Topic report 1/2002

Analysis and comparison of national and EU-wide projections of greenhouse gas emissions

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1. Summary

1.1. General

1. This report was prepared by the European Topic Centre on Air and Climate Change as part of the work programme of the European Environment Agency. It serves as a contribution to the report prepared by the European Commission under the EU greenhouse gas monitoring mechanism, published annually in October.

2. Under the UNFCCC and the Kyoto Protocol, the European Community and its Member States have made commitments to reduce greenhouse gas (GHG) emissions by 8 % from 1990 levels in the period 2008–12 (Kyoto target). To assess the progress in emission reduction, the European Community has established a 'monitoring mechanism of Community CO_2 and other greenhouse gas emissions' (Council Decision 1999/296/EC). The 'actual' progress is assessed on the basis of past and current trends of greenhouse gas emissions, which are reported by the EEA (EEA, 2001b). This is the second input from the EEA–ETC/ACC to the Commission's annual report under the monitoring mechanism.

3. The assessment of future ('projected') progress is based on projections of GHG emissions for the commitment period 2008–12, taking into account the effects of implemented and planned policies and measures. The total projected EU emissions in 2010 can either be estimated by aggregating nationally compiled projections or by using EU-wide models. Within the monitoring mechanism the EU totals are compiled through aggregation, while results of EU-wide models are also used for comparison purposes. This approach of comparing EU-aggregated national projections and EU-wide projections is followed in this report.

4. The two approaches (EU-aggregated national projections and EU-wide projections) produce different results, most markedly at the sectoral level (energy, waste, etc). This report compares the results from these different approaches and tries to identify key differences and factors that may explain these differences.

5. In this report two main sources of information are used:

   - national reports under the 'monitoring mechanism', provided by Member States delivering **national emission projections** and, derived from these, **EU-aggregated national emission projections** and

   - the study 'Economic evaluation of sectoral emission reduction objectives for climate change' (sectoral objectives study) (Ecofys, NTUA, AEAT, 2001a), delivering **EU-wide emission projections** and **EU-wide emission projections disaggregated for individual Member States**.

6. All data in this report is data recently available in early 2001. This is due to the fact that officially submitted reports and finally published studies were used. In consequence, the data used can be one or two years old. In the future, it is intended to update this report according to the 'monitoring mechanism' reports of the Member States due at the end of 2001 and new EU-wide emission projections for CO_2 from energy expected in mid-2002.

7. The main objectives of the report are threefold:

   - to identify key differences in the emission projections in 2010 by country, by greenhouse gas and by source sector;

   - to identify key underlying factors that may explain these differences (these can be in underlying socioeconomic scenarios; in general model assumptions on GDP, etc.; in future emission factors; in different assumptions on the effectiveness of policies and measures) and thus help to improve the transparency of both national and EU-wide projections;

- to improve the quality of both national and EU-wide projections regarding comparability (e.g. harmonisation of definitions and methods), consistency (e.g. consistency between the inventory data, the base year and the target years of the models) and completeness (e.g. inclusion of all important source and sink categories).

8. The most comprehensive, detailed (on sectoral level) and best-reviewed (by stakeholders: industry, Member States, environmental NGOs) EU-wide projection of greenhouse gas emissions in 2010 is the sectoral objectives study, which was prepared in 2000/01 for the Environment DG. This report uses the results of that study for a comparison with national projections. In addition, the report also provides a first analysis and comparison of the sectoral objectives study results with several other EU-wide model results.

9. In this report, the projection year 2010 is a synonym for the commitment period 2008–12 according to the Kyoto Protocol. All data provided in this report exclude removals by sinks as well as emissions from the sector land use change and forestry.

10. This report only makes use of baseline scenarios from the information sources mentioned above. In the baseline scenarios only the effects of existing (implemented and adopted) policies and measures to reduce GHG emissions are taken into account. Scenarios with additional (planned) policies and measures, being introduced to ensure the fulfilment of the commitments under the Kyoto Protocol, are not included in this report since these scenarios fall outside the scope of this report.

11. National emission projections are described in Section 1.2 and Chapter 3, EU-wide emission projections are described in Section 1.3 and Chapter 4, the comparison of national with EU-wide emission projections is described in Section 1.4 and Chapter 5, while conclusions and recommendations are provided in Chapter 6.

1.2. Aggregation of national emission projections

12. National emission projections provided by Member States suggest that existing policies and measures will not be sufficient to continue the reductions of total EU greenhouse gas emissions achieved in the period 1990–99. Instead, progress made so far is projected to be outweighed by increases of emissions in some sectors. By 2010, at best, a stabilisation of emissions at the 1990 level will be achieved. All Member States, except the UK, project their baseline emissions (by 2010), only including existing policies and measures, to be above their EU burden sharing target.

13. According to the national emission projections, EU-aggregated CO_2 emissions will increase by 3 % between 1990 and 2010 whereas EU-aggregated CH_4 and N_2O emissions are projected to decline by 31 and 15 % respectively (Figure 1). Data for national emission projections of fluorinated gases are incomplete, but the aggregated data of those Member States that reported these emission projections show a rise of 66 % compared with 1990.

14. The EU aggregate of national emission projections for the energy sector ([1]) indicates a decline of GHG emissions from 1990–2010 of 17 % (Figure 2). EU-aggregated national GHG emissions from the transport sector are projected to increase by 25 % and this sector continues to show the biggest increase in greenhouse gas emissions, in particular of CO_2 and N_2O. EU-aggregated national emission projections for agriculture and waste show a decline in GHG emissions by 2010 of 8 and 38 % respectively.

15. Meeting the EU Kyoto target of an 8 % reduction of emissions from the 1990 level will require significant efforts from most Member States, especially in the transport sector. Although the effect of a number of planned policies and measures in the Member States is not included in the aggregated projections,

(1) The energy sector in this report includes 'energy industries' (1A1) and 'fugitive emissions from fuels' (1B), as defined under UNFCCC.

significant effort in this sector will still be required to enable the EU and Member States to reach the Kyoto and burden sharing targets.

16. The draft progress report of the European Commission under the monitoring mechanism (European Commission, 2001a) provides the following information: 'Member States have identified additional policies and measures that could help reduce emissions to minus 5 % from 1990 emissions. The remaining gap of 3 % will need to be closed by further measures both at Member State and EU level.'

1.3. EU-wide emission projections

17. For EU-wide emission projections, the sectoral objectives study (SOS) (Ecofys, NTUA, AEAT, 2001a) has been analysed and used for comparison purposes in this report. The aim of the sectoral objectives study, carried out for the Environment DG, was to identify the least-cost options to achieve the Kyoto target, taking into account all GHGs and sectors. The study used a top-down approach, which is based on the Primes energy system model. It was combined with a bottom-up approach using the Genesis database, which contains information on mitigation technologies, costs and potentials for detailed source categories/ sectors.

18. In the SOS baseline scenario, policies and measures existing at the end of the 1990s are taken into account on an aggregated level but not in detail, due to the top-down approach used in the SOS.

19. EU-wide emission projections from the SOS, under baseline conditions ('with measures'), by 2010, compared with 1990, show a slight increase in total GHG emissions by 1 % and an increase of 4 % in CO_2 emissions (Figure 1). Emissions of CH_4 and N_2O are projected to be reduced by 18 and 16 % respectively. Emissions of SF_6 are projected to increase by 26 %, whereas HFC and PFC emissions are projected to increase most drastically by 61 and 154 % respectively (Figure 35).

20. EU-wide GHG emissions are projected to decrease in all sectors apart from transport and services. In the transport sector, EU-wide GHG emissions are projected to grow substantially by over 30 % by 2010 (Figure 2). In some sectors, GHG emissions are projected to decrease significantly (18 % in the waste sector and 15 % in the industry sector).

21. A comparison of the SOS results with results from other EU-wide baseline emission projection studies shows large differences, with GHG emissions ranging from a 1 to 16 % increase in 2010 compared with 1990. This means that none of the EU-wide baseline projection estimates meets the commitments made by the EU under the Kyoto Protocol to reduce GHG emissions by 8 % from 1990 levels. The sectoral objectives study results are within the range of the various EU-wide baseline emission projections provided by the other studies — but at the lower end of the projected increase. Important explanations for different projections are different assumptions on carbon emission intensity, energy intensity and emission factors for methane. Different assumptions on the effectiveness of policies and measures have a major impact as well.

1.4. Comparison of national emission projections with EU-wide emission projections

22. The EU-wide emission projections of the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) show a slight increase of GHG emissions by 1 %, whereas the aggregated national projections for the EU show a stabilisation of GHG emissions by 2010.

23. The EU-aggregated national emission projections for the individual gases are, in most cases, also very similar to the projection results of the SOS (Figure 1). The exception is methane, where the EU-wide projections are significantly higher than the EU-aggregated national emission projections.

24. The conclusions change significantly if the two approaches are compared on a more detailed sectoral level (Figure 2). The comparison is limited because national projections cannot always be disaggregated to the required detailed sectoral level. The national emission projections are lower in all cases, since they generally include the effect of more

Figure 1

Comparison, by gases, of EU-aggregated national emission projections and the EU-wide emission projection for EU-15 in 2010

Sources: EU-wide projections: Ecofys, NTUA, AEAT (2001a); national projections: AEA Technology (2001).

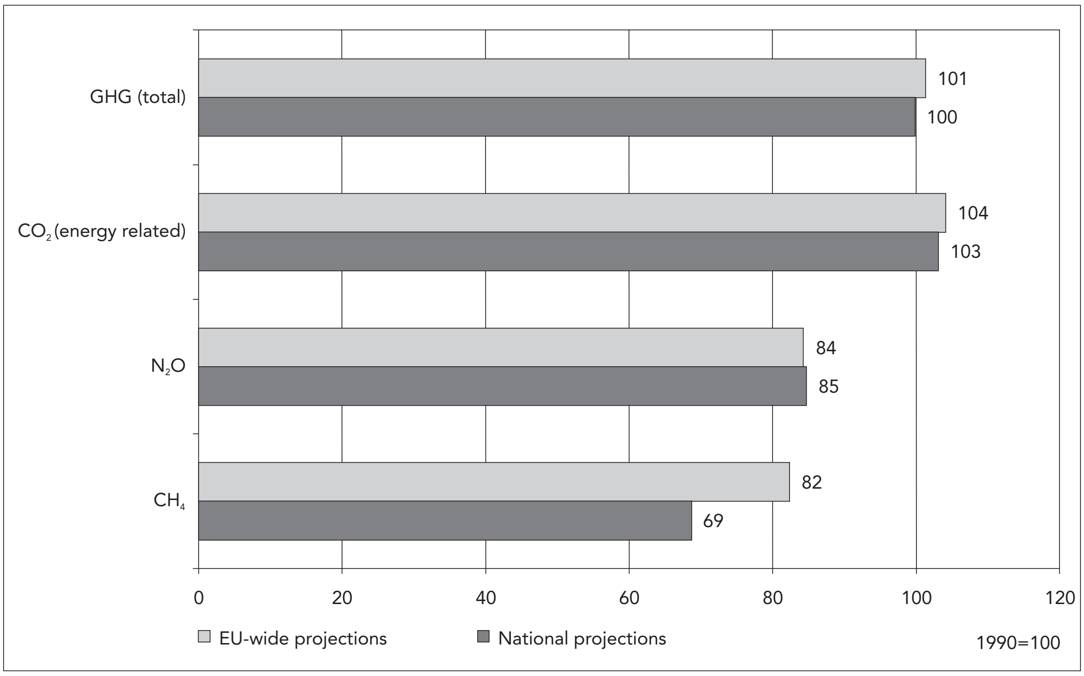
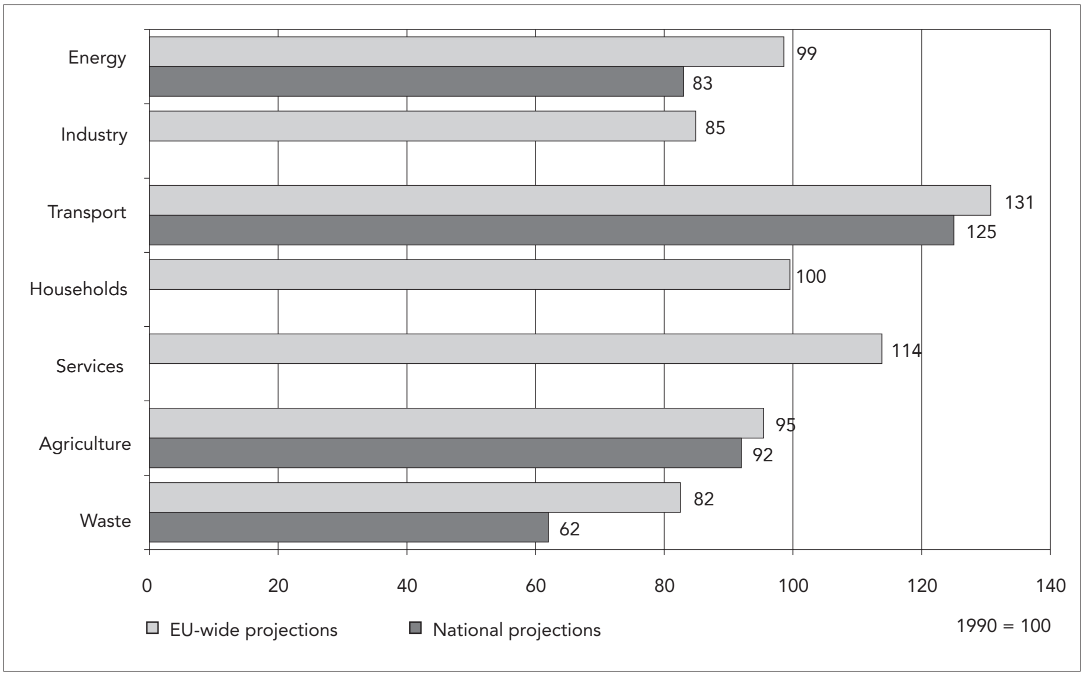


Figure 2

Comparison, by sectors, of EU-wide national emission projections and the EU-wide emission projection for total GHGs for EU-15 in 2010

Sources: EU-wide projections: Ecofys, NTUA, AEAT (2001a); national projections: AEA Technology (2001).



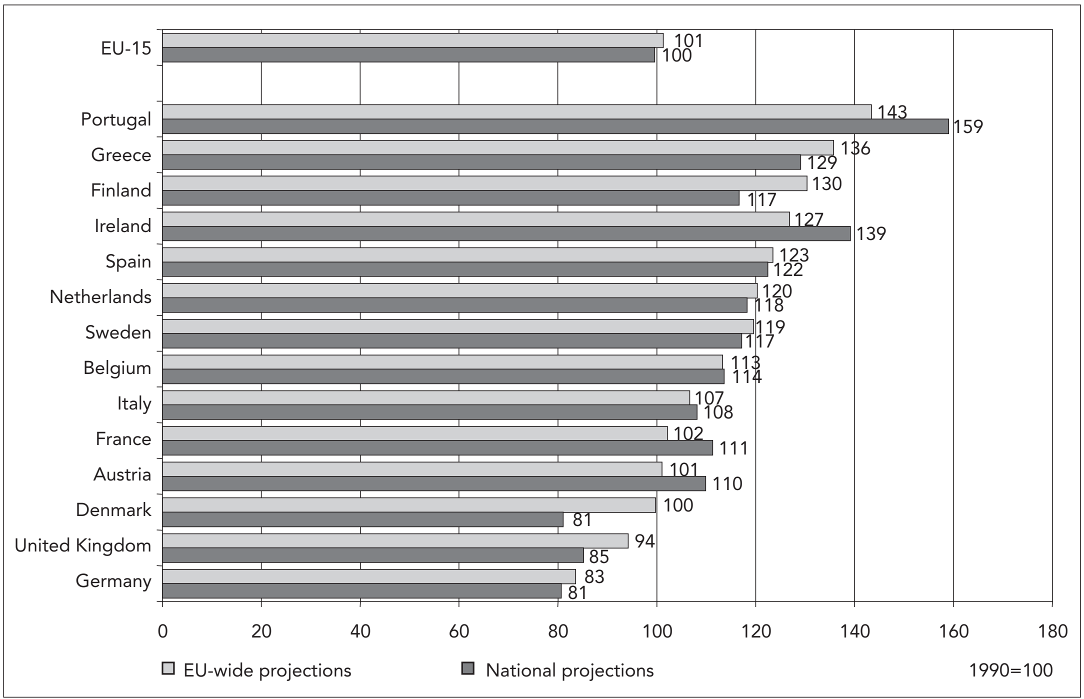
policies and measures. The largest percentage differences occur for the waste sector and, most significantly, for the energy sector (2), which emits the largest share of GHG emissions.

25. Key differences between the national emission projections and the EU-wide emission projections of the SOS are also obvious on a Member State level (Figure 3). Although the trend for the EU as a whole is similar for the two approaches, there are marked

(2) The energy sector in this report includes 'energy industries' (1A1) and 'fugitive emissions from fuels' (1B), as defined under UNFCCC.

Comparison of national emission projections and the EU-wide emission projection, disaggregated for Member States, for total GHGs in 2010

Figure 3



Sources: EU-wide projections: Ecofys, NTUA, AEAT (2001a); national projections: AEA Technology (2001).

differences for some Member States. For Austria, France, Ireland and Portugal, the national emission projections show higher emissions in 2010 than the disaggregated EU-wide emission projections from the SOS. These differences are caused by different assumptions about, for example, general economic growth and assumptions about the effectiveness of national and EU policies.

26. To help identify possible reasons for the various differences, this study attempted to analyse the influence of the expected main drivers for the projections (population growth, change in gross domestic product). The comparison of projections for population and gross domestic product of several projections studies has shown that the underlying assumptions for these drivers do not deviate substantially. Consequently, the sectoral differences between national emission projections and EU-wide emission projections, i.e. the sectoral objectives study, cannot be explained by substantially different assumptions for these factors alone.

27. A second reason for differences in the emission projections could be differences in the assessment of the effectiveness of policies and measures, due to different national circumstances. However, this study found a major difficulty in drawing conclusions on this aspect due to the lack of sufficient information on the assumptions underlying the national emission projections. There is also a lack of transparency on whether and how national policies and measures in some sectors included in the EU-wide sectoral objectives study have been taken into account.

28. At this stage, it is concluded that, apart from different assumptions on policies and measures, further possible key factors that could explain the differences are variance in: coverage of sectors; level and detail of sectoral disaggregation; methods, concepts and definitions applied. It is, however, unclear at present which are the most important factors that determine the main differences between EU-aggregated national emission projections and EU-wide projections.

1.5. Recommendations and future work

29. The following aspects of quality of emission projections need to be improved:

- completeness (inclusion of all important source and sink categories);

- comparability (harmonisation of definitions, in particular for sectors, and of methods for preparing sectoral projections and of assumptions such as GDP development);
- consistency (use of the same methodologies for the base year of the projection and for the target year, usually 2010);
- transparency (providing all necessary background and underlying information, especially for the national projections — much of this information is lacking, in particular on the assumed effectiveness of packages of policies and measures).

30. The comparability of national and EU-wide projections could be enhanced by more detailed guidelines on both the reporting format (e.g. in a similar way to the reporting format for inventories) and on the harmonisation of methodologies.

31. As part of the ongoing work under the EU GHG Monitoring Mechanism Committee, the following steps are proposed.

- Comparing further the methods, both for individual national emission projections provided by Member States and for EU-wide emission projections, with the aim of further identifying key factors that determine the main differences.
- Organising workshops for specific sectors with both national and EU-wide modelling experts, to further identify key factors that determine main differences, and discussing the feasibility of developing more detailed guidelines for reporting emission projections and policies/measures and for methodologies for compiling emission projections. (A workshop on energy-related GHG emission projections will take place on 27 and 28 February 2002.)

32. Such EU monitoring mechanism guidelines might also serve as EU input for the international UNFCCC process.

2. Introduction

2.1. Background

The main goal of the Council decision on the monitoring mechanism of Community CO_2 and other greenhouse gas emissions (1999/296/EC) is to assess annually whether the progress of Member States in their GHG emissions reductions is sufficient for the Community and its Member States to be on course to fulfil their commitments under the UNFCCC and the Kyoto Protocol. The European Commission reports annually in October to the Council and the European Parliament on progress based on information provided by the Member States and other relevant information.

The monitoring mechanism assesses the effects of the policies and measures that Member States have adopted, implemented or planned to reduce their GHG emissions. There are two elements of evaluation, the actual progress and the projected (future) progress.

The actual progress is assessed by an annual analysis of EU GHG emission trends (total, by sector, by gas and by Member State) starting in 1990 and including the latest year for which emission data are available. (For example, in 2001 the 1999 data are available.) This evaluation aims to show whether the EU and the Member States are currently on target to meet their commitments under the Kyoto Protocol and EU burden sharing. The burden sharing targets for Member States were reaffirmed in the Commission's proposal for ratification of the Kyoto Protocol by the European Community (European Commission, 2001b). The evaluation of actual progress is performed by comparing the latest annual GHG emissions (in 2001 this means 1999 data) with values of emissions interpolated between 1990 and their commitment for 2008–12 (the so-called 'linear target path').

The projected progress is based on an annual assessment of EU and MS projections of GHG emissions for the commitment period 2008–12. This assessment takes into account the effects of all national and/or EU-wide adopted policies and measures. The projected progress helps to assess if the commitments on GHG emission reduction will be fulfilled in the commitment period 2008–12.

The European Commission is responsible for reporting annually on the overall progress in GHG emission reduction in the EU, including both the analysis of actual and of projected progress.

The EEA is helping the annual Commission's progress report, on the aspect of actual progress, with the publication of 'European Community and Member States greenhouse gas emission trends 1990–99' (Topic report 10/2001) and, on the aspect of projected progress, with this topic report 'Analysis and comparison of national and EU-wide projections of greenhouse gas emissions'. Both topic reports were prepared by the European Topic Centre on Air and Climate Change (ETC/ACC).

