
Metals	1.07	15.49	10.34
Minerals	0.21	4.41	0.31
Agricultural biomass	0.63	5.90	0.89
Total	0.94	4.18	1.51

Source: Wuppertal Institute

Hidden flows from the import of metal resources are 14 times higher than those from domestic extraction. Ore mining is only a minor activity within the EU, which imports most of its base metals (iron, aluminium, copper, etc.) and almost all its precious metals.

Imports of agricultural products by EU Member States are associated with more erosion than domestic agriculture. This is mainly due to the import of products such as coffee and cocoa. In a number of Member States, consumers have shown some interest in supporting more sustainable agricultural practices by buying specific and labelled products.

16.4. Resource productivity of 'Direct Material Inputs'

Calculation of TMR requires connecting production and import statistics with coefficients for the hidden flows. Production of a time series of Direct Material Inputs (DMIs), i.e. inputs of primary materials without the hidden flows, would be much easier and would give a straightforward and up-to-date indicator for trends in resource productivity. When comparing countries for which TMR and DMI have been calculated, there is an indication that a high DMI goes with a high TMR and vice versa. If such a correlation could be proved, the more easily calculated DMI could be used for regular monitoring of materials productivity. A full domestic TMR would then only need to be calculated if the burden of resource extraction to the national environment was required. In addition, foreign TMR can be used to indicate the sharing of burdens and the shifting of problems between countries and regions.

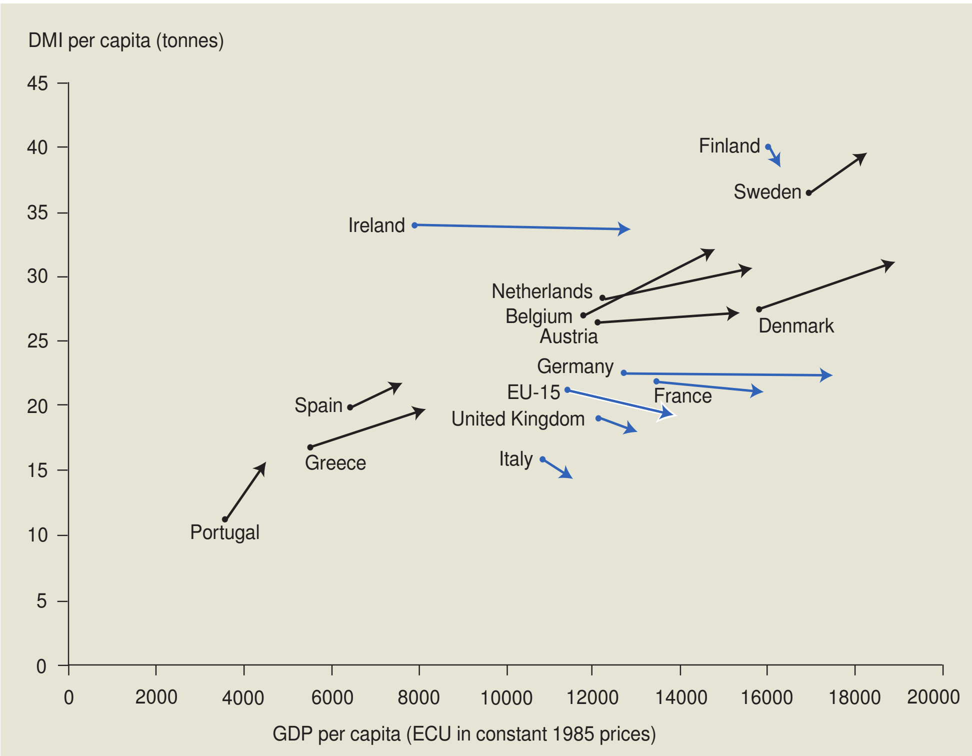
The DMI of the EU showed a moderate reduction in absolute terms of 6 % between 1988 and 1995 (Figure 16.5). On a per-capita basis, it declined by 8 % from 21.2 tonnes/capita to 19.5 tonnes/capita. Most of the change occurred at the beginning of the 1990s and was mainly due to a decline in imports of 1 tonne/capita. Since 1993, however, the DMI of most EU Member States has been increasing slightly. Thus in terms of DMI, there is no sign of an absolute decrease in material use.

When comparing DMI and GDP for EU Member States between 1988 and 1995, three groups of Member States can be distinguished:

1. A higher economic performance is associated with higher DMI in Austria, the Benelux countries, Denmark, Greece, the Netherlands, Spain, Sweden and Portugal.
2. Germany and Ireland achieved significantly higher GDP with a constant DMI. In these two Member States, a relative decoupling of direct material requirements and economic growth has occurred.
3. Finland, France, Italy and the UK managed to combine economic growth with reduced DMI. Reduced extraction of building minerals allowed these four Member States to demonstrate that absolute dematerialisation is possible.