2.1.1. Scope of this report

As described in Section 1, part of the Commission's annual assessment of projected progress in reducing GHG emissions is to compile emission projections for the EU as a whole. There are two ways to proceed in assessing EU-wide emission projections. Firstly, the emission projections reported by Member States can be used with an aggregation procedure to calculate EU-aggregated emission projections. Secondly, models or procedures which focus on the EU as a whole can be used to derive EU-wide emission projections directly.

Both approaches produce different results, at least in several greenhouse gas emitting sectors. This is not unexpected, since different framework conditions have to be taken into account by each Member State and, furthermore, consistency between Member States' conditions has to be ensured (in EU-wide models).

The main objectives of the report are threefold:

- to identify key differences in the emission projections in 2010 by country, by greenhouse gas and by source sector;

- to identify key underlying factors that may explain these differences (these can be in underlying socioeconomic scenarios, in general model assumptions on GDP, etc., in future emission factors or in different assumptions on the effectiveness of policies and measures) and thus help to improve the transparency of both national and EU-wide projections;

- to improve the quality of both national and EU-wide projections with regard to comparability (e.g. harmonisation of definitions and methods), consistency (e.g. consistency between the inventory data, the base year and the target years of the models) and completeness (e.g. the inclusion of all important source and sink categories).

This report analyses both GHG emission projections reported by Member States (called **national emission projections**) and projections produced by EU-wide models or studies (called **EU-wide emission projections**). For comparison at EU level, national emission projections have been aggregated to **EU-aggregated national emission projections** and, on the other hand, **EU-wide emission projections disaggregated for Member States** have been used from the EU-wide models or studies for comparison on a Member State level.

There are several potential reasons for differences in the two approaches:

- different assumptions of key factors used in models (GDP, world oil prices, etc.);

- different level of disaggregation, definitions and coverage of sectors;

- differences in the assessment of the effectiveness of policies and measures considered to be due to national circumstances.

The latter explanation might be the most important., The sets of policies and measures that are assumed to be in effect in different approaches or studies may be of greater importance than the other possible differences listed above. However, because of lack of information on assumptions on packages of policies and measures in the different baseline projections and due to the complexity in making the information on these comparable and usable for the objectives of this report, it has been decided to analyse policies and measures in this report to a small extent only. More work on comparison of the assumptions on the effectiveness of national and EU-wide policies in the various projections needs to be performed in future.

The results of this report can serve as input for the ongoing consultation process with Member States and various modellers, under the monitoring mechanism. The work undertaken and presented in this report by the ETC/ACC is a first step in the process. The EEA and the ETC/ACC plan to continue this work in future, in close consultation with the Member States and the European Commission, as part of the support to the monitoring mechanism.

This report can help to fulfil the obligation of the Commission to promote comparability and transparency of national reporting under the monitoring mechanism within the EU.

2.1.2. EU-wide emission projections

Projections of greenhouse gas emissions have been addressed in several studies and model-based assessments. Some of them cover the whole world disaggregated by several regions or groups of countries. Other approaches cover mainly the EU but also consider the impacts of trends and developments in the global economy and the global energy system on European developments. In this report we focus on EU-wide studies only, as they are usually more detailed (e.g. at Member State level) than the global studies.

The report compares results of national emission projections (AEA Technology, 2001) of GHG emissions submitted by the Member States under the EU monitoring mechanism with EU-wide emission projections of the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a). This assessment was selected because it is the most comprehensive, best reviewed (by stakeholders: industry, Member States, environmental NGOs), and most recent and gives the most detailed EU-wide emission projection ([3]). Furthermore the

(3) The sectoral objectives study covers all Member States of the EU (excluding Luxembourg), all six greenhouse gases and differentiates between eight GHG emitting sectors. It encompasses both a top-down approach for CO_2 as well as a bottom-up approach, which assesses the other GHG emissions on sector-by-sector bases (for more details see Section 1).

Environment DG recommended the SOS to be used in this report, because it is building on widely accepted models, in particular the Primes model, and is used by the Energy and Transport DG.

2.1.3. Key methodological approaches and terminology

In order to avoid misunderstandings, relevant concepts and terminology used in this report are described and explained below.

- **Projections —** Projections are understood to be forecasts of GHG emissions. These projections are based on underlying projections or forecasts of basic activity data, such as population, GDP, etc., that are often called socioeconomic scenarios. The focus of the projections analysed here is on the first commitment period of the Kyoto Protocol (2008–12). However, since it is more difficult to forecast for a time-span of five years, all projections focus on the year 2010 as representative of the entire commitment period. In this report 'projections' always means 'baseline emission projections' (see below).

- **Model —** A model is a set of hypotheses and parameter assumptions often described in mathematical language and implemented in computerised form. The intention of models is to forecast future developments, taking into account historical observations, technological developments and socioeconomic scenarios. Projections of GHG emissions are usually based on energy-economic models with different levels of regional coverage and sectoral and technological disaggregation.

- **Policies and measures (PAM) —** Policies are actions and instruments that can be taken by national governments (and may be EU-wide) to spur the application of measures which mitigate GHG emissions. Measures are technologies, processes and practices which reduce GHG emissions. In this report, 'existing' policies and measures have the same meaning as 'implemented and adopted' policies and measures according to the UNFCCC definitions.

- **Baseline scenario or baseline emission projection —** These refer to the projection of GHG emissions which would occur taking into account all policies and measures and other conditions which are already in effect at the starting year of the projection and without further and additional policy intervention. In other words, a baseline emission projection is the development of the GHG emissions that would occur in the case of the so-called business as usual (BAU) or reference scenario or within the FCCC and EU monitoring mechanism, also called 'with measures scenario'. The baseline is useful and necessary to assess effects of further and additional mitigation policies or measures. This report focuses entirely on 'baseline emission projections', which in this report are also called '(emission) projections'.

- **'With additional measures scenario' —** Projections that are based on the 'with additional measures scenario' consider additional policies and measures that have to be implemented to achieve the Kyoto targets of the Member States. The need for additional policies and measures becomes obvious if a baseline or 'with measures scenario' shows a gap between projected emissions and emission targets. This report does not include any analysis of 'with additional measures scenarios'.

It should be noted that all estimates of emission projections presented in this report exclude removals and emissions from the sector 'land use change and forestry'.

2.1.4. Assessment methodology in this study

Emission projections considered in this report are taken as provided officially by Member States or published in literature.

In practice, the national emission projections can be 1 or 2 years old for some Member States, and can be EU-wide emission projections taken from the sectoral objectives study. The national reports under the monitoring mechanism are due by the end of each year but national emission projections have to be updated only when new national policy programmes have been adopted. Although the sectoral objectives study was published in February 2001, the research and analysis work of this study was performed during the two previous years. Therefore, this study is based on data that was available until the year 2000 at the latest. This disadvantage of older data was compensated by the advantage of basing this report on well-reviewed and most-accepted information.

No additional modelling work has been carried out for this report. However, since most emission projections differ as regards base year, base year data, time-span, coverage (sectoral, geographical) and sectoral and technological disaggregation, the different emission projections cannot be compared directly. In many cases, it is also impossible to disaggregate the available information further into individual countries or subsectors. Thus, a direct comparison of the projections in absolute terms (in Mega (million) tonnes of CO_2 equivalents) is impossible and inadequate for the purposes of this report.

To be able to compare the projections in a transparent way, the available emission projections have been normalised or indexed for the purposes of this report. Absolute values of the base year have been indexed to 100 in all projections that were analysed. The emission projections for 2010 have been calculated relative to the base year and can thus be compared. In other words, the different emission projections are only compared in relative terms.

Gaps occurred mainly on a sectoral level in the data of the national emission projections provided by individual Member States. If the gaps were too large, no effort has been made to fill them. Smaller gaps, however, have been closed by appropriate methods. As these methods differ from case to case, they are described, usually in footnotes, in the various sections of the report where they have been applied.

3. National projections of greenhouse gas emissions for the year 2010 provided by Member States

3.1. Introduction

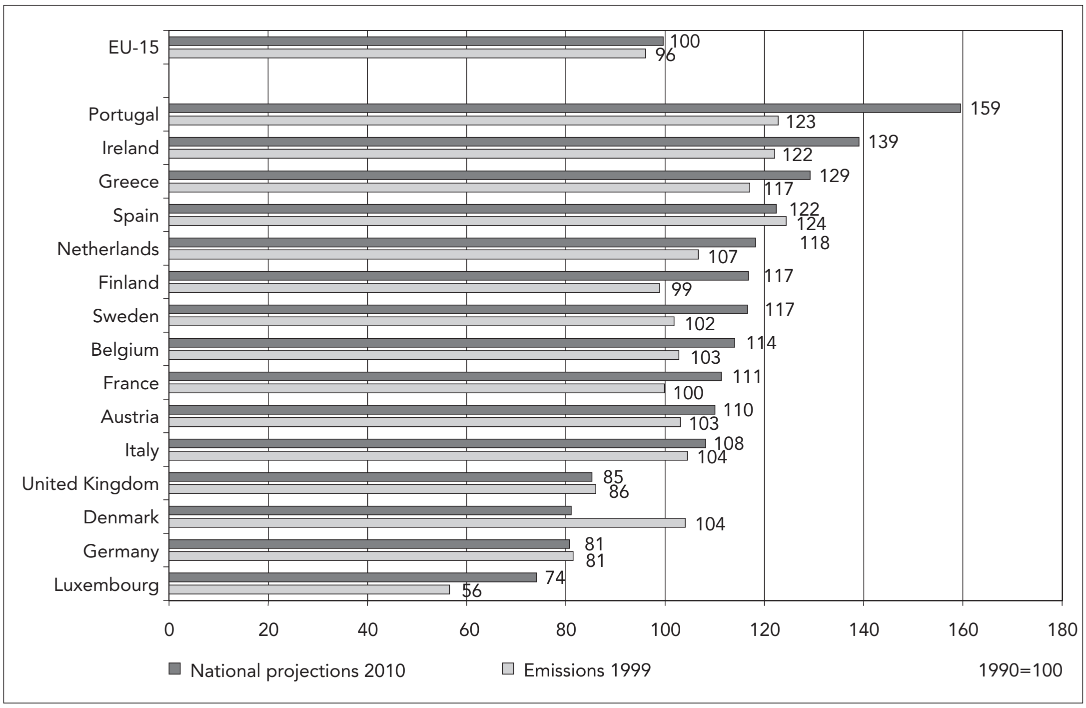
For almost all Member States, greenhouse gas emissions in the 'with measures scenario' (baseline scenario) are projected to be higher in 2010 than in 1999.

Figure 4 shows the national GHG emission projections for 2010 as the result of a baseline or 'with measures scenario' and the emissions in 1999, by Member State. In 1999, emissions for the EU as a whole had decreased by 4 % compared with 1990. However, the EU-wide emission projections aggregated from national emission projections are expected to increase again to 1990 levels by 2010. The emission reductions to date stem largely from Germany and the UK, while emissions from Luxembourg also were falling significantly. The main reasons for the favourable trend in Germany are efficiency increases in German thermal electricity production and the economic restructuring in the five new *Länder* after German unification. The reduction of GHG emissions in the UK was primarily the result of the liberalisation of the energy market and the subsequent fuel switches from oil and coal to gas in electricity production, but over half the reductions in 2000 have resulted from other measures.

For almost all Member States, greenhouse gases in the 'with measures scenario' are projected to be higher in 2010 than in 1999. The United Kingdom, Spain and Germany project GHG emissions at approximately the same volume in 2010 as in 1999 and Denmark projects a further decrease.

The breakdown of the national baseline emission projections (4) ('with measures scenario') by greenhouse gas is presented in Figure 5 to Figure 7. Fluorinated gases have not been presented, as many Member States do not provide an emission projection. Where there is data for the Member States, the aggregate emission projection for fluorinated gases indicates a 66 % increase

National emission projections for total GHGs in 2010 and total GHG emissions in 1999 for EU Member States Figure 4



Sources: National projections: AEA Technology (2001); emissions: EEA (2001b).

(4) Normalised to 1990 emissions from 2001 submission to the monitoring mechanism and to UNFCCC.

Figure 5

National emission projections for CO_2 for Member States in 2010

Source: AEA Technology (2001).

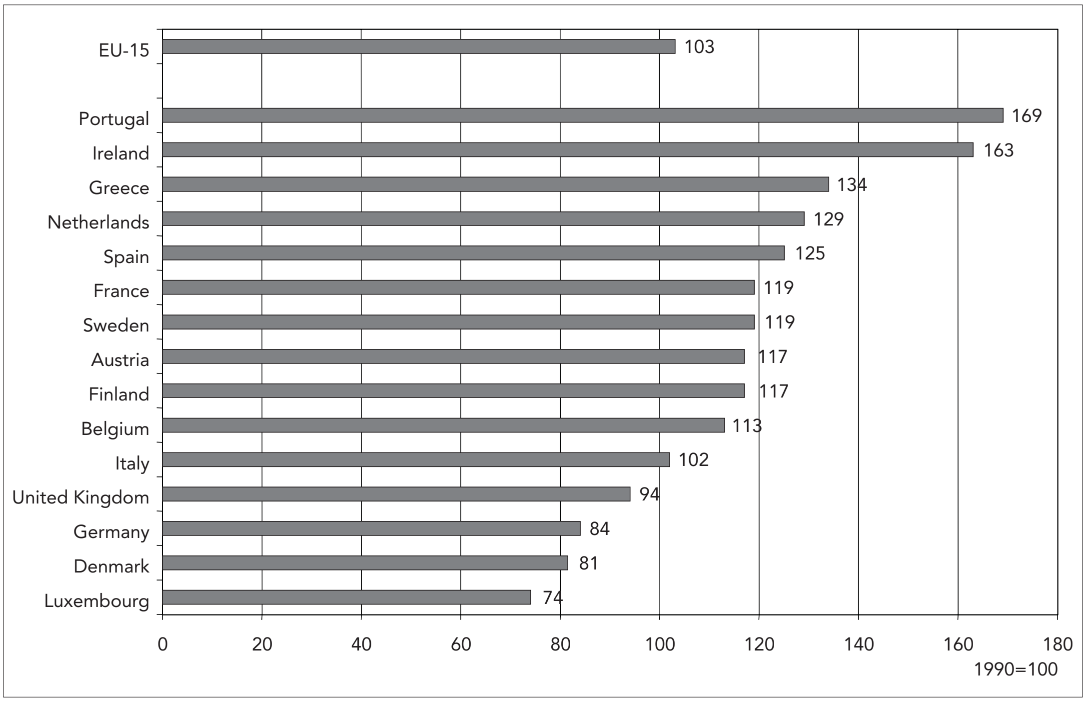
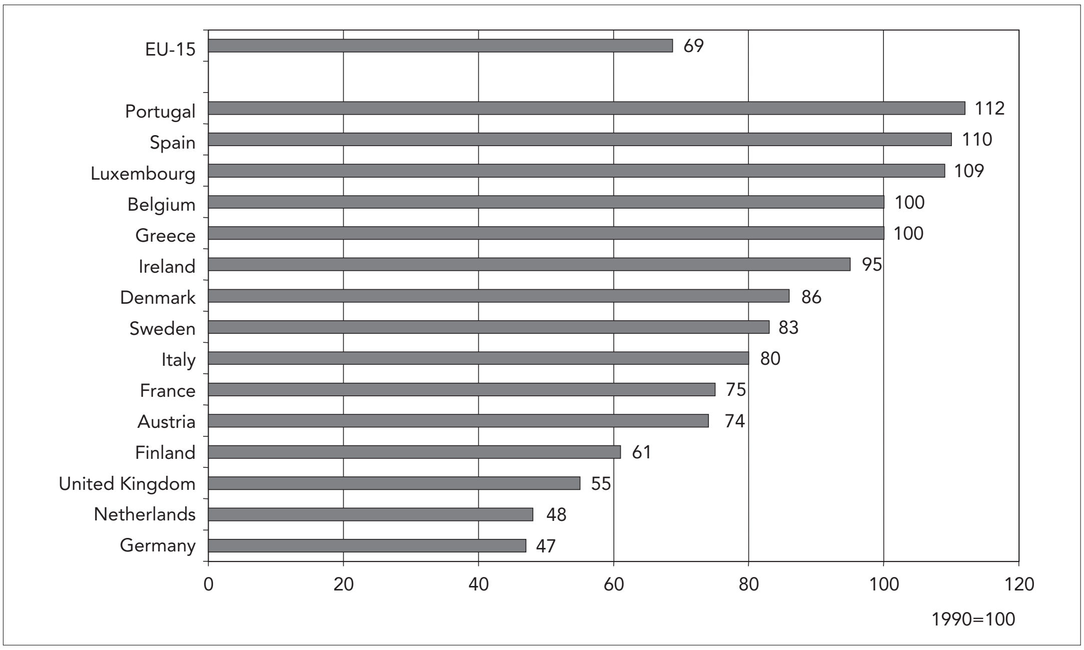


Figure 6

National emission projections for CH_4 for Member States in 2010

Source: AEA Technology (2001).

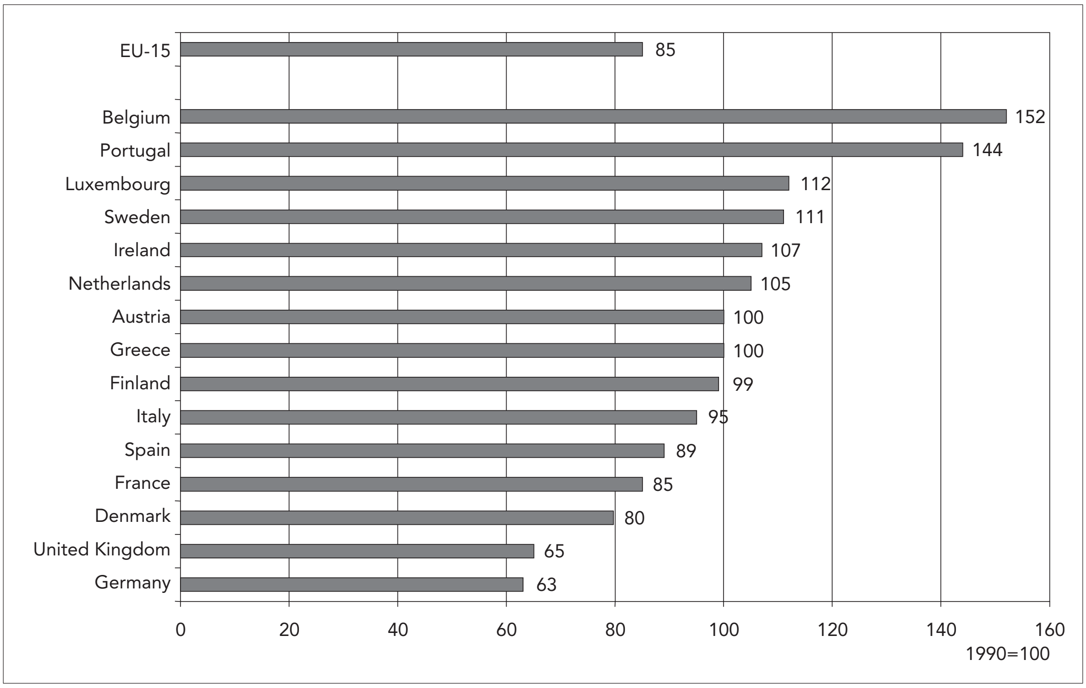


between 1990 and 2010 (5). Overall CO_2 emissions are projected to increase by 3 % and CH_4 and N_2O to decrease by 31 and 15 % respectively. These decreases are in part due to policies such as the landfill directive and control of N_2O in industry, and to change in agricultural practices leading to reducing animal numbers. Socioeconomic trends, for example increased use of fuel in transport, are tending to increase CO_2 emissions, but these are in part counteracted by improvements in efficiency and changes in the energy sector (6), such as increased use of renewables and CHP.

(5) Second Commission annual progress report under the EU monitoring mechanism, October 2001.
(6) The energy sector in this report includes ‘energy industries’ (1A1) and ‘fugitive emissions from fuels’ (1B), as defined under the UNFCCC.

National emission projections for N_2O for Member States in 2010

Figure 7



Source: AEA Technology (2001).

The information on the sectoral split of national emission projections from the Member States is not complete and the sector definitions used by Member States also differ. The most comprehensive datasets are for the energy industries with fugitive emissions from fuels, transport, agriculture and waste, and these splits are shown below. For the other sectors, comparison is not possible because of the problems with sector definitions and coverage. Following the publication of the third national communication to UNFCCC, it is hoped that more detail will be available and sector splits can be presented for the majority of Member States.

3.2. Total greenhouse gas emissions in 2010 compared to the EU Kyoto and MS burden sharing targets

Existing policies and measures when aggregated at the EU level deliver savings of only 22 Mt CO_2 equivalents compared with a commitment of a required 340 Mt CO_2 equivalents reduction for the EU. The Kyoto target could be reached with additional measures, which some Member States have identified, with a large contribution expected from Germany and the UK.

In Table 1, the savings projected for the existing policies and measures are compared with the commitment implied by the burden sharing agreement. The resulting gap is then compared with the additional measures identified by some Member States. Existing policies and measures when aggregated at the EU level deliver savings of only 22 Mt CO_2 equivalents savings compared with a commitment of 340 Mt CO_2 equivalents (required reduction from 1990 levels). This leaves a gap to be filled by additional measures for 318 Mt CO_2 equivalents. Not all Member States have identified additional measures. For those that have, the savings from additional measures are expected to amount to about 402 Mt CO_2 equivalents. This includes a remarkably large contribution from Germany. If Germany and the UK were to go as far as to meet but not exceed projections for their commitments under the EU burden sharing agreement, the savings from additional measures would total only 209 Mt CO_2 (7). This would result in a shortfall of 131 Mt CO_2 equivalents between the 'with additional measures' projection at 2010 and the EU's Kyoto commitment. This would have to be met by further, as yet not quantified, additional measures in most Member States and/or for the EU as a whole.

(7) This assumption is reached using a value for savings equal to the gap which Germany's additional measures would fill and a value of zero for the UK, given that the latter is projected to surpass its burden sharing agreement obligation on the basis of existing measures alone.

Table 1

Comparison of national emission projections from the Member States with the burden sharing agreement

Sources: EU monitoring mechanism and EC submission to the UNFCCC (2001).

Country	**EU burden sharing**	**Base year emissions 1990 (used in projection estimation)**	**Change in emissions between 1990 and 1999**	**Commitment implied by burden sharing (required reduction or maximum increase)**	**Change in emissions between 1990 and 2010 in projections with existing PAM (1) (baseline)**	**Gap (2)**	**Additional emission reduction in projections for 2010 with additional PAM**
	(%)	(Mt CO_2 equivalents)					
Belgium	– 7.5	114.6	3.7	– 8.6	15.5	– 24.1	
Denmark	– 21	76.4	3.0	– 16.1	– 14.2	– 1.8	1.9
Germany	– 21	1 208.4	– 224.2	– 253.8	– 234.4	– 19.4	19.3 (3)
Greece	25	99.3	17.9	24.8	28.8	– 4.0	
Spain	15	309.7	74.4	46.5	69.3	– 22.8	
France	0	526.1	– 1.2	0.0	59.1	– 59.1	59.6 (4)
Ireland	13	53.7	11.8	7.0	21.0	– 14.0	14.7
Italy	– 6.5	543.0	22.8	– 35.3	44.0	– 79.3	31.7
Luxembourg	– 28	12.4	– 4.7	– 3.5	– 2.9	– 0.6	
Netherlands	– 6	219.0	14.3	– 13.1	39.8	– 52.9	50
Austria	– 13	77.0	2.3	– 10.0	7.6	– 17.6	13.9
Portugal	27	60.0	14.7	16.2	35.4	– 19.2	
Sweden	4	70.9	1.2	2.8	12.1	– 9.3	
Finland	0	77.1	– 0.9	0.0	12.8	– 12.8	14.1
United Kingdom	– 12.5	776.2	– 104.0	– 97.0	– 115.5	18.5	0 (5)
EU-15	**– 8**	**4 223.7**	**– 168.8**	**– 340.1**	**– 21.6**	**– 318.4**	**209** (6)

(1) Based on projections normalised to the 1990 emissions from the 2001 submission to the UNFCCC.
(2) In this table: – means insufficient reduction; + means overcompliance (both with existing PAM).
(3) This figure assumes that Germany meets but does not exceed its burden sharing target. In the draft climate change strategy for Germany, additional measures are identified which could deliver 150–186 Mt CO_2 equivalents savings.
(4) With the base year emissions used in the projection, these additional measures were sufficient to fill the gap to the burden sharing agreement.
(5) This figure assumes that the UK meets but does not exceed the 'with measures' projections (which already exceed its burden sharing target). In the climate change strategy for the UK, additional measures are identified which could deliver savings of 65 Mt CO_2 equivalents.
(6) This figure assumes that the UK and Germany meet but do not exceed their burden sharing target, if all the additional measures from the UK and Germany are included the total is 402 Mt CO_2 equivalents, which more than covers the gap to meet the Kyoto commitment.

The largest gaps are for France, Italy and the Netherlands. France and the Netherlands have identified additional policies and measures that would fill their gap. For the Netherlands, these policies and measures include the use of flexibility mechanisms to fill a significant proportion of the gap and they are already developing projects in that area. It should be noted though that the additional policies and measures identified by countries tend to be in the early stage of development and that the scale of their effect is subject to a significant degree of uncertainty.

Table 1 can also be used to compare actual progress by each Member State over the period 1990–99 with the projections for the period 1990–2010. It shows whether the national emission projection appears credible in the light of the historical trend. Such a comparison shows that the biggest discrepancies are for Denmark (upward trend over the period 1990–99, compared with a projected decrease over the period 1990–2010), Finland, France (downward trend over the period 1990–99, compared with a projected increase over the period 1990–2010) and Spain (upward trend over the period 1990–99 has already exceeded that projected for the period 1990–2010).

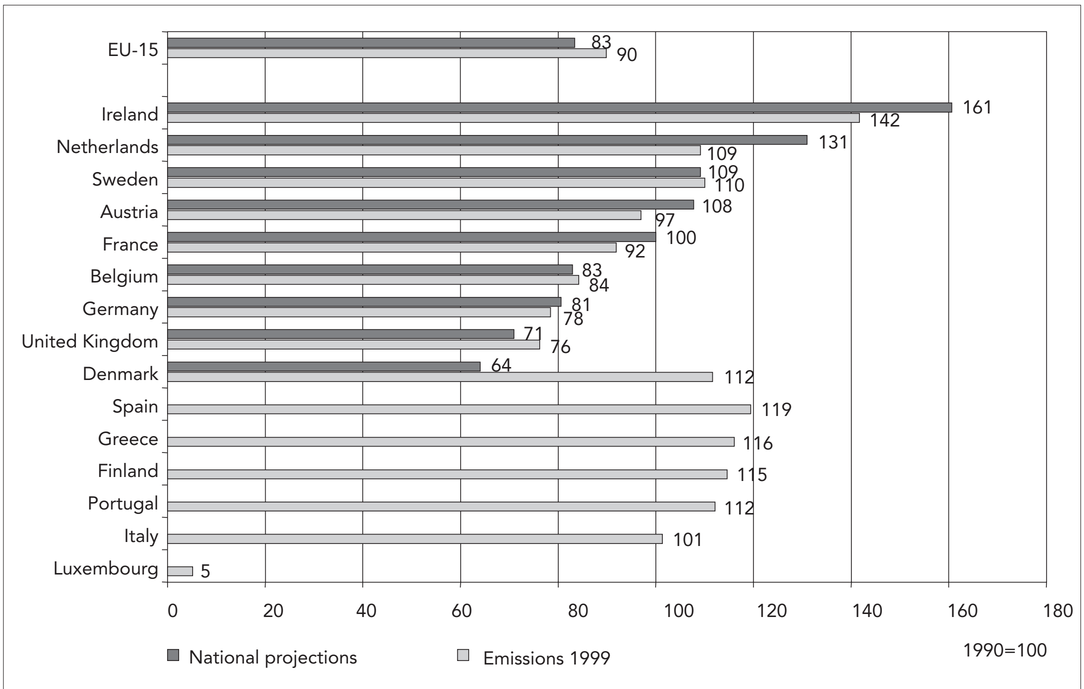
3.3. Energy sector

The EU-aggregated emission projection is for a decrease of emissions by 17 % from 1990–2010, arising from existing measures such as encouragement of renewables and the fuel switch to gas. However, in some Member States, emissions are projected to increase due to increasing demand for energy.

National emission projections from the Member States for 2010 for a baseline or 'with measures scenario' in the energy sector ([8]) are shown in Figure 8, together with the emissions in 1999. In some Member States, it has not been possible to disaggregate the projections to give trends in the different sectors. Overall, the EU-aggregated emission projection is for a decrease of emissions by 17 % from 1990–2010, arising from existing measures such as encouragement of renewables and the switch to gas. Between 1990 and 1999 emissions from the energy sector have already decreased by 10 %. In some Member States, emissions are projected to increase due to increasing demand for energy.

Figure 8

National emission projections for total GHGs in 2010 and 1999 total GHG emissions for Member States for the energy sector



Sources: National projections: AEA Technology (2001); emissions: EEA (2001b).

The main policies and measures for the Member States are listed in Table 2. The table also shows whether the effect of the measures has been included in the baseline ('with measures scenario'), the estimated CO_2 savings and the status with regard to implementation.

The main policies and measures are similar in all the countries and are:

- to promote renewables;
- to support the development of CHP; and
- to replace existing power plants with CCGT.

In some countries, the replacement of existing power plants by CCGT is being driven by market forces, for example in the UK. In other countries there are specific policies to promote replacement, for example in Ireland.

Policy in the energy sector is well developed and in most countries the measures have been implemented or are planned.

(8) The energy sector in this report includes 'energy industries' (1A1) and 'fugitive emissions from fuels' (1B), as defined under the UNFCCC.

Table 2 **Policies and measures in the energy sector**

Source: AEA Technology (2001).

Energy sector	**In baseline?**	**CO_2 saving ($Mt\ CO_2$ eq.)**	**Status**
Belgium			
Access to the grid for renewables	No	Not given	Part implemented
Promotion of CHP	No	Not given	Part implemented
Use of CCGT	No	6.5	Possible
Denmark			
Emissions quotas	No	12.8	Planned
Package of measures including CHP and fuel switching	Yes		Implemented
Subsidies for environmentally friendly production of CO_2	Yes	5.5	Implemented
Germany			
Encouragement of renewable energy sources	No	15	Implemented
Promotion of thermal solar and biomass energy	No	6	Implemented
CHP quotas	No	10	Planned
Greece			
Replacement of existing power plants by CCGT	No	4.2	Implemented
Incentives for solar and wind energy	No	2	Implemented
Spain			
Promotion of renewables and co-generation	No	26	Implemented
France			
Replacement of existing power plants by CCGT	Yes	5.5	Planned
Wind energy production	Yes	1.47	Implemented
Ireland			
Replacement of existing power plants by CCGT	No	5.5	Possible
Increased share of renewables	No	1.6	Part implemented
Italy			
Replacement of existing power plants by CCGT	No	21	Implemented
Increased share of renewables	No	6.5	Implemented
Additional cogeneration	No	4.7	Implemented
Luxembourg			
Replacement of existing power plants by GT	Not known	Not known	Planned
Promotion of CHP	Not known	Not known	Implemented
Promotion of renewables	Not known	Not known	Implemented
The Netherlands			
Measures at coal fired power plants	No	6	Implemented
Promotion of renewables	In part	4 (additional)	Part implemented
Austria			
Financial support for district heating	Yes ([1])	2.5	Implemented
Support to CHP and renewables through higher tariff	Yes	1.1	Implemented
Portugal			
Replacement of existing power plants by CCGT	Not known	Not known	Implemented
Promotion of renewables	Not known	Not known	Implemented
Sweden			
Promotion of renewables	No	Not known	Implemented
Support to CHP	No	Not known	Implemented
Finland			
Action plan for RES	No	4 to 5	Implemented
UK			
Promotion of renewables	Yes	2.5	Implemented
Support to CHP	Yes	Not known	Implemented

([1]) The measures for Austria in this table were given in the second national communication. It has been assumed that they are included in the latest projections.

3.4. Industry

For the industry sector an analysis cannot be provided on a consistent basis for all Member States due to differences in sector definitions

Separate national emission projections for the industry sector cannot be provided on a consistent basis for all Member States due to the lack of disaggregated information provided by some Member States and differences in sector definitions used by countries. Emissions from this sector are, however, included in the projection of total greenhouse gases described in Section 2. For the industry sector, many of the policies and measures are less well defined than for the energy sector. Table 3 shows the policies and measures for the industry sector for those countries where the measures are well defined and quantified.

Policies and measures in the industry sector Table 3

Industry	In baseline?	CO_2 saving ($Mt\ CO_2$ eq.)	Status
Denmark			
Voluntary agreements on fluorinated gases	No	0.8	Planned
Germany			
Voluntary commitments on CO_2	No	32.5	Implemented
CHP	No	15	Planned
Greece			
Energy efficiency programme	No	0.81	Implemented
France			
Regulation of N_2O and fluorinated gases	No	4	Planned
Energy taxation	No	7.33	Planned
Ireland			
Demand side management	No	0.6	Implemented
Italy			
Voluntary agreements	No	6	Implemented
Austria			
Information on optimisation of mechanical systems	Yes (1)	0.8	Implemented
Voluntary fuel switching	Yes	0.3	Implemented
Netherlands			
Agreements on fluorinated gases	No	4	Part implemented
Energy efficiency	No	2.3	Planned
Finland			
Energy efficiency programme	No	2 to 5	Implemented
United Kingdom			
Climate change levy package (tax plus negotiated agreements and energy efficiency programme)	Part	5	Implemented

(1) The measures for Austria in this table were given in the second national communication. It has been assumed that they are included in the latest projections.

Source: AEA Technology (2001).

The range of policies and measures is wider in the industry sector but two important strands are energy efficiency and control of fluorinated gases from processes. The measures to encourage energy efficiency depend on the Member State but include:

- voluntary agreements,
- taxation,
- information programmes, and
- financial incentives.

In most Member States, voluntary agreements are used to reduce fluorinated gases but in some countries, e.g. France, this is backed up by regulation.

In general, the savings from policies and measures in the industry sector are smaller than from the energy sector but the policies and measures are well developed and have been implemented or are planned.

3.5. Tertiary sector

For the tertiary sector an analysis cannot be provided on a consistent basis for all Member States due to differences in sector definitions

Separate national emission projections for the tertiary sector cannot be provided on a consistent basis for all Member States due to the lack of disaggregated information provided by some Member States and differences in sector definitions used by countries. Emissions from this sector are, however, included in the projection of total greenhouse gases described in Section 2. As in the industry sector, the policies and measures in the tertiary sector are less well defined and Table 4 shows only those where there is a reasonable definition. Most Member States have policies and measures related to the energy performance of buildings and energy efficiency in electrical appliances. The design of the policies and measures is dependent on the local situation in the Member State. The expected savings are slightly less than for policies and measures in the industry sector and not all the policies and measures are implemented or planned.

Table 4 **Policies and measures in the tertiary sector**

Source: AEA Technology (2001).

Tertiary	In baseline?	CO_2 saving ($Mt\ CO_2$ eq.)	Status
Denmark			
Improvement of building heating/lighting performance	No	1	Implemented
Germany			
Building regulations (heating ordinance)	No	7	Implemented
Boiler requirements	No	9.7	Implemented
Greece			
Introduction of natural gas	No	1.09	Implemented
France			
Thermal regulations	Yes	Not known	Implemented
Energy saving in public buildings	No	1.8	Planned
Ireland			
Building regulations	No	Min. 0.2	Implemented/ possible
Energy saving in public buildings	Not known	Not known	Planned
Italy			
Standards for electrical appliances	No	4.5	Implemented
Taxation of electricity use	No	10	Implemented
Netherlands			
Energy performance advice for buildings	No	3	Planned
United Kingdom			
Community heating	No	0.9	Possible
Domestic energy savings	No	0.8	Implemented

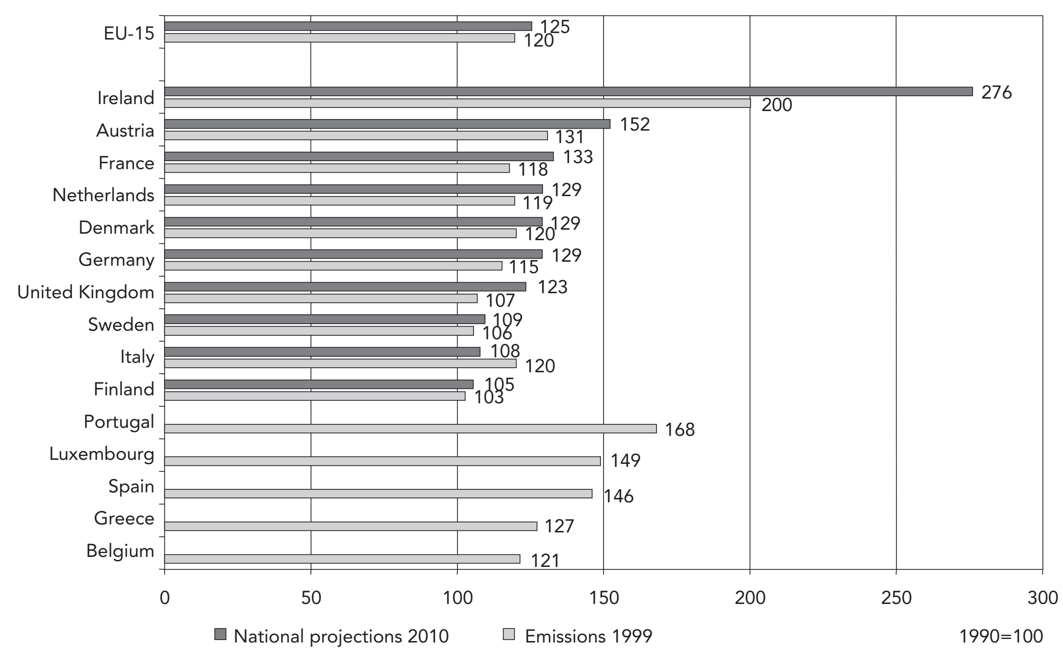
3.6. Transport

Since 1990, emissions from the transport sector in the EU have increased by 20 % and the EU-aggregated emission projection is for an increase of 25 % by 2010 (Figure 9).

The data presented below exclude emissions from international transport (aviation and shipping) in accordance with the UNFCCC. These emissions in 1999 were estimated to be 6 % of total greenhouse gas emissions or 26 % of the transport emissions. Emissions from international transport are also projected to rise significantly by 2010.

The largest projected increases occur in Ireland, Austria and France; the smallest in Finland, Sweden and Italy. The increase in emissions from the transport sector in Italy between 1990 and 1999 is already larger than that projected for 2010. The policies and measures in the transport sector, other than the EU-wide agreement with the European, Japanese and Korean car manufacturers

National emission projections for total GHGs in 2010 and 1999 total GHG emissions for Member States for the transport sector Figure 9



Source: National projections: AEA Technology (2001); emissions: EEA (2001b).

Policies and measures in the transport sector Table 5

Transport	**In baseline?**	**CO_2 saving ($MtCO_2$ eq.)**	**Status**
Denmark			
Various initiatives	No	0.8 -1	Planned
Germany			
Annual increases in mineral oil tax	No	Not known	Implemented
Greece			
Improvements in public transport	No	0.4	Implemented
Infrastructure improvements	No	0.5	Implemented
France			
Carbon tax	No	3.7	Planned
Measures on fluorinated gases from air conditioning	No	1	Possible
Ireland			
Car taxes	No	Not known	Implemented
Italy			
Encouraging public transport	No	3.2	Implemented
Austria			
Fuel tax	Yes (1)	0.1	Implemented
Transport measures including traffic reduction	In part	0.7	Implemented/to be revised
Netherlands			
Car taxes	No	0.6	Planned
Enforcement of speed limits	No	0.3	Planned
United Kingdom			
Fuel duty	Yes	1–2.5	Implemented
Transport white paper	No	1.6	Planned

(1) The measures for Austria in this table were given in the second national communication. It has been assumed that they are included in the latest projections.

Source: AEA Technology (2001).

(ACEA, JAMA and KAMA agreements) (European Commission, 2001c), are unlikely to deliver significant savings, so the national emission projections for Italy will be difficult to achieve. There have already been significant increases in emissions in Ireland, Portugal, Spain and Luxembourg.

Emissions from the transport sector are projected to be growing from all Member States and policies and measures to reduce this growth are not as well developed as in some of the other sectors. The ACEA agreement is an important measure in this sector and is recognised as such by Member States. Table 5 shows policies and measures in Member States for the transport sector (excluding the ACEA agreement which has been analysed at an EU level — see Section 4).

Car taxes are used in a number of Member States to encourage the consumer to buy more energy efficient vehicles, and fuel taxes are used to discourage consumption. Measures encouraging the use of public transport are also important in some Member States. The estimated savings for individual policies and measures are of a similar order to policies and measures in the tertiary sector, but in general there are fewer aimed at transport. The sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) suggests that there are fewer cost-effective savings available in the transport sector in the first commitment period.

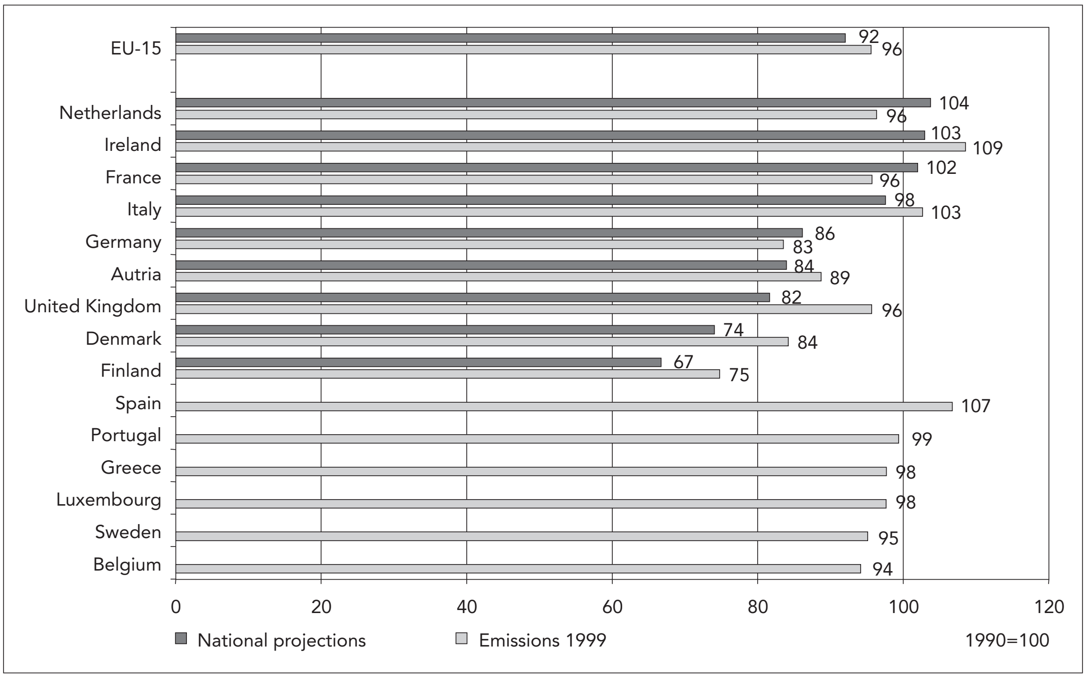
3.7. Agriculture

The EU-aggregated emission projection is for an 8 % reduction in emissions between 1990 and 2010, despite small increases in some Member States.