The EU as a whole performed well with a reduction of DMI/capita by 8 % while GDP/capita increased by 19 %. Altogether direct materials productivity grew by 29 % in the EU between 1988 and 1995. The difference in EU results compared with those of individual countries is due to the exchange of goods between the countries: Member States' DMIs include intra-EU trade whereas the EU's DMI does not. Due to the constant level of DMI since 1992, the EU as a whole can be grouped with Germany and Ireland (group 2) - leaving it the challenge of following the countries in group 1 to use less material resources while achieving a higher economic performance.

Direct Material Input versus GDP per capita in EU Member States, 1988-1995 Figure 16.5.



Notes: GDP in ECU at constant prices of 1985. DMI of Member States includes intra-EU trade, but the DMI of the EU does not.
Source: Wuppertal Institute

☺ Direct resource productivity of the EU increased by 29 % between 1988 and 1995.

16.5. References and further reading

Adriaanse, A., *et al*. (1997). *Resource flows: the material basis of industrial economies*. Eds: World Resources Institute Wuppertal Institute; Netherlands Ministry of Housing, Spatial Planning, and Environment; National Institute for Environmental Studies, Japan. WRI Report, Washington.

Adriaanse, A., *et al*. (1998). *Stoffströme: Die materielle Basis von Industriegesellschaften* (German revised version of Adriaanse *et al*. 1997). Eds.: Wuppertal Institute; World Resources Institute; Netherlands Ministry of Housing, Spatial Planning, and Environment; National Institute for Environmental Studies, Japan. Wuppertal Texte, Birkhäuser Verlag, Basel.

Bringezu, S. (1997). 'Accounting for the physical basis of national economies: material flow indicators' in *SCOPE 58 - Sustainability Indicators*: 170-180 Eds. B. Moldan *et al*.

Bringezu, S. and Schütz, H. (1995). 'Wie mißt man die ökologische Zukunftsfähigkeit einer Volkswirtschaft? - Ein Beitrag der Stoffstrombilanzierung am Beispiel der Bundesrepublik Deutschland' in *Neue Ansätze der Umweltstatistik*: 26-54. Ed. S. Bringezu.

Juutinen, A. and Mäenpää, I. (1999). *Time Series for the Total Material Requirement of Finnish Economy - Summary*. Eco-efficient Finland project, interim report 15 August 1999. University of Oulu, Thule Institute. http://thule.oulu.fi/ecoef

Mündl, A. *et al.* (1999). *Sustainable development by dematerialization in production and consumption - strategy for the new environmental policy in Poland*. Report 3, 1999. Institute for Sustainable Development, Warsaw.

Acronyms and abbreviations

BAT	Best available technology
CAP	Common Agricultural Policy (EU)
CEE	Central and Eastern Europe
CCE	Coordinating Centre for Effects (UNECE)
CFCs	Chlorofluorocarbons
CLRTAP	Convention on Long Range Transboundary Air Pollution (UNECE)
DG III	EC Directorate-General III (Industry); now DG Industry
DG XI	EC Directorate-General XI (Environment, Nuclear Safety and Civil Protection); now DG Environment
DMI	Direct Material Input
DPSIR	Driving forces, Pressures, State, Impact, Responses
5EAP	fifth environmental action programme of the European Union
ECU	European Currency Unit (now EUR or euro)
EEA	European Environment Agency
EFTA	European Free Trade Association
EMEP	Cooperative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollution in Europe
ETC/AE	European Topic Centre on Air Emissions
ETC/AQ	European Topic Centre on Air Quality
ETC/IW	European Topic Centre on Inland Waters
ETC/LC	European Topic Centre on Land Cover
ETC/NC	European Topic Centre on Nature Conservation
ETC/W	European Topic Centre on Waste
EU	European Union
Eurostat	Statistical Office of the European Union (Luxembourg)
FCCC	Framework Convention on Climate Change (UN)
FAO	Food and Agriculture Organisation (UN)
GDP	gross domestic product
GWP	global warming potential
HCFCs	hydrochlorofluorocarbons
HELCOM	Helsinki Commission
HFCs	hydrofluorocarbons
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IPPC	Integrated Pollution Prevention and Control (EU Directive)
ktonnes	thousand tonnes
MAC	maximum admissible concentration
MSC-W	EMEP Meteorological Synthesising Centre-West (UNECE)
New Cronos	general statistical database at Eurostat
NMVOCs	non-methane volatile organic compounds
NO_x	nitrogen oxides, including nitric oxide (NO) and nitrogen dioxide (NO_2)
OECD	Organisation for Economic Cooperation and Development
ODP	ozone-depleting potential
OSPAR	Joint Oslo and Paris Commissions
PCBs	polychlorinated biphenyls
PFCs	perfluorcarbons
PM	particulate matter

POPs	persistent organic pollutants
ppb	parts per billion
ppm	parts per million
Ramsar	Convention on Wetlands of International Importance especially as Waterfowl Habitat
RIVM	National Institute of Public Health and Environmental Protection, the Netherlands
TMR	Total Material Requirement
toe	tonnes of oil equivalent
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UUA	utilised agricultural area
VOCs	volatile organic compounds
WHO	World Health Organization

European Environment Agency

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