Figure 10 shows national emission projections for Member States for the agricultural sector and their 1999 emissions. All Member States except Ireland, Italy and Spain show a fall in emissions since 1990 and for most this is projected to continue. Animal numbers (and types of animals) and fertiliser use determine emissions in the agricultural sector. There is a general trend for reducing animal numbers (mainly due to increased productivity rather than decreased demand) and also for reduced use of nitrogenous fertilisers. The EU-aggregated emission projection is for an 8 % reduction in emissions between 1990 and 2010, which results from relatively large decreases in some Member States (e.g. the UK and Germany) and small increases in others (France and the Netherlands). The largest projected decreases occur in Denmark and Finland and there have already been significant reductions since 1990.

Figure 10 — **National emission projections for total GHGs in 2010 and 1999 total GHG emissions for Member States for the agricultural sector**

Sources: National projections: AEA Technology (2001); emissions: EEA (2001b).



Policies and measures in the agricultural sector — Table 6

Agriculture	In baseline?	CO_2 saving ($Mt\ CO_2$ eq.)	Status
Denmark			
Forestry	No	0.4	Implemented
Germany			
Fertiliser ordinance	No	0.13–0.26	Implemented
Greece			
Support for utilisation of agricultural by-products	No	1.48	Planned
France			
Afforestation	Some	0.55 (additional)	Implemented/ planned
Control of nitrogenous fertilisers	No	1.28	Planned
Ireland			
Afforestation	No	0.25	Implemented
Fertiliser ordinance	No	Not known	Implemented
The Netherlands			
Energy saving in horticulture	No	2	Part implemented
Austria			
Afforestation	Yes (1)	13.7	Part implemented
Finland			
Forestry	No	0.8–2.7	Planned
United Kingdom			
Afforestation	No	0.6	Implemented

(1) The measures for Austria in this table were given in the second national communication. It has been assumed that they are included in the latest projections.

Source: AEA Technology (2001).

In agriculture, most savings are the result of policies and measures that are not directly aimed at greenhouse gas reductions, e.g. regulations on nitrogen fertiliser use aimed at reducing nitrate pollution and reform of the common agricultural policy. The policies and measures in Table 6 are therefore mainly aimed at afforestation. In the Netherlands, horticulture is an important sector in which measures are aimed at energy savings.

3.8. Waste

The EU-aggregated emission projection is for a 38 % decrease in emissions from 1990–2010. This results from emission decreases in some Member States due to measures controlling landfills, which more than compensate for emission increases due to increased waste generation.

National emission projections for Member States for the waste sector are shown in Figure 11. The EU-aggregated emission projection is for a 38 % decrease in emissions from 1990–2010. There has already been a 19 % decrease since 1999. In some Member States, e.g. Spain, Greece, Portugal and Italy, there have been increased emissions since 1990 probably due to increased waste generation. Most other Member States are showing decreased emissions due to measures controlling landfills.

An important policy in the waste sector is the landfill directive and the legislation introduced by Member States to implement it. In some Member States, there are measures to minimise waste and to promote recycling (see Table 7). Significant savings can come from the waste sector, but these are mainly due to the landfill directive.

Figure 11

National emission projections for total GHGs in 2010 and 1999 total GHG emissions for Member States for the waste sector

Sources: National emission projections for total GHGs in 2010 and 1999 total GHG emissions for Member States for the waste sector

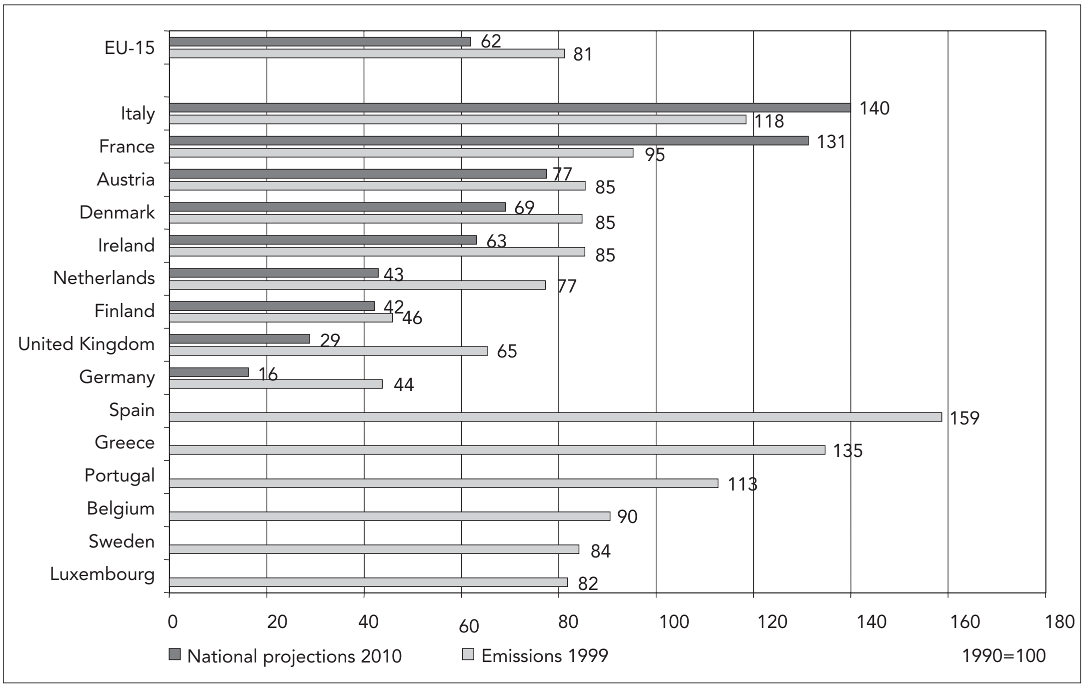


Table 7

Policies and measures in the waste sector

Source: AEA Technology (2001).

Waste	In baseline?	CO_2 saving ($Mt\ CO_2$ eq.)	Status
Denmark			
Waste minimisation	No	0.6	Implemented
Germany			
Reduction of solid waste to landfills, promotion of waste separation and recycling	No	27.3	Implemented
Greece			
Waste programme	No	Not known	Implemented
France			
Prohibition of dumping of decomposable waste	Yes	Not known	Implemented
Ireland			
Waste management — promotion of recycling	Not known	Not known	Implemented
Italy			
Reduction of waste and increase in incineration	No	2.8	Planned
Netherlands			
Measures to reduce methane from landfills	Yes	Not known	Implemented
Finland			
Waste management and gas reclamation	Not known	Not known	Not known
United Kingdom			
Landfill tax	Yes	0.1–0.4	Implemented

4. Greenhouse gas emission projections for the year 2010 provided by EU-wide model studies

4.1. Model approaches and assumptions

Greenhouse gas emission projections from the sectoral objectives study are based on both a top-down approach using the Primes model and a bottom-up analysis considering 250 greenhouse gas mitigation options from the Genesis database.

EU-wide emission projections of the sectoral objective study (Ecofys, NTUA, AEAT, 2001a) are based on a two-track approach. EU-wide emission projections for energy related CO_2 emissions have been derived from a top-down approach using the Primes model. EU-wide emission projections for the other greenhouse gases have been developed with a bottom-up approach, which makes an engineering-economic analysis of individual emission reduction options using the Genesis database. These EU-wide projections have been extensively discussed and reviewed by various stakeholders (Member States, industry, others).

Primes is a partial equilibrium model of the energy and economic system of the European Union ([9]). Primes includes the entire energy system with all supply and demand sectors. A specific emphasis has been placed on the power and steam sector, although other technologies were also explicitly modelled. It generates results for each of the Member States and for each of the eight modelled sectors ([10]) separately.

Based on assumptions such as population and GDP growth, development of prices of primary energy and investment cost for energy technologies, the model simultaneously compiles the least-cost primary energy structure and the resulting GHG emissions, considering technologies for each energy use, the capital replacement procedure and the fuels selected. In addition, various policies and measures (for instance, emissions trading) as well as other constraints and boundaries can be modelled. Primes calculates the consequences regarding economic development as differential GDP growth compared to the baseline scenario as well as the cost for CO_2 mitigation in euro per tonne of CO_2.

The Genesis database contains information on technology and costs of about 250 GHG mitigation options, several being considered for each sector. Cost data often depend on regional or national conditions. Basically, these differences cannot be considered in a general database. However, some regional cost adjustment has been made if necessary. The analysis of each sector starts with the identification of processes which cause energy related or other GHG emissions. In a second step, available GHG mitigation options are identified and inventoried. Options that can contribute to GHG mitigation in 2010 have been characterised by reduction potential, investment cost, operation and maintenance, potential cost savings and lifetime. Based on this information, sectoral mitigation cost curves can be developed. These can be compared with the mitigation cost curves of the other sectors.

The bottom-up approach is more detailed than the top-down approach. However, all mitigation options within each sector and between the individual sectors are assessed in isolation. Side effects with regard to, for example, cost and energy demand cannot be considered simultaneously. Nevertheless, the bottom-up approach bridges the gaps that cannot be covered by a less detailed top-down approach with a partial equilibrium model.

(9) Luxembourg is excluded because of its small size.
(10) (1) Energy supply; (2) fossil fuel extraction, transport and distribution; (3) industry; (4) transport; (5) household; (6) services; (7) agriculture; (8) waste.

4.2. EU-wide greenhouse gas emission projections from the sectoral objectives study

The EU-wide baseline projection from the sectoral objectives study considers all greenhouse gases. In this study, the EU-wide projection is compared with EU-aggregated national emission projections provided by the Member States.

The overall goal of the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) was to identify the least-cost options which should be applied in order to achieve the commitments that have been agreed in the Kyoto Protocol and in the burden sharing agreement of the European Union. Thus, SOS covers not only — like most other projections — CO_2 but all greenhouse gases and a detailed set of greenhouse gas emitting sectors. The aim of the study is to identify the policies and measures for the individual sector/gas combinations which provide GHG mitigation at the lowest possible cost.

However, these options can be identified only in comparison with the 'business as usual' development (baseline), which considers existing policies and measures but does not consider additional policies and measures [11]. This EU-wide emission projection baseline is comparable to the national emission projections carried out by the Member States. In this section we will describe the results of the baseline EU-wide emission projections of the SOS. In Chapter 5 these results will be compared with the results of the national emission projections.

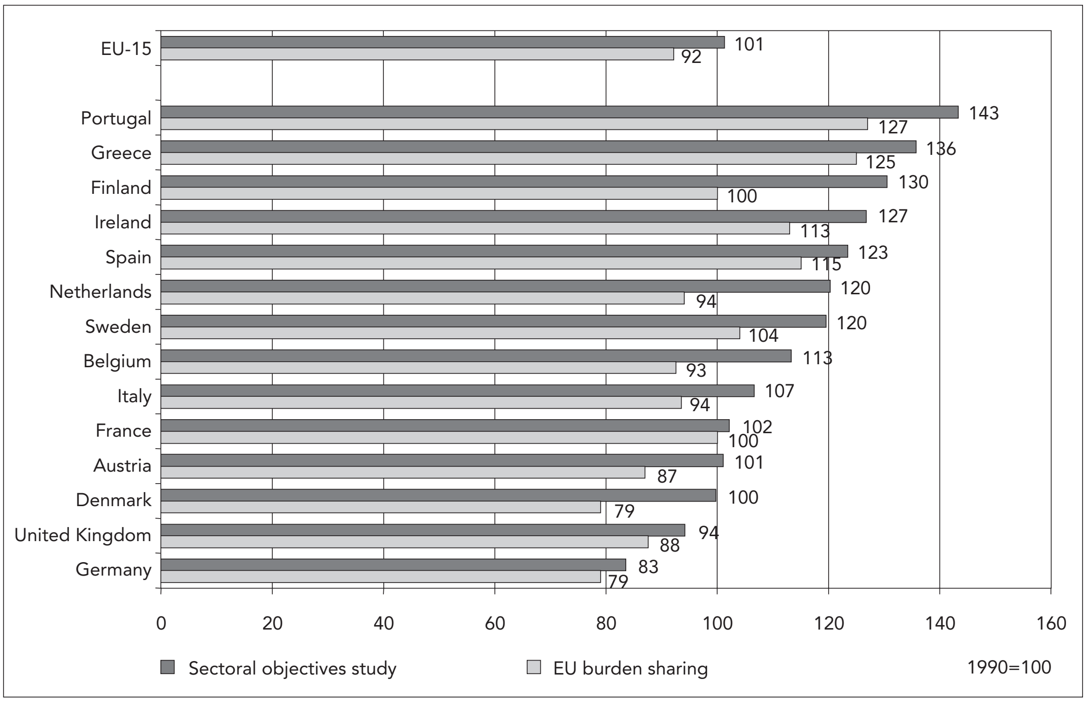
4.2.1 Total greenhouse gases

Total greenhouse gas projections from the sectoral objective study result in emissions 1 % higher in 2010 than in 1990 and, thus, well above the Kyoto target of minus 8 %. More than 80 % of total EU GHG emissions are CO_2 emissions. Both methane and N_2O account for less than 10 % and F-gases account for less than 3 % of total EU GHG emissions.

Figure 12 shows the EU-wide emission projections and the disaggregated emission projections for individual Member States in the SOS baseline scenario. The EU-wide emission projections are normalised to the 1990 emissions as described in Section 1.1.4.

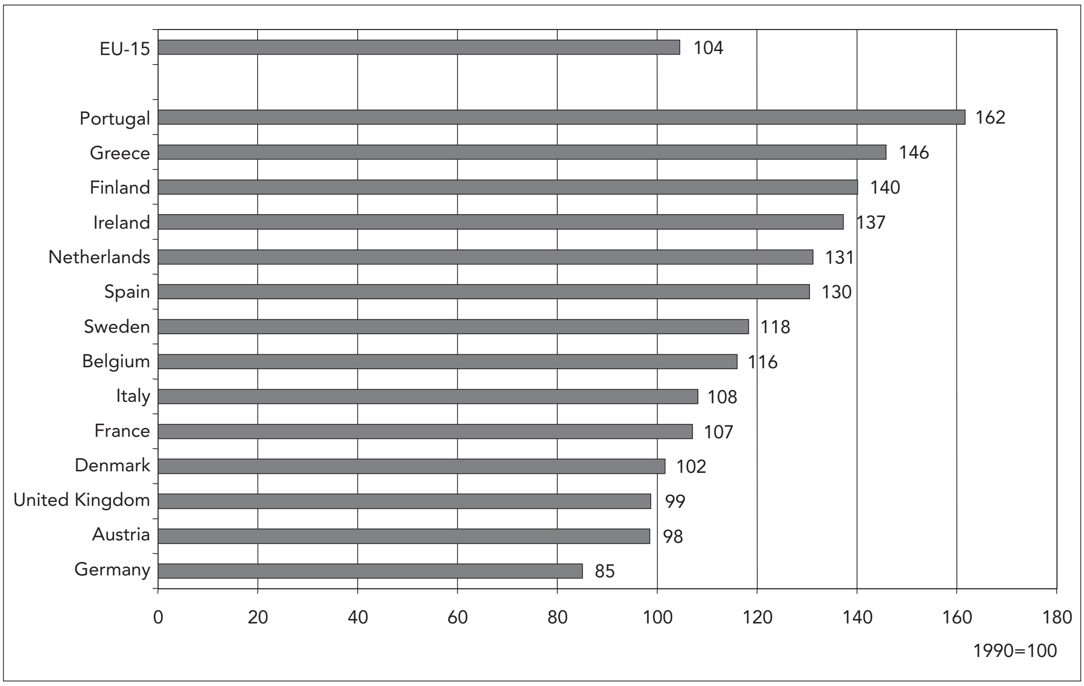
Figure 12 EU-wide emission projection for total GHGs in 2010, with disaggregation for Member States and commitments according to the burden sharing agreement

Source: Ecofys, NTUA, AEAT (2001a).



(11) The baseline projection of the SOS for CO_2 is based on the results of the Shared Analysis Project (European Commission, 1999).

EU-wide emission projection for CO_2 in 2010, with disaggregation for Member States Figure 13



Source: Ecofys, NTUA, AEAT (2001a).

According to the SOS baseline projection, EU total GHG emissions are projected to be 1 % higher in 2010 than in 1990. Only the United Kingdom and Germany are projected to reduce their GHG emissions. All other Member States are projected to have higher GHG emissions in 2010. The highest increases are projected to occur in Portugal, Greece, Finland and Ireland, where emissions are projected to grow by more than a quarter. Compared to the commitments of the burden sharing agreement, the EU is projected to be about 10 % above its target of minus 8 % compared with the 1990 levels. In the baseline development France's distance to the target is only 2 %. Germany, Spain, the United Kingdom and Greece are also closer to their individual targets than the EU on average. Finland's GHG emissions are projected to be most distant from the target (30 %). The Netherlands', Denmark's and Belgium's distances from target are projected to be greater than 20 % without additional measures.

With regard to the individual greenhouse gases, the pictures are quite different. Emissions of CO_2 are projected to increase for the EU by 4 % according to the baseline projection (Figure 13). Only in Germany are CO_2 emissions projected to decrease substantially, by 15 %. In Austria, the United Kingdom and Denmark, CO_2 emissions are projected at more or less 1990 levels. The greatest increase in CO_2 emissions is projected in Portugal (plus 62 %).

Total methane (CH_4) emissions are projected to decrease in the EU by 18 % (Figure 14). Apart from Ireland — where CH_4 emissions increase by 17 % due to substantial increases in agriculture — all EU countries are projected to reduce or at least stabilise their methane emissions.

The highest reduction in CH_4 emissions (38 %) is projected for Germany because of policies and measures in fossil fuel extraction, waste treatment and agriculture. In Finland, the United Kingdom and the Netherlands, CH_4 emissions are also projected to decrease substantially (by more than 20 %) mainly through policies and measures in fossil fuel extraction and waste treatment.

Overall N_2O emissions are projected to decrease in the EU by 16 % in the period up to 2010, although N_2O emissions are projected to increase in Sweden and Austria by 24 and 21 % respectively (Figure 15). These increases are overcompensated by substantial reductions in the United Kingdom and Germany.

Figure 14 **EU-wide emission projection for CH_4 in 2010, with disaggregation for Member States**

Source: Ecotys, NTUA, AEAT (2001a).

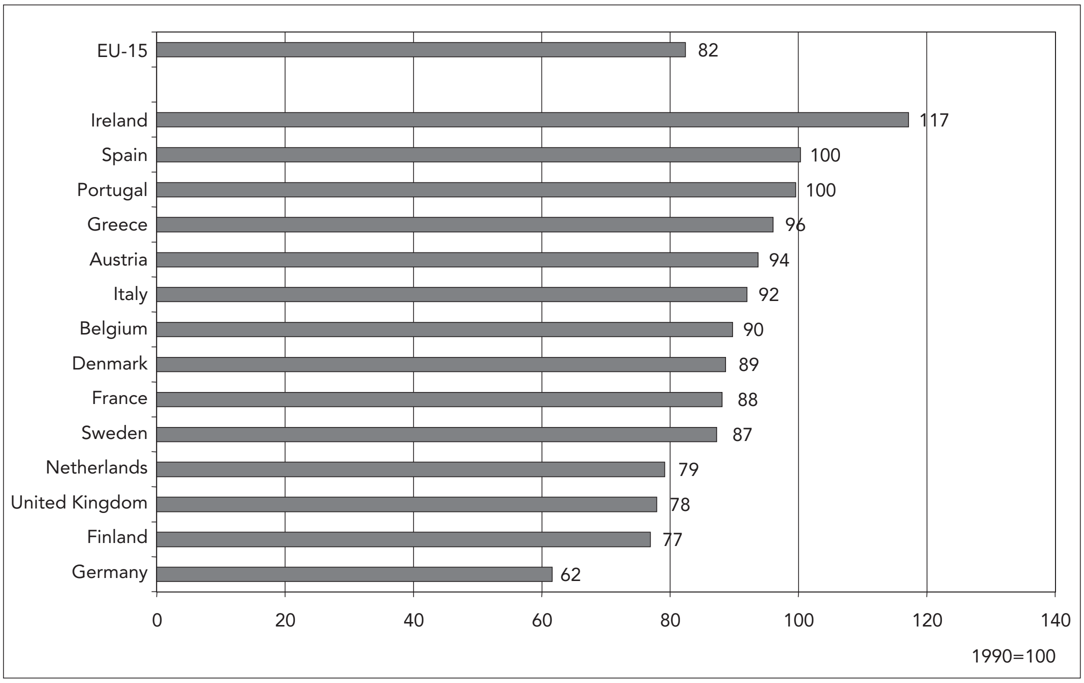
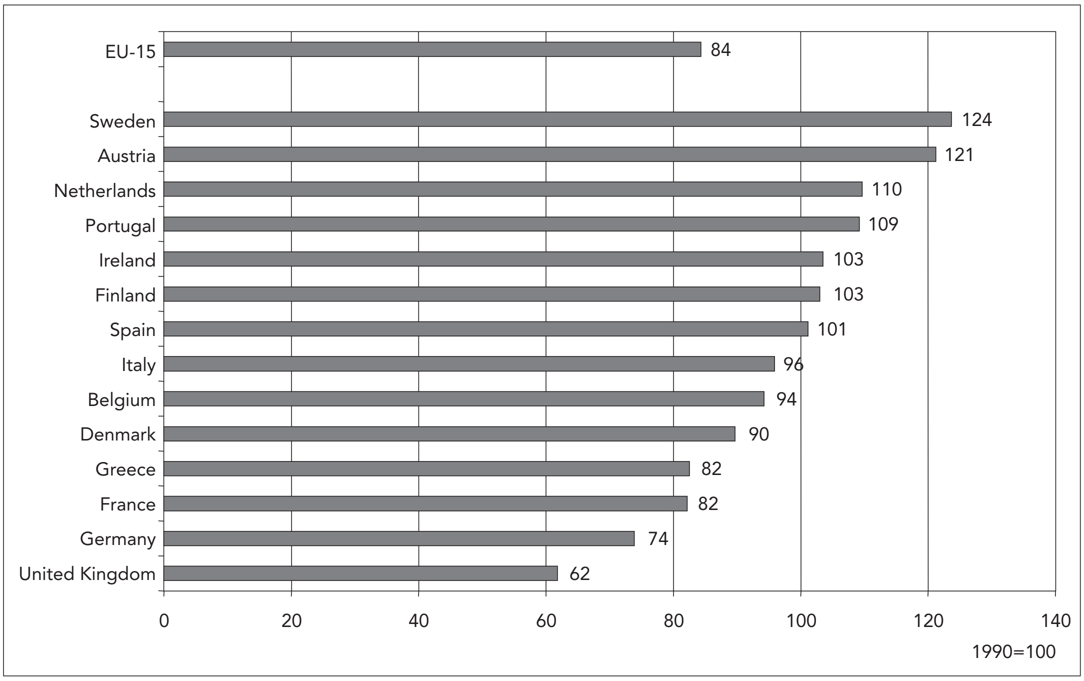


Figure 15 **EU-wide emission projection for N_2O in 2010, with disaggregation for Member States**

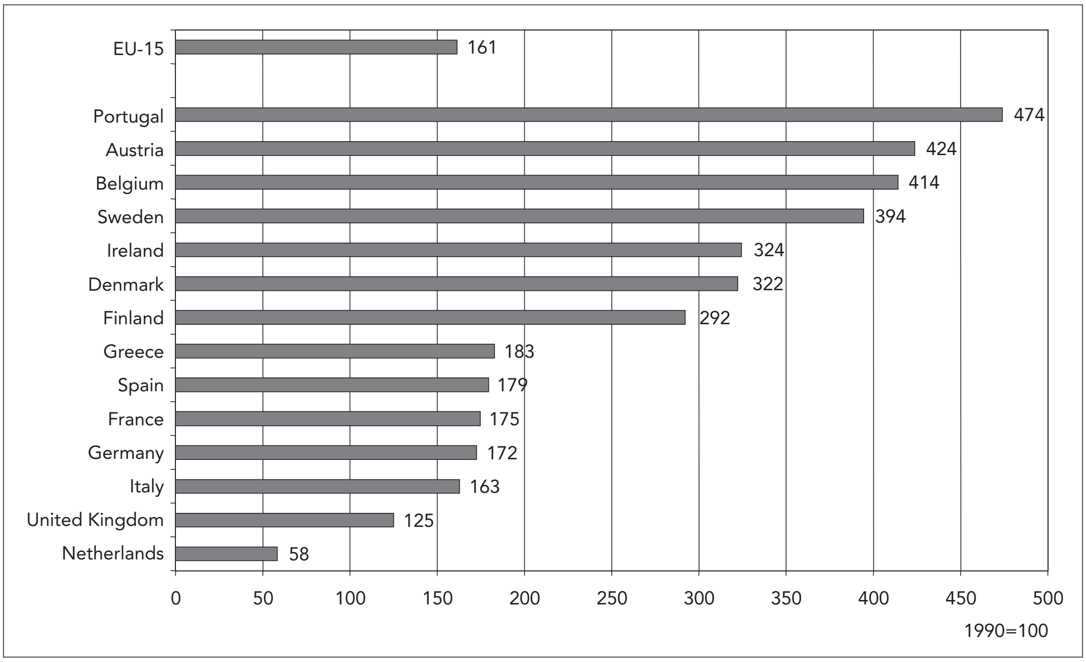
Source: Ecotys, NTUA, AEAT (2001a).



The emission reductions will be achieved mainly through emission reductions in the industry sector where emissions are projected to decrease by almost 80 % in the United Kingdom and by more than 70 % in Germany. Substantial reductions are also expected in France (56 %) and Italy (33 %). However, these remarkable improvements are partly counteracted by an increase of N_2O emissions in the transport sector, where emissions in 2010 are projected to double (Belgium, the UK, Finland, France, Portugal and Austria), triple (Germany, Sweden and the Netherlands) or even increase fourfold (Italy and Spain) in the period up to 2010.

Total HFC emissions are projected to increase substantially (61 %) in the EU up to the year 2010 (Figure 16). However, the projections differ remarkably by Member State. In the Netherlands, HFC emissions are projected to decrease by more than 40 %,

EU-wide emission projection for HFCs in 2010, with disaggregation for Member States — Figure 16



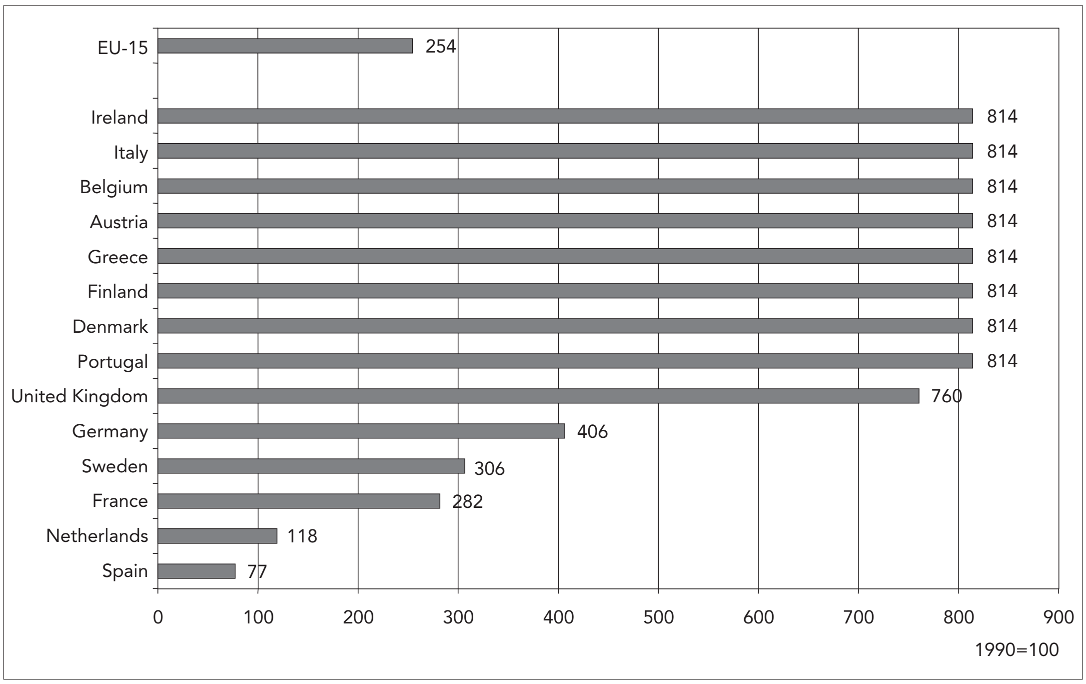
Source: Ecofys, NTUA, AEAT (2001a).

whereas they are projected to increase more than fourfold in Portugal, Austria and Belgium up to the year 2010.

HFC emissions from industry are projected to decrease in the Netherlands (63 %) and in the United Kingdom (28 %). In contrast, HFC emissions from Germany's industry sector are projected to increase by 14 %. However, the highest growth rates for HFC emissions are projected for the transport sector, where HFC emissions are projected to increase at least 10-fold and in some countries even increase by factors greater than 20.

With regard to PFC emissions, the picture is as follows. PFC emissions are projected to increase by more than 150 % in the EU (Figure 17). PFC emissions are projected to decrease only in Spain. In contrast, PFC emissions are projected to increase more than eightfold in Ireland, Greece, Austria, Belgium, Italy, Portugal, Denmark and Finland.

EU-wide emission projection for PFCs in 2010, with disaggregation for Member States — Figure 17



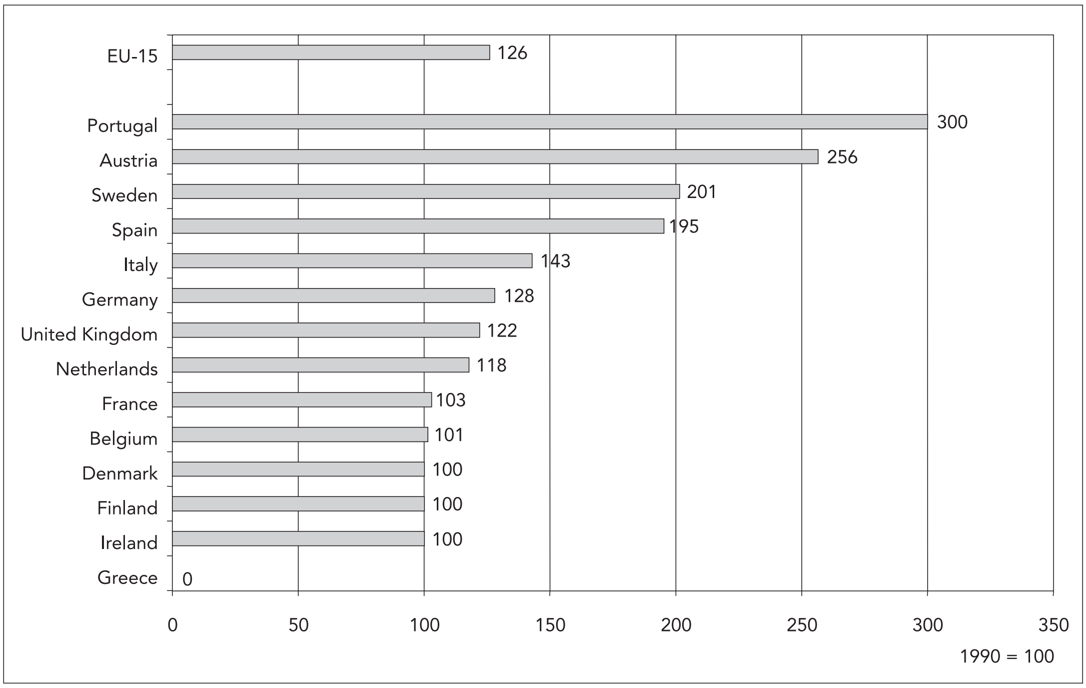
Source: Ecofys, NTUA, AEAT (2001a).

These emissions increases occur only in the industry sector. However, it has to be considered that total PFC emissions account for less than 0.5 % of total GHG emissions of the EU in the year 2010.

Total SF_6 emissions contribute even less to the EU total emissions. Only 0.1 % of total GHG emissions of the EU are projected to derive from SF_6 emissions in the year 2010. Overall EU SF_6 emissions are projected to increase by 26 % (Figure 18). All SF_6 emissions derive from energy supply (12) and from the industry sector. It is projected that SF_6 emissions in the energy sector will be the same in 2010 as in 1990 (stabilisation). Without additional measures, SF_6 emissions from industry are projected to increase threefold in most countries except in the United Kingdom and France. Emissions of SF_6 from industry are projected to increase only twofold in the United Kingdom and to increase by merely 8 % in France.

Figure 18 **EU-wide emission projection for SF_6 in 2010, with disaggregation for Member States**

Source: Ecofys, NTUA, AEAT (2001a).



Several countries are projected to reduce their emissions more than the EU average, whereas total SF_6 emissions in Portugal, Austria, Sweden and Spain are projected as being substantially above the EU average.

4.2.2. Energy sector

Total GHG emissions from the energy (13) sector are projected to be 1 % below the 1990 level in 2010. However, the projection results for individual countries differ greatly and range from an increase by more than 100 % in Finland to almost 25 % lower emissions in Germany.

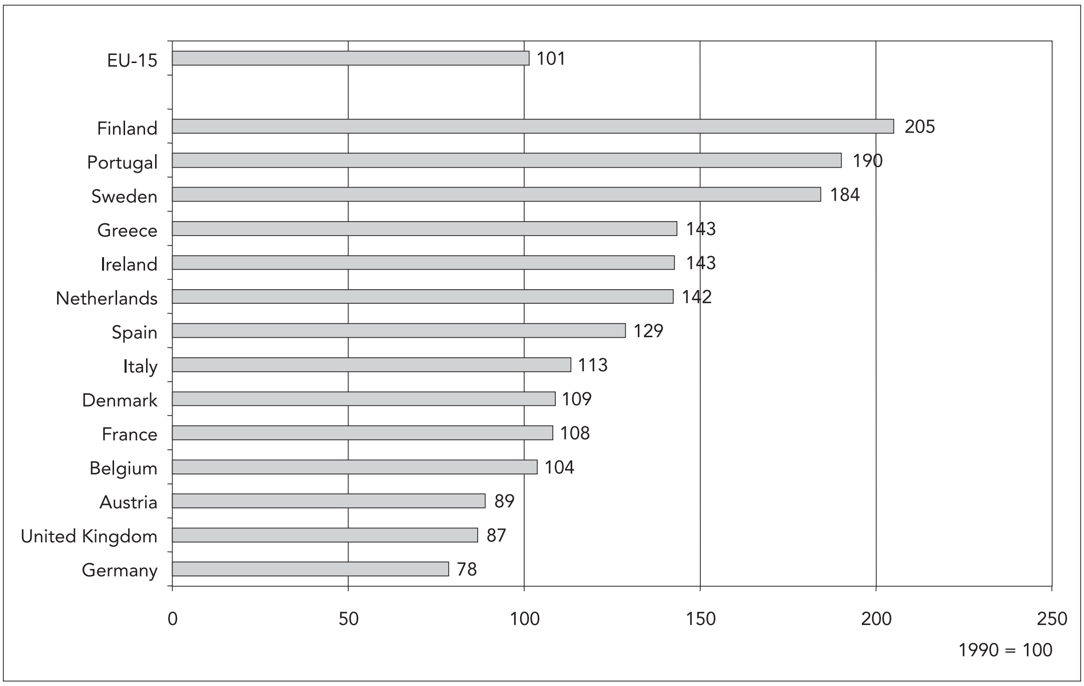
GHG emissions from the energy sector arise from two main subsectors: emissions from energy supply (14), which concern mainly CO_2, and from fossil fuel extraction (15), which concern mainly CH_4. The EU-wide emission projection for GHG emissions in energy supply and the disaggregation for Member States are shown in Figure 19.

EU-wide emissions in energy supply are projected to be almost the same in 2010 as in 1990. Only Germany, the United Kingdom and Austria are projected to reduce their GHG emission from energy supply. In contrast, Finland's, Portugal's and Sweden's GHG emissions from energy supply are projected to increase substantially, by more than 80 %.

(12) 'Energy industries' (1A1), as defined under the UNFCCC.
(13) The energy sector in this report includes 'energy industries' (1A1) and 'fugitive emissions from fuels' (1B), as defined under the UNFCCC.
(14) 'Energy industries' (1A1), as defined under the UNFCCC.
(15) 'Fugitive emissions from fuels' (1B), as defined under the UNFCCC.

EU-wide emission projection for total GHGs in 2010, with disaggregation for Member States, for energy supply

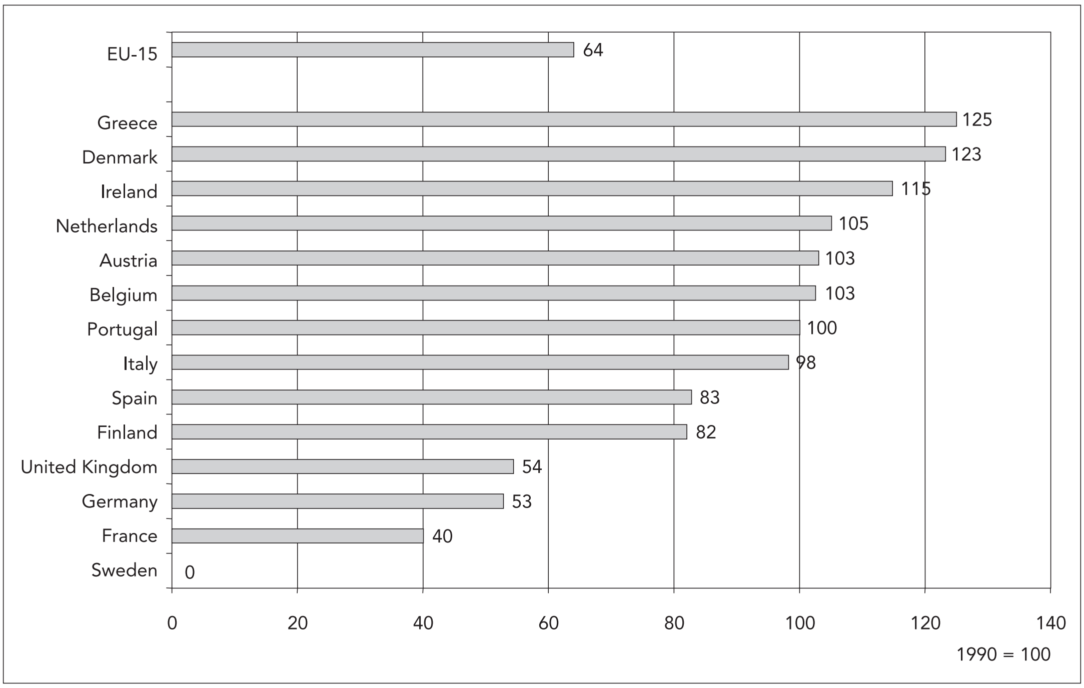
Figure 19



Source: Ecofys, NTUA, AEAT (2001a).

EU-wide emission projection for total GHGs in 2010, with disaggregation for Member States, for fossil fuel extraction, transportation and distribution

Figure 20



Source: Ecofys, NTUA, AEAT (2001a).

EU-wide emissions from fossil fuel extraction are projected to decrease by 36 % (Figure 20), although GHG emissions from fossil fuel extraction in Greece, Denmark, Ireland, the Netherlands, Austria and Belgium are projected to increase. Portugal and Italy are projected to have stable conditions between 1990 and 2010. Substantial reductions of GHG emissions from fossil fuel extraction are projected for France (60 %), Germany (47 %) and the United Kingdom (46 %) ([16]). This will be partly due to declining fossil fuel extraction

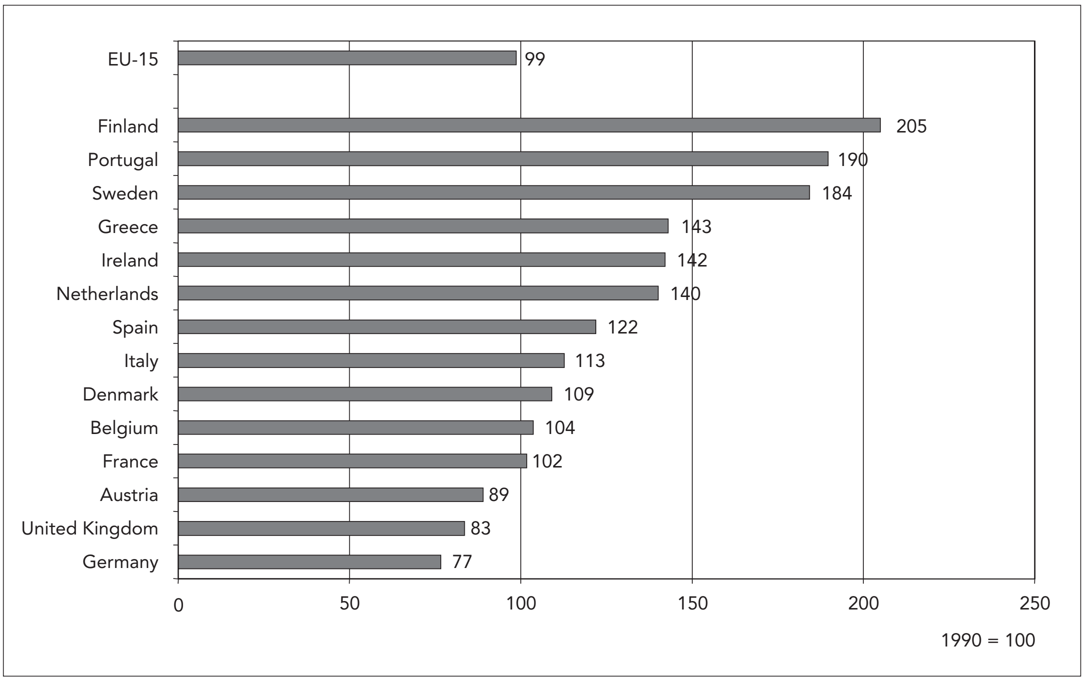
(16) Sweden did not have any CH_4 emissions in the base year. Consequently, GHG emissions from fossil fuel extraction cannot be further reduced.

in these countries and partly due to implementing policies and measures for fossil fuel extraction, mainly the capture of coal bed methane and methane from crude oil extraction.

For the total energy sector ([17]), EU-wide emissions are projected to decrease by just 1 % up to the year 2010 (Figure 21). GHG emissions from the energy sector are projected to decrease in Germany (27 %), the United Kingdom (17 %) and Austria (11 %). In all other Member States, GHG emissions from the energy sector are projected to increase, most significantly in Finland (105 %), Portugal (90 %) and Sweden (84 %).

Figure 21 **EU-wide emission projection for total GHGs in 2010, with disaggregation for Member States, for the energy sector**

Source: Ecofys, NTUA, AEAT (2001a).



However, in absolute terms, the highest growth of GHG emissions from the energy sector is projected for the Netherlands, Spain, Finland and Italy.

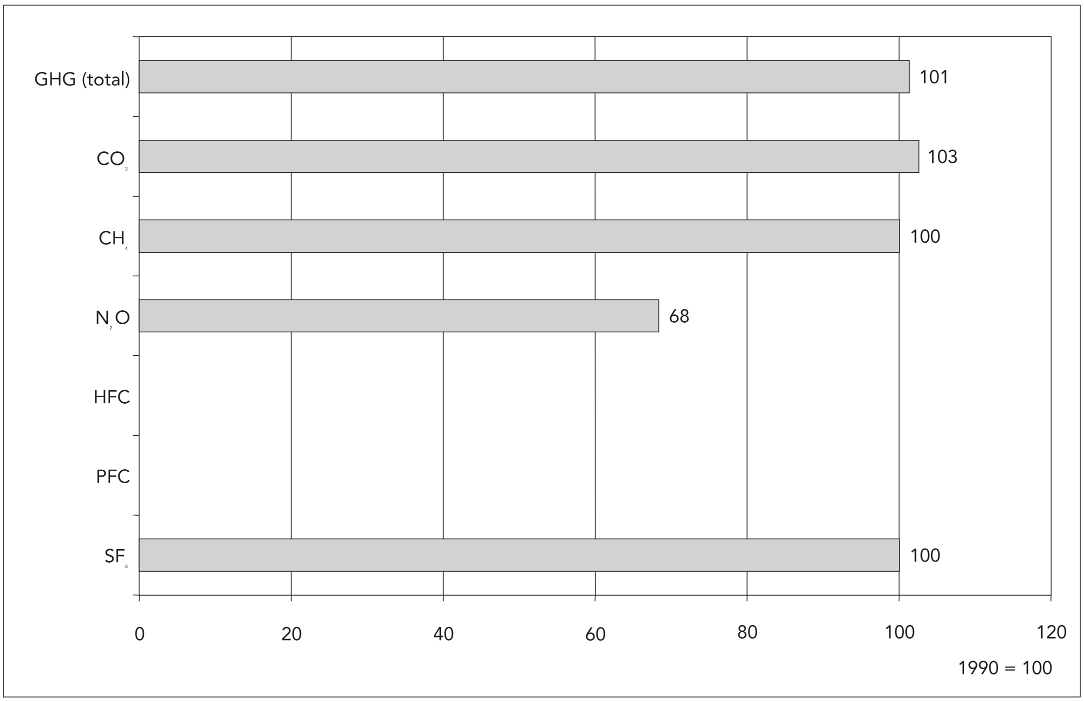
With regard to the individual greenhouse gases, the development is as follows: SF_6 and CH_4 EU-wide emission projections for energy supply are projected to be on the same level in 2010 as the 1990 emissions (Figure 22). Only N_2O emissions are projected to decrease substantially by 32 % and, thus, partly compensate the increase of CO_2 emissions from energy supply. This results in a small increase of total GHG EU-wide emissions, by 1 %, in 2010.

Fossil fuel extraction, transportation and distribution cause only N_2O and CH_4 emissions (Figure 23). Emissions of N_2O are projected to be on the same level in 2010 as in 1990. Due to the decrease of CH_4 emissions by 36 %, EU-wide total GHG emissions of this sector are reduced correspondingly.

EU-wide total GHG emissions from the energy sector ([18]) are projected to decline by only 1 % (Figure 24) although CO_2 emissions are projected to increase by 3 %. However, this increase is compensated by substantial reductions of CH_4 (32 %) and N_2O (31 %) in the period until the year 2010. Emissions of SF_6 from the energy sector are projected to be on the same level as in 1990.

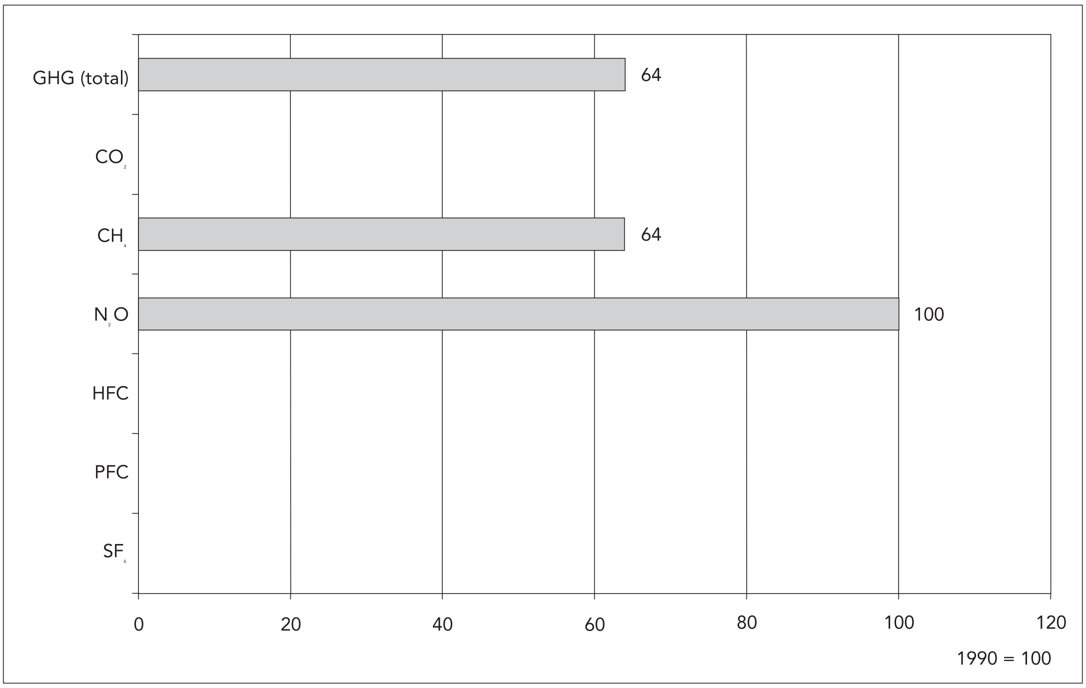
(17) The energy sector in this report includes 'energy industries' (1A1) and 'fugitive emissions from fuels' (1B), as defined under the UNFCCC.
(18) The energy sector in this report includes 'energy industries' (1A1) and 'fugitive emissions from fuels' (1B), as defined under the UNFCCC.

EU-wide emission projection for relevant GHGs in 2010 for energy supply Figure 22



Source: Ecofys, NTUA, AEAT (2001a).

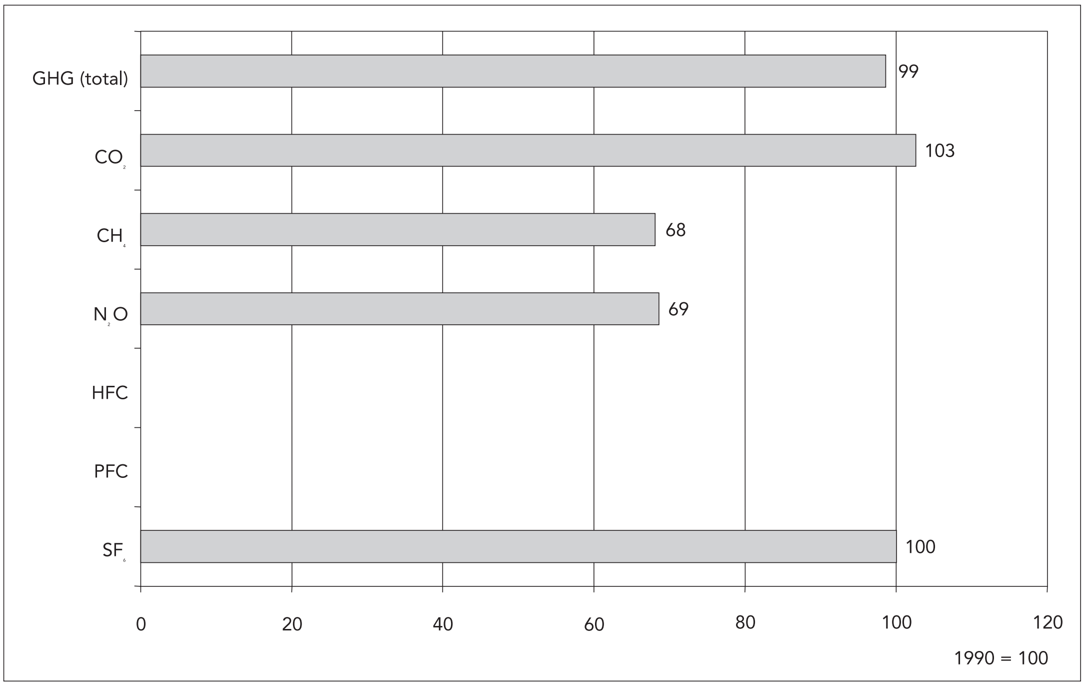
EU-wide emission projection for relevant GHGs in 2010 for fuel extraction, transportation and distribution Figure 23



Source: Ecofys, NTUA, AEAT (2001a).

Figure 24 EU-wide emission projection for relevant GHGs in 2010 for the energy sector

Source: Ecofys, NTUA, AEAT (2001a).



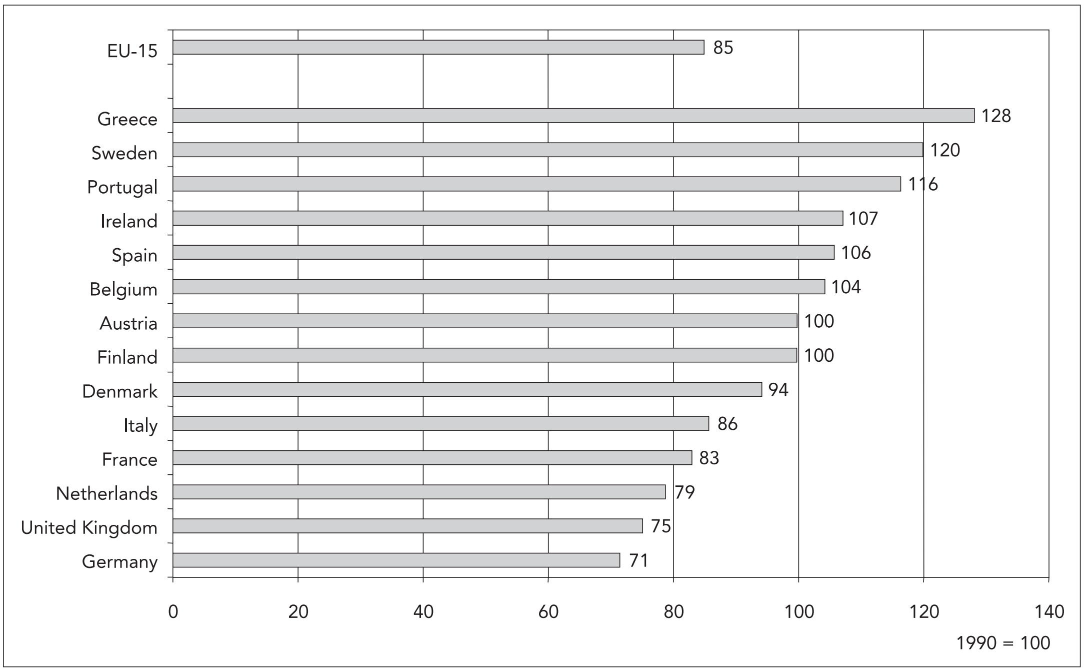
4.2.3. Industry

Total GHG emissions from industry are projected to be 15 % lower in 2010 than in 1990. More than 80 % of total GHG emissions are CO_2 emissions. In contrast to the overall decreasing trend, F-gas emissions are projected to grow substantially due to increased production of semiconductors, magnesium, switchgears and noise insulating double glazed windows.

EU-wide total GHG emissions from industry are projected to decrease by 15 % up to the year 2010 (Figure 25). The most substantial reductions are projected to be achieved in Germany (29 %), the United Kingdom (25 %) and the Netherlands (21 %).

Figure 25 EU-wide emission projection for total GHGs in 2010, with disaggregation for Member States, for the industry sector

Source: Ecofys, NTUA, AEAT (2001a).



The projected reductions are only slightly above the EU average in France, Belgium and Denmark. Only small reductions of GHG emissions in the industry sector are projected in Austria, Finland, Spain, Sweden and Ireland, whereas GHG emissions in the industry sector are projected to rise to 108 and 120 % in Portugal and Greece, respectively.

In absolute terms, reductions in the industry sector are projected to be reduced most substantially by policies and measures which are targeted to fuel-related CO_2 emissions in Germany and Italy as well as policies and measures which are targeted to N_2O emissions in the United Kingdom, Germany and France.

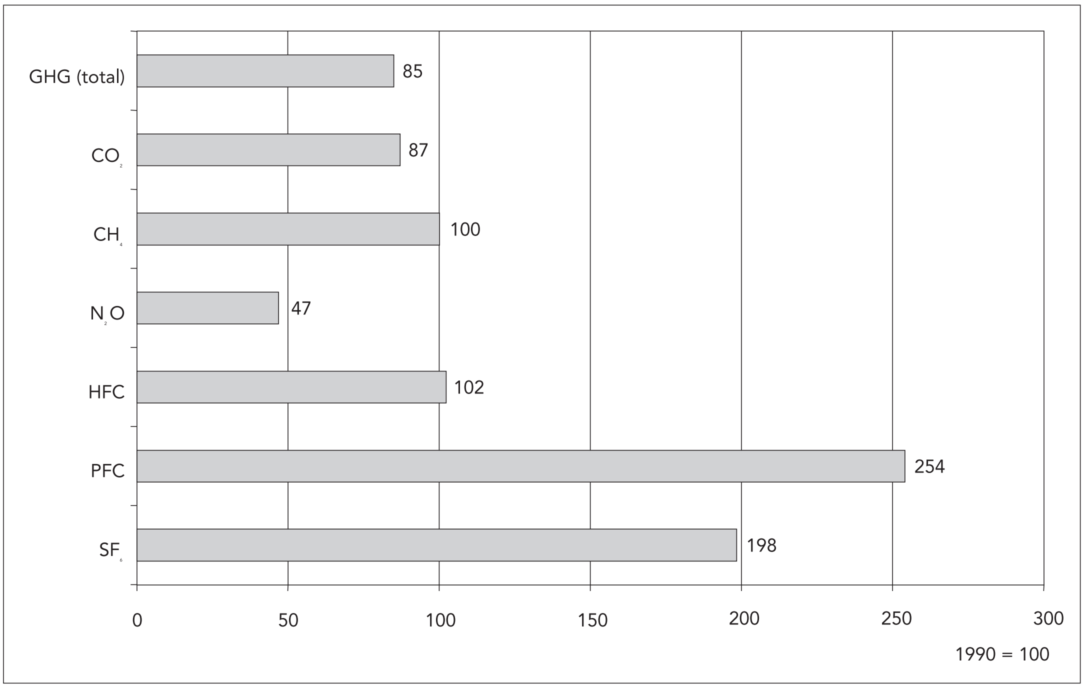
In 1990, F-gases (HFC, PFC and SF_6) accounted for 7 % of total GHG emissions in European industry. In the EU-wide emission projection for 2010, under baseline conditions (SOS) their share is projected to increase by 4 % to 11 %, although HFC emissions are more or less constant (Figure 26). However, significant changes in PFC (154 %) and SF_6 (98 %) emissions result in an increase of total F-gas emissions by more than a quarter (26 %).

PFC emissions result from the use of solvents and refrigerants as well as from aluminium and semiconductor production. Increased PFC emissions are mainly caused by semiconductor production, which is growing substantially. Their share of all PFC emissions from industry is projected to develop from less than 5 % in 1990 to more than 60 % in 2010.

Emissions of SF_6 derive from magnesium production and from their use in gas insulated switchgears in the electrical sector. Additionally, SF_6 is used for sound insulation in double glazed windows and for reducing leakage in car tyres. Due to substantial production growth of these products, SF_6 emissions are projected to almost double by 2010. However, as all products show comparable growth rates, the shares of the individual products remain more or less stable between 1990 and 2010.

Emissions of CH_4 from the industry sector are virtually irrelevant, due to their very small contribution to total EU emissions. Further substantial reductions are projected for CO_2 emissions (13 %) and more drastic reductions for N_2O (53 %).

EU-wide emission projections for relevant GHGs in 2010 for the industry sector Figure 26



Source: Ecotys, NTUA, AEAT (2001a).

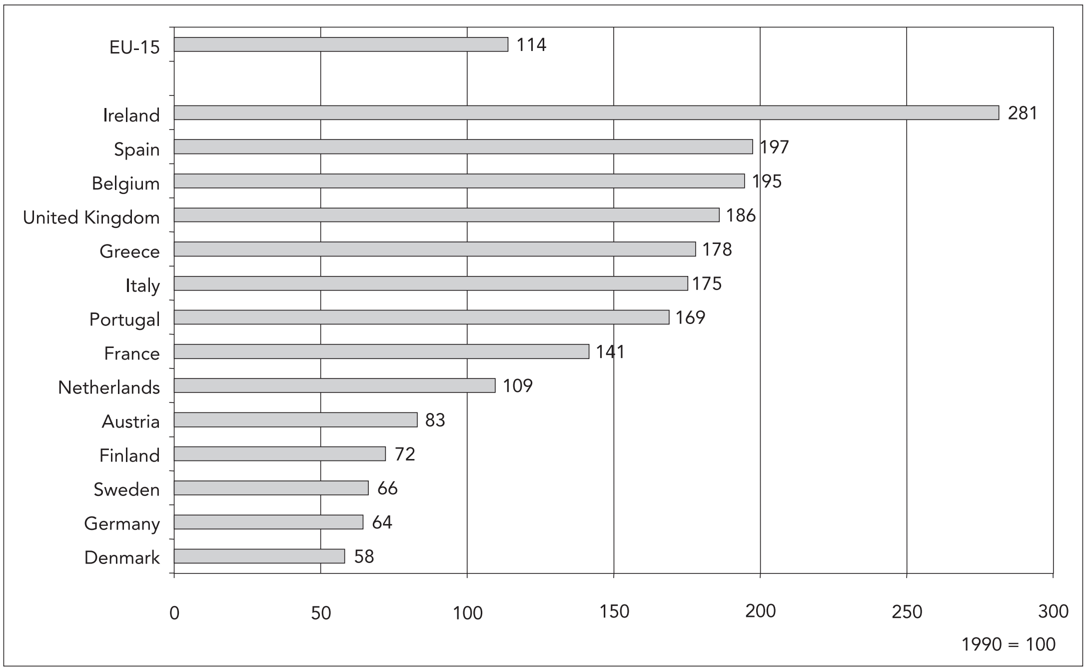
4.2.4. Services

Total GHG emissions from the services sector are projected to increase by 14 %. However, country differences are substantial. GHG emissions from the service sector are projected to be lower in 2010 than in 1990 in only five countries (Denmark, Germany, Sweden, Finland, Austria). In all other countries, GHG emissions are projected to grow, in some countries substantially.

From the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) EU-wide total GHG emission projections increase by 14 % (Figure 27). However, Member State differences are substantial. The disaggregation for Member States shows that total GHG emissions from the service sector in the Scandinavian countries are projected to decrease by at least 28 % (Denmark 42 %, Sweden 34 %, Finland 28 %). In Austria and Germany, reductions amount to 36 and 17 %, respectively.

Figure 27 **EU-wide emission projection for total GHGs in 2010, with disaggregation for Member States, for the services sector**

Source: Ecofys, NTUA, AEAT (2001a).



In contrast, GHG emissions from the services sector are projected to increase substantially in all other Member States, notably in Ireland, where a 2.8-fold increase is projected for the year 2010. In Spain, Belgium, the United Kingdom, Greece, Italy and Portugal, emissions from the services sector are projected to increase by more than 50 %.

In absolute terms, GHG emissions in the services sector are projected to decrease most substantially in Germany. These achievements are partly offset by considerable emission growth in the United Kingdom, France, Spain and Belgium.

Total GHG emissions in the services sector are derived in 1990 exclusively from fuel-related CO_2 emissions. However, HFC emissions are projected to increase until 2010 up to a share of almost 3 % of total GHG emissions from the services sector.

4.2.5. Residential sector

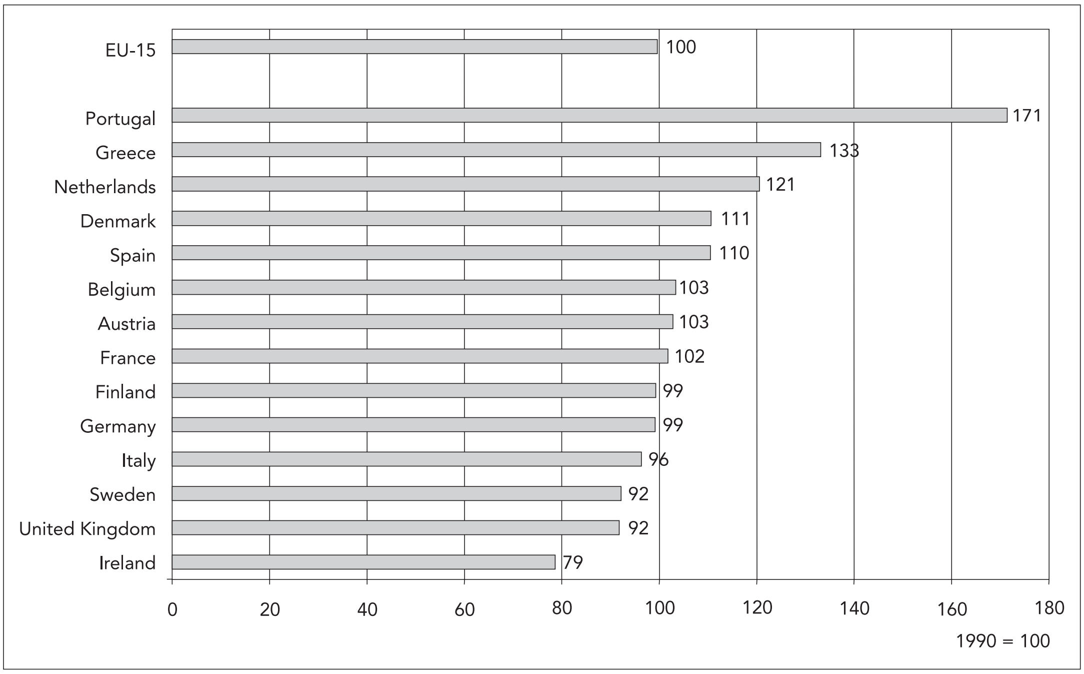
Total GHG emissions from the residential sector are projected to be on the same level as 1990. In contrast to emission projections from the services sector, the country differences are relatively small for the residential sector.

The sectoral objectives study shows (Ecofys, NTUA, AEAT, 2001a) EU-wide GHG emission projections from the residential sector (i.e. private households) for the year 2010 remaining on the same level as 1990 emissions (Figure 28). They derive basically from fuel related CO_2 emissions, although small amounts of HFC emissions are projected for the year 2010 (less than 1 % of total GHG emissions from the household sector in 2010).

In contrast to the services sector, the disaggregated emission projections for Member States do not differ that much.

Disaggregated GHG emission projections from the residential sector are reduced most in Ireland (21 %). In the United Kingdom, Sweden, Italy, Germany and Finland, GHG emissions are projected to decrease between 1 and 8 %.

EU-wide emission projections for total GHGs in 2010, with disaggregation for Member States, for the residential sector Figure 28



Source: Ecofys, NTUA, AEAT (2001a).

In all other Member States GHG emissions from the residential sector are projected to increase, particularly in Portugal (more than 70 %).

4.2.6. Transport

Total GHG emissions from the transport sector are projected to grow by more than 30 % between 1990 and 2010. This is the highest growth rate of all sectors. More than 90 % of total GHG emissions are CO_2 emissions. However, due to increased use of air conditioning and catalytic converters in vehicles, HFC and N_2O emissions are projected to increase 20-fold and to triple respectively.

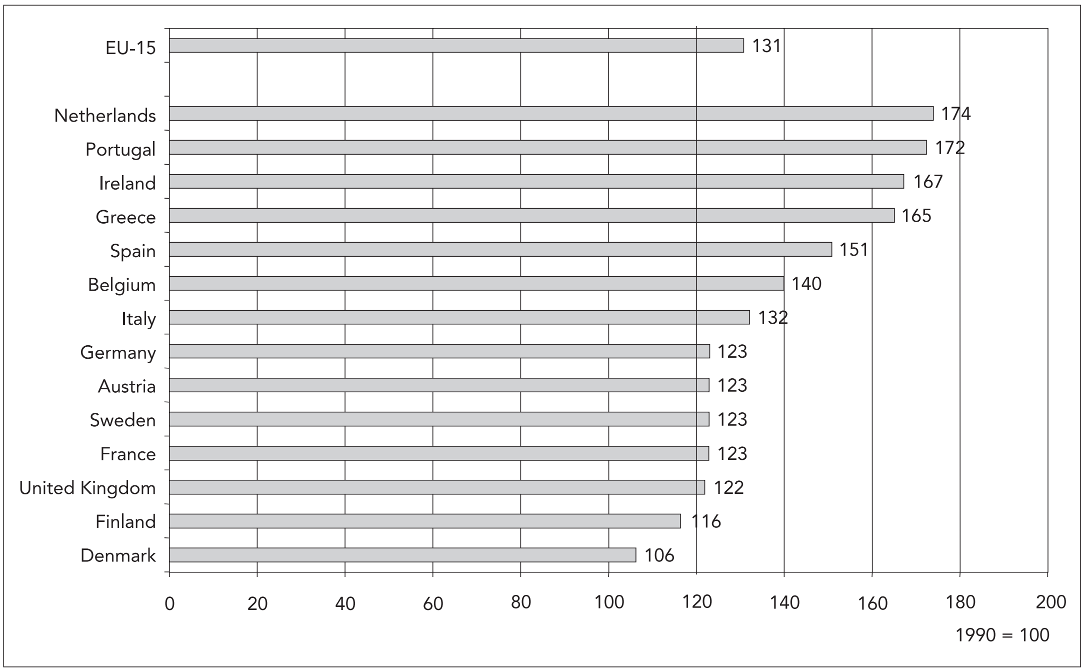
In the transport sector, EU-wide GHG emission projections from the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) are expected to grow substantially until the year 2010, by more than 30 % (Figure 29). Disaggregated transport emissions are projected to increase in all Member States. The increase, however, is projected to be the least in Denmark where GHG emissions from the transport sector grow only by 6 %. Smaller growth than the EU average is also projected for Finland, the United Kingdom, France, Sweden, Austria and Germany.

The highest emission growth is projected for the Netherlands, Portugal, Ireland, Greece and Spain, where emissions are projected to increase by more than 50 % compared with 1990 emissions.

Almost 98 % of total GHG emissions in the transport sector are fuel related CO_2 emissions. This share is projected to decrease by 5 % due to the enormous growth of EU-wide HFC and N_2O emission projections for 2010 (Figure 30).

Figure 29 **EU-wide emission projection for total GHGs in 2010, with disaggregation for Member States, for the transport sector**

Source: Ecotys, NTUA, AEAT (2001a).

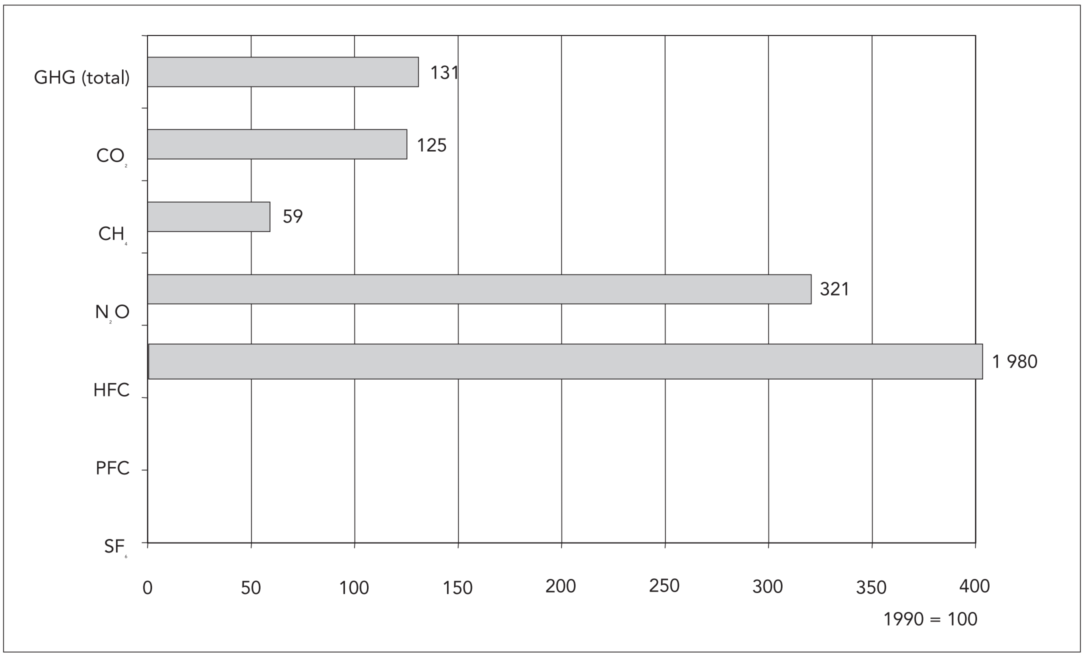


The projected increase of N_2O emissions by more than factor 3 is caused by the higher infiltration of cars with catalytic converters. These emit (per car) about five times more N_2O than cars without catalytic converters. HFC emissions grow mainly because of a substantially higher presence of air conditioning in new cars. Although the use of air conditioning in new cars is already high in some countries (e.g. 60 % in France), it is expected to increase to 90 % in 2010. Thus, HFC-134a emissions are projected to increase almost 20-fold.

Due to the small share of CH_4 emissions (less than 1 %), the reduction of CH_4 emissions by more than 40 % has virtually no relevance for the development of total GHG emissions from the transport sector.

Figure 30 **EU-wide emission projections for relevant GHGs in 2010 for the transport sector**

Source: Ecotys, NTUA, AEAT (2001a).



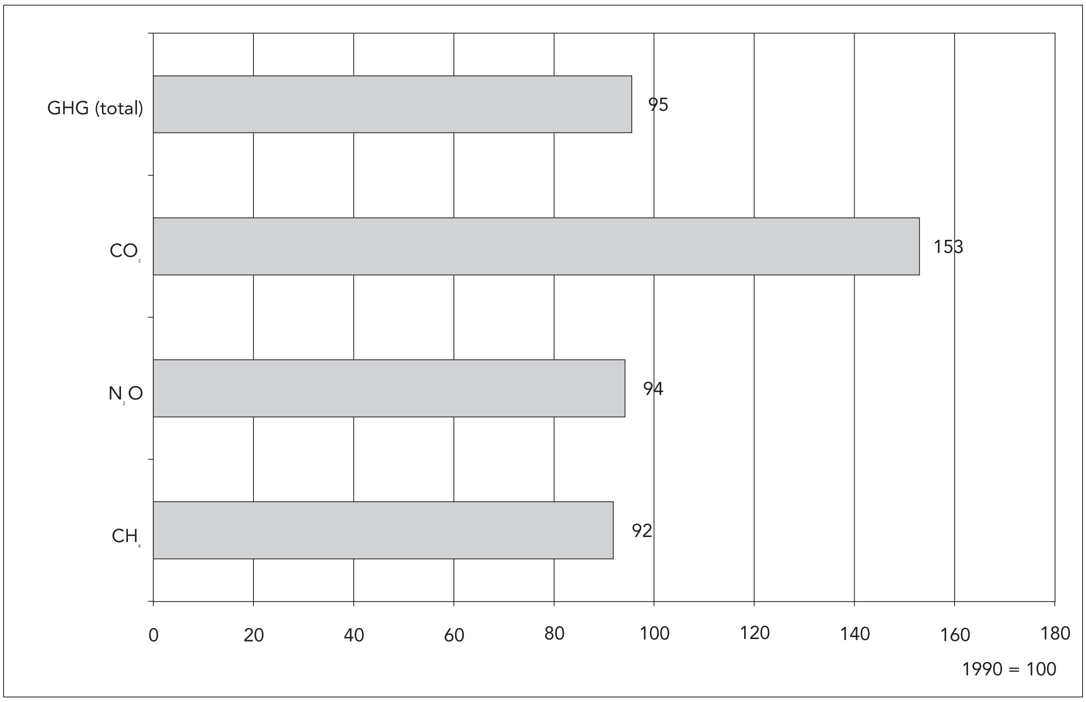
4.2.7. Agriculture

The EU-wide emission projections for total GHGs from agriculture are projected to decrease by 5 %. The common agricultural policy and, indirectly, the nitrates directive lead to falling livestock numbers and some decrease in the use of fertiliser.

The most important emissions from agriculture are methane and nitrous oxide. Sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) EU-wide emission projections for agriculture are based on a bottom-up approach.

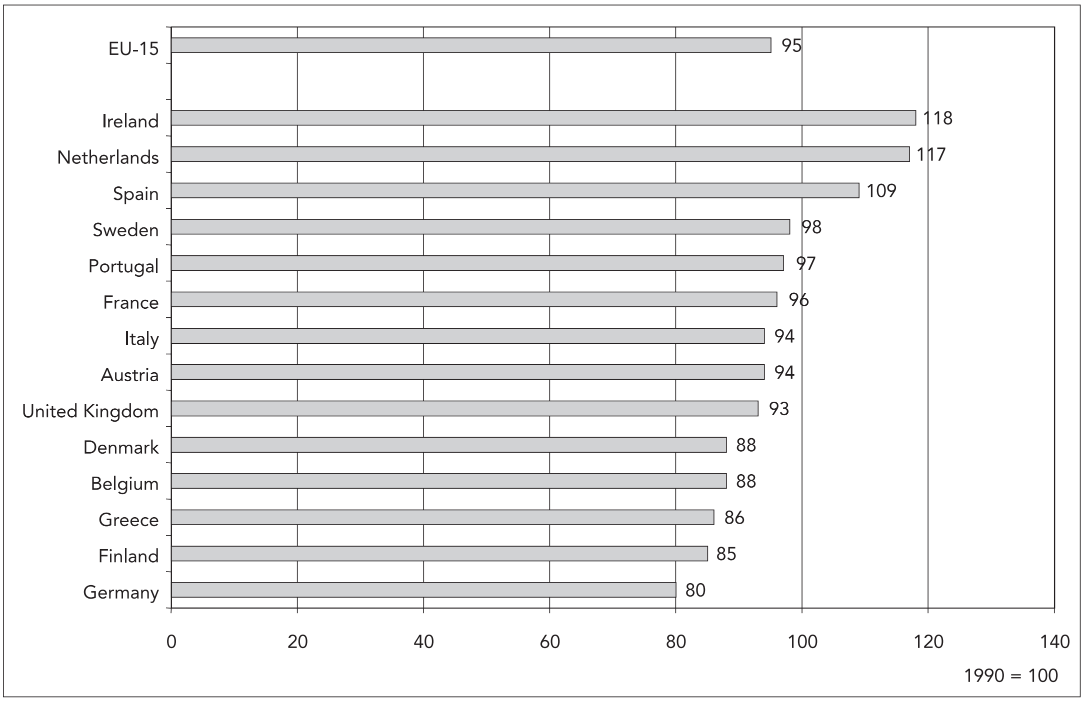
The EU-wide emission projections for total GHGs are expected to decrease by 5 % due mainly to falling livestock numbers and some decrease in the use of fertiliser (Figure 31).

EU-wide emission projection for relevant GHGs in 2010 for the agricultural sector Figure 31



Source: Ecofys, NTUA, AEAT (2001a).

EU-wide emission projection for total GHGs in 2010, with disaggregation for Member States, for the agricultural sector Figure 32



Source: Ecofys, NTUA, AEAT (2001a).

At the Member State level, most countries are projected to have lower emissions in 2010 than in 1990 (Figure 32). Ireland and Spain have increased emissions due to increasing livestock numbers. Emissions in the Netherlands are projected to increase because of an increase of fuel use in horticulture.

The reform of the common agricultural policy, adopted in the framework of Agenda 2000, is included in the baseline projections. Indirectly, through the projections of fertiliser use, the effect of the nitrates directive is also included.

Methodology for methane

The two main sources of methane emissions in agriculture are enteric fermentation and manure management. These are largely dependent on livestock numbers. A projection of livestock numbers in 2010 was therefore made to provide a basis for estimating future agricultural emissions (Ecofys, NTUA, AEAT, 2001c). Data on livestock numbers in 1990 and 1998 (1997 for some animals) is available from Eurostat. This also provides information on current trends in livestock numbers at the Member State level. Information on trends in markets for agricultural products between 1997 and 2006 was taken from *Prospects for agricultural markets 1999–2006* ([19]). The projections include a substantial reduction in the number of dairy cows despite almost constant milk production due to a continuation of the trend in improved milk yield.

Projections for 2010 emissions were made on the basis of emissions factors and the forecast livestock numbers. A new emissions factor for enteric fermentation for 2010 was calculated to take account of improved milk yields based on the net energy system recommended by the IPCC (1996). For manure management, the emissions were projected on the basis of the 1990 emissions and forecast changes in livestock numbers.

The strength of this approach is its relative simplicity and dependence on the physical measure of activity, i.e. the number and types of livestock. However, with this approach it is difficult to identify the effect of individual policies and measures.

Methodology for nitrous oxide

The main sources of N_2O emissions from agriculture are from manure management and from soils. Emissions from manure management were projected on the same basis as methane, discussed above, i.e. based on an emissions factor and livestock numbers.

The projections for emissions from soils used the IPCC methodology which assumes that 1.25 % of the nitrogen contained in mineral fertilisers is released directly as N_2O, with further N_2O emissions arising from volatilisation and subsequent deposition of NH_3 and NO_x from the application of fertilisers (IPCC, 1996). Emissions in 2010 have been forecast using as a basis:

- a recent forecast by the European Fertiliser Manufacturer's Association on changes in cropped area and application rates for nitrogen for major crops (EFMA, 1999);
- the forecast of livestock numbers described in the section on methane.

The projections were on a Member State level, allowing for differences in cropping and livestock.

The uncertainty surrounding the emissions factor is high (± 1 %, i.e. 0.25 to 2.25 % of the nitrogen in mineral fertilisers released), meaning that estimates of emissions have a relatively high level of uncertainty. As with the methane emissions, it is difficult to identify the effect of individual policies and measures using this approach.

4.2.8. Waste

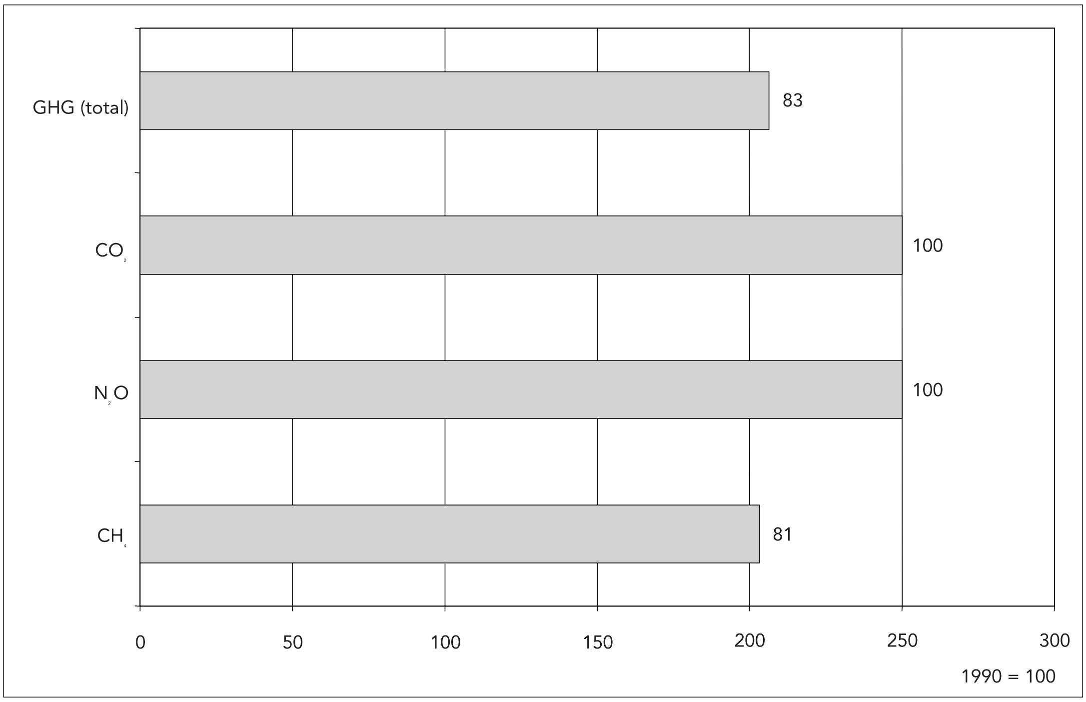
The EU-wide total GHG emissions for 2010 from the waste sector are projected to be 17 % lower than in 1990 due to the implementation of the landfill directive.

The largest emissions of methane from waste in the EU are from landfills. The EU-wide emission projections for the waste sector are based on a bottom-up approach in the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a).

The EU-wide total GHG emissions for 2010 are projected to be 17 % lower than in 1990 due to the implementation of the landfill directive (Figure 33).

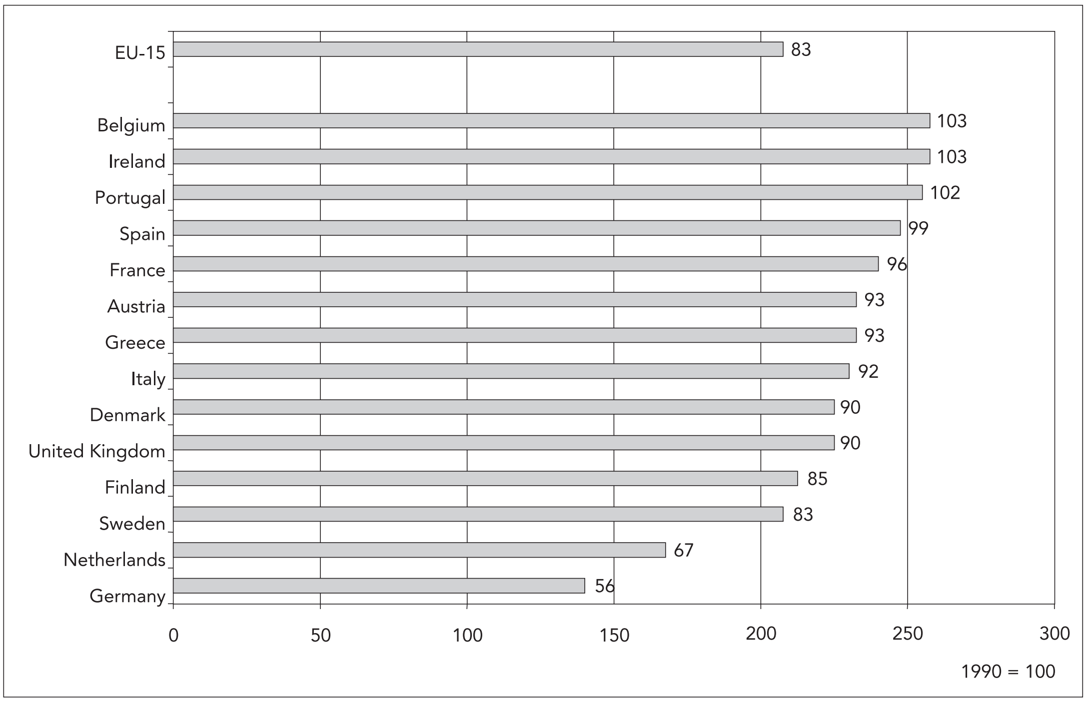
(19) *Prospects for agricultural markets 1999–2006*, European Commission, Agriculture DG.

EU-wide emission projections for relevant GHG emissions in 2010 for the waste sector Figure 33



Source: Ecofys, NTUA, AEAT (2001a).

EU-wide emission projection for total GHGs in 2010, with disaggregation for Member States, for the waste sector Figure 34



Source: Ecofys, NTUA, AEAT (2001a).

In Belgium, Ireland and Portugal, the emissions from waste (Figure 34) are projected to increase slightly in the baseline scenario (SOS) but to decrease in the longer term because of the implementation of the landfill directive. The other Member States are projected to have decreased emissions by 2010. The largest reductions in emissions are projected for Germany and the Netherlands, where there is early implementation of the provisions of the landfill directive.

In the study from which the projections are taken (Ecofys, NTUA, AEAT, 2001d), a 'no action' baseline was estimated against which to assess the impact of further measures. The projections presented above are this 'no action' baseline minus the calculated effect of the landfill directive. They therefore represent a 'with existing EU measures' projection. Measures taken at Member State level are not included.

The 'no action' baseline was calculated assuming that waste generation per capita, the proportion of waste disposed of to landfill and the landfill gas recovery rates remain constant. The landfill emissions were estimated using the time-dependent IPCC methodology (IPCC, 1996), and values for the per capita waste generation rate, fraction of MSW disposed to landfill and degradable organic content from the same reference unless new Member State specific data was available from the second national communication on climate change (as submitted to the UNFCCC). The percentage of methane recovered was derived from information in the second national communications, wherever possible. In all other cases, estimates were taken from the common policies and measures paper on landfill (CCPM, 1997).

The landfill directive requires that the proportion of biodegradable waste disposed to landfill is reduced and that landfill gas recovery rates are increased. The effect of the landfill directive was calculated by first reducing the amount of waste going to landfill, then increasing the landfill gas recovery rate. The projections are at a Member State level and therefore allow for the different rate of compliance required by the directive. In the projections, the alternative routes for treatment of the biodegradable waste have not been quantified, so any greenhouse gases from those routes have not been included. A study on greenhouse gas emissions from waste treatment is nearing completion ([20]).

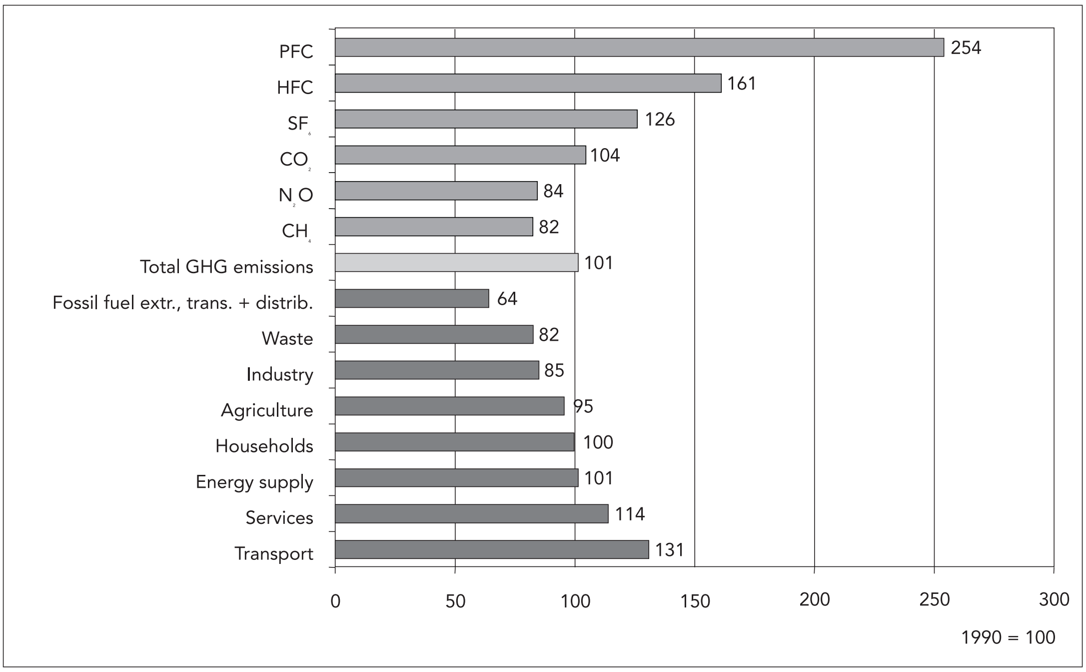
Estimates of landfill emissions generally have a fairly high level of uncertainty, mainly because of the difficulties in estimating emissions accurately from what is a complex emissions mechanism. In addition, accurate waste statistics can be difficult to collect especially when waste management is unregulated and an improvement in the collection of statistics often reveals that previous figures were underestimates.

4.2.9. Aggregate results

According to the projections of the SOS baseline scenario, total GHG emissions in the EU will be more than 380 Mt CO_2 eq. above the Kyoto target (1 % above 1990 level). Emissions are projected to grow most in the transport sector (231 Mt CO_2 eq.), which is only partly compensated by decreasing GHG emissions in industry (135 Mt CO_2 eq.) and other sectors.

Figure 35 **EU-wide (SOS) total emission projections by gas and by sector in the EU in 2010**

Source: Ecofys, NTUA, AEAT (2001a).



(20) K. Brown study.

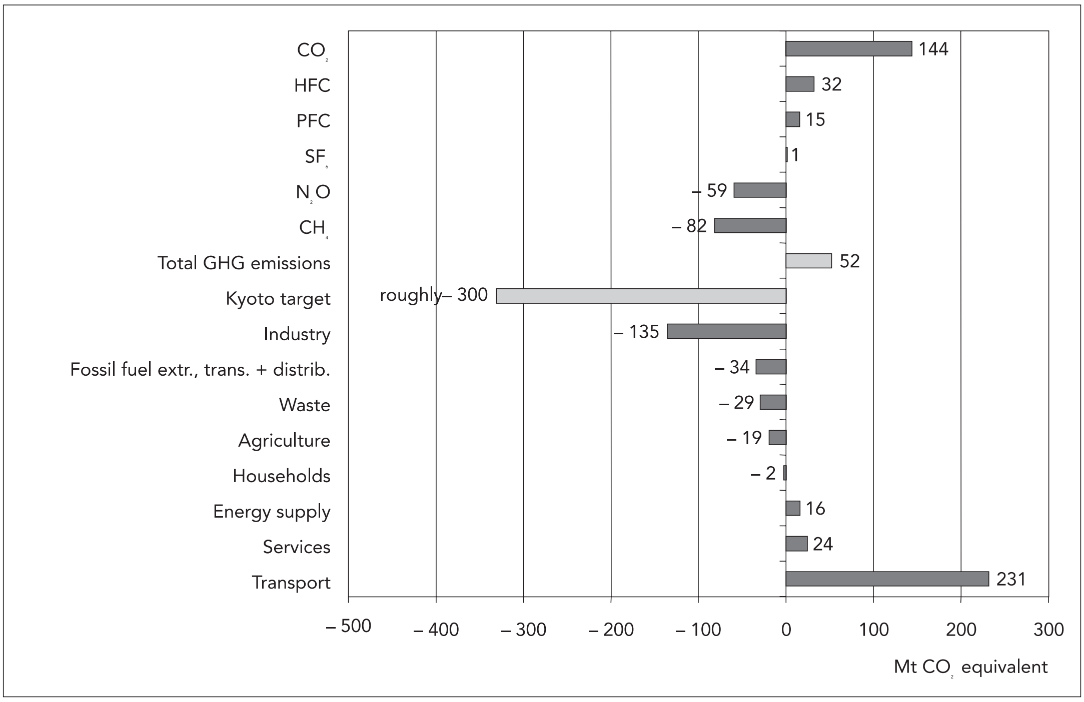
Finally, from the sectoral objective study (Ecofys, NTUA, AEAT, 2001a) the EU-wide emission projections for the individual gases and sectors are compared (Figure 35). Total GHG emissions in the EU are projected to grow by 1 % from 1990 to 2010 under baseline conditions (policies and measures existing at the end of the 1990s are taken into account but no additional PAMs). This 1 % total increase in GHG emissions is the result of projected decreasing CH_4 and N_2O emissions (18 and 16 %, respectively) and increasing CO_2 (4 %) and F-gases (e.g. PFC emissions more than doubling). It is worth noting that almost 80 % of total GHG emissions in 1990 derive from fuel related CO_2 emissions and, in contrast, F-gases account for less than 2 % of total GHG emissions. Emissions of CO_2 are projected to remain the most important share of total GHG emissions in 2010, despite their relatively small increase, which amounts to 4 %.

The individual sectors also develop differently. Emissions from transport will grow substantially, i.e. by more than 30 %. Apart from the transport sector, emissions will also grow significantly in the services sector. These increases are partly compensated for by emission reductions in other sectors (fossil fuel extraction 36 %, waste 18 %, industry 15 %).

Regarding the shares by sector of total GHG emissions in the EU in 1990, more than 30 % of total GHG emissions derive from the energy sector. The sector with the next largest share in emissions was industry. Following the EU-wide total GHG emission projections from the sectoral objective study (Ecofys, NTUA, AEAT, 2001a), this will change by 2010. The industry sector will be overtaken by the transport sector where the share of total GHG emissions will grow from 18 % in 1990 to more than 23 % in 2010.

Expressed in total amounts of CO_2 equivalents, the EU-wide total GHG emission projections for 2010 are expected to grow in the baseline scenario by 52 million tonnes of CO_2 equivalents (Mt CO_2 eq.) (Figure 36), which corresponds to the 1 % increase shown in Figure 35. In contrast, according to the Kyoto target, total GHG emissions have to be reduced in the EU by 8 % or roughly 340 Mt CO_2 eq. Under the assumed baseline conditions, this goal will not be achieved. Emissions of CO_2 are projected to grow — mainly due to increases in the transport sector — by more than 140 Mt CO_2 eq. This growth will be almost compensated for by substantial reductions of N_2O (59 Mt CO_2 eq.) and CH_4 emissions (82 Mt CO_2 eq.). Nevertheless, projected CO_2 emissions and

Contributions of the individual GHGs and sectors to the change of total GHG emissions for EU-15 in 2010, and the comparison with the EU Kyoto target Figure 36



Source: Ecofys, NTUA, AEAT (2001a).

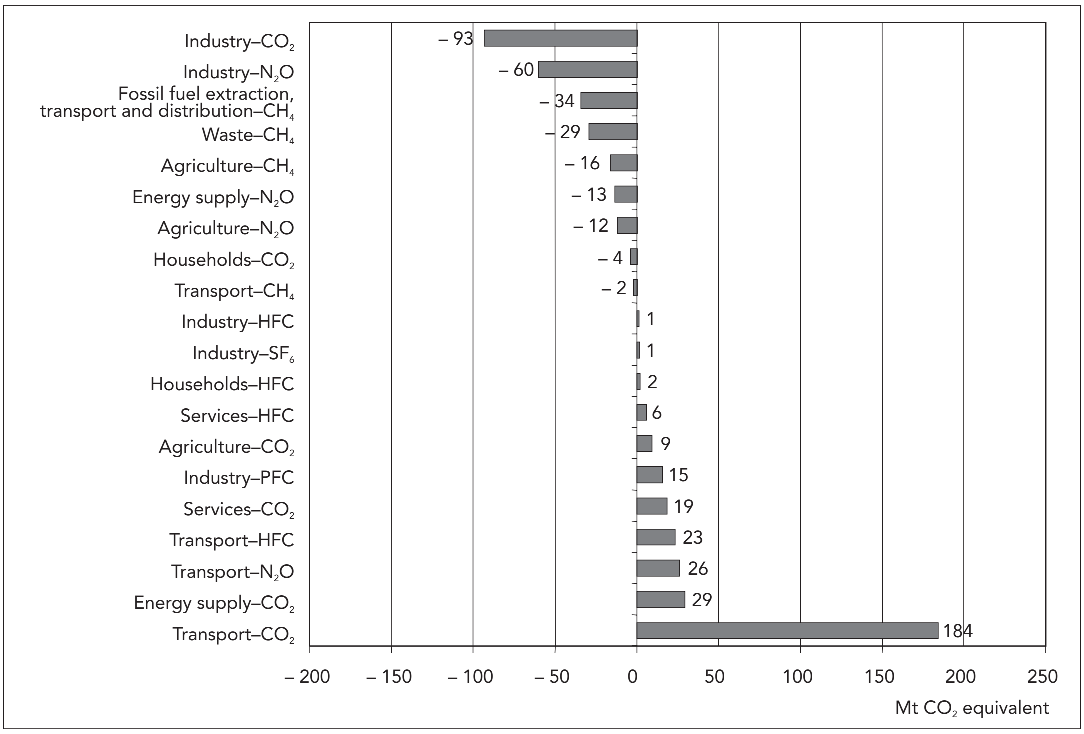
additional F-gases contribute to the increase of total GHG emissions in 2010 instead of the required decrease according to the Kyoto target.

Transport emissions are projected to grow by more than 230 Mt of CO_2 eq. Furthermore, EU-wide total GHG emission projections also show a growth for the services and for energy supply. The greatest GHG reductions can be achieved in industry (135 Mt CO_2 eq.). However, considerable contributions to the reduction of GHG emissions are also projected for fossil fuel extraction (34 Mt CO_2 eq.), waste (29 Mt CO_2 eq.) and agriculture (19 Mt CO_2 eq.).

With regard to applicable sector–gas combinations, the picture is as follows: growing CO_2 emissions in the transport sector account for almost 60 % of the entire emissions growth (Figure 37). However, N_2O and HFC emissions from the transport sector are also projected to grow, albeit to a much smaller extent.

Figure 37 **Contributions of individual sector–gas combinations to the change of total GHG emissions for EU-15 in 2010**

Source: Ecofys, NTUA, AEAT 2001a.



The highest contributions towards the reduction of EU GHG emissions come from reductions of CO_2 and N_2O emissions in industry. Considerable contributions can also be achieved through mitigation of methane emissions in waste as well as in fossil fuel extraction.

4.3. EU-wide greenhouse gas emissions projections from other studies

The objective of this section is to compare the EU-wide emission projections of the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) with other EU wide projections. Although none of the EU-wide emission projections meets the Kyoto target of the EU, large differences exist between them, with GHG emissions ranging from a 1 to 16 % increase in 2010 compared with 1990. The SOS is within this range of emission projections — but at the lower end of projected increases. Important explanations for different projections are different assumptions on carbon emission intensity (CO_2 emission per unit of primary energy supply), energy intensity (primary energy supply per unit of GDP) and emission factors for methane. Different assumptions on the effectiveness of policies and measures are also important explanations. Other factors can be differences in definitions (e.g. for sectors). Lack of information has made analysis and comparison difficult in several cases.

Several studies and model-based assessments have addressed the issue of the future development of European GHG emissions (e.g. for 2010). Differences between them exist, caused, among other factors, by the different tools used, different assumptions and because some of them try to assess development without additional climate policies (so-called baseline scenarios), while others try to assess the impact of new policies (mitigation scenarios or 'with additional measures scenario'). In addition, differences among baseline projections are caused by different assumptions about the inclusion of current policies (e.g. with respect to the landfill directive, this results in differences in CH_4 projections). The goal of our analysis was to compare the projections of the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) with other baseline scenarios. Such a comparison may be helpful, for example, to show the range of different projections and how the SOS fits into this. The comparison might also provide some insights on possible key factors explaining differences in results. These factors are possibly also relevant for the differences between the national and EU-wide emission projections. Because of the former objective, we first compare in this section the GHG emission projections produced in the SOS with 10 other projections. Next, we examine some of the key underlying forces in each of these projections, in order to have a better idea of the differences between them.

Table 8 shows the compilation of models and projection approaches considered in this assessment. A similarity between the projections is that they all describe a kind of reference case or baseline which does not contain additional policies to mitigate GHG emissions.

The basis for the comparison is the SOS, as used in the previous chapters. The other scenarios considered are those listed below (see Table 8).

- The EU shared analysis project, where a baseline (BL) scenario as well as three GHG reduction scenarios have been developed (S0, S3, S6). We only consider here the baseline (in the remaining text called EC-BL).

- Projections by the EEA ShAIR project (the shared baseline scenario for air pollution up to the year 2020 (EEA, 2001b) which has updated projections on air pollution and greenhouse gas emissions, based on the EU shared analysis project.

- The *World energy outlook*, which is carried out by the International Energy Agency. Here the projection from 1998 is considered assuming that no climate policies will be introduced (business as usual — BAU, called IEA).

- The results of the reference scenario in the International Energy Outlook provided by the Energy Information Administration (EIA).

- The world energy projections to 2030 based on the Poles model, which assesses GHG reductions, calculates marginal reduction costs and is prepared to consider emissions trading (called Poles).

- Four scenarios from the IMAGE implementation of the SRES scenarios (Special report on emissions scenarios) prepared for the Intergovernmental Panel on Climate Change (IPCC). Each represents a different philosophy about a future world (called SRES A1, B1, A2 and B2).

- The reference case scenario for Europe developed by the MIT, using the EPPA model (called MIT).

Table 8 **EU-wide GHG emission projections based on various EU-wide models**

Source: Compilation for this report by ETC/ACC.

Name	Year	Philosophy	Source
SOS	2001	Baseline (no policies for achieving the Kyoto target)	Ecofys, NTUA, AEAT (2001a): Economic evaluation of sectoral emission reduction objectives for climate change — Sectoral objectives study (SOS), Utrecht
EC-BL	1999	Baseline (no climate change policy)	European Commission (1999): European Union energy outlook to 2020, Brussels
IEA	1998	BAU, excludes policies adopted to meet the Kyoto targets	IEA (International Energy Agency) (1998): *World energy outlook*, Paris
EIA	2001	Reference scenario	EIA (Energy Information Administration) (2001): *International energy outlook*, Washington, DC
SRES A1 (1)	2001	Globalising world, rapid economic growth, strong economic development	IMAGE team (2001): *The IMAGE 2.2 implementation of the SRES scenarios*, RIVM CD-ROM publication, Bilthoven
SRES B1 (1)	2001	Globalising world, orientation on sustainable development, improving quality of life (considerable technology development)	IMAGE team (2001): *The IMAGE 2.2 implementation of the SRES scenarios*, RIVM CD-ROM publication, Bilthoven
SRES A2 (1)	2001	Strong regional orientation, emphasis on economic development (technology development in low-income regions slower)	IMAGE team (2001): *The IMAGE 2.2 implementation of the SRES scenarios*, RIVM CD-ROM publication, Bilthoven
SRES B2 (1)	2001	Oriented on regional development in combination with solving regional environmental and social problems	IMAGE team (2001): *The IMAGE 2.2 implementation of the SRES scenarios*, RIVM CD-ROM publication, Bilthoven
MIT	2001	Reference scenario without additional climate policies	Viguier, L., Habiker, M. H. and Reilly, J. M. (2001): 'Carbon emissions and the Kyoto commitment in the European Union', MIT joint programme on the science and policy of global change, report, 70, Cambridge, USA.
Poles	2001	Outlook on long-term energy systems — achieving GHG targets, calculation of marginal reduction cost and considering emissions trading	Criqui, P. and Kouvaritakis, N. (2000): 'World energy projections to 2030', *International Journal of Global Energy Issues*, Vol. 14 (1, 2, 3 and 4), pp. 116–136.
ShAIR	2001	Baseline scenario with no climate policies, based on SOS	EEA (2001): 'Air pollution outlooks — An evaluation. Integrated assessment methodologies and tools applied to air pollution and greenhouse gases', (draft), May 2001

(1) As prepared by the IMAGE 2.2 model.

In the comparison we have included several scenarios produced by the same model, i.e. four SRES baselines of the IMAGE group and several projections based on the Primes model. Among others, Primes has also been used for the SOS study (Table 9). By using different scenarios based on the same model we hope to get a better insight into the importance of different scenario assumptions (e.g. with respect to climate and energy policy being included). Comparing projections from different models may, on the other hand, show the importance of having different model assumptions.

Table 9 gives an overview of the characteristic features of each of these projections. It shows that direct comparison of the scenarios faces some obstacles, since they are not fully compatible with respect to spatial coverage and disaggregation. Some of them (e.g. MIT and SRES) cover the whole world disaggregated by several regions, in which Europe is one. Other projections only cover Europe, but consider the impacts of trends in the global economy and the global energy system on European developments (e.g. SOS). Further, some of the projections deal with the OECD Europe, whereas others cover the European Union. The SOS, the shared analysis project and the ShAIR project cover the European Union of 14 Member States (in most cases Luxembourg is excluded), whereas most of the other approaches cover OECD Europe, which includes, for example, Switzerland and Norway. As we compare mainly the relative changes between 1990 and 2010 and as the share of the countries that are part of OECD Europe but not part of EU is comparatively small, it seems to be justified to neglect differences in the regional coverage.

Furthermore, the projections also include different gases. All projections include (energy related) trends in CO_2 emissions, so that a full comparison is possible. Projections for non-CO_2 greenhouse gases (especially CH_4 and N_2O) and thus total GHG emissions are only given for 6 out of the 11 projections.

Description of models cited in this assessment Table 9

	SOS	EC-BL	EIA	IEA	SRES	MIT	Poles	ShAIR
Model used	PRIMES, GENESIS	PRIMES, GENESIS	WEPS	Various	IMAGE 2.2	EPPA	POLES	PRIMES, GENESIS
Type	ESM/BDB	ESM/BDB	SSM	SSM	IAM	CGE	ESM	ESM/BDB
Coverage								
World			X	X	X	X	X	
EU	X	X				X	X	X
OECD Europe			X	X	X		X	
Included GHGs								
CO_2	X	X	X	X	X	X	X	X
Other GHGs	X				X			X

NB: ESM = energy system model; BDB = bottom-up technology database; SSM = spreadsheet-based models; IAM = integrated assessment model; CGE = computable general equilibrium model.

Source: Compilation for this report by ETC/ACC.

4.3.1. Comparison of EU-wide greenhouse gas emission projections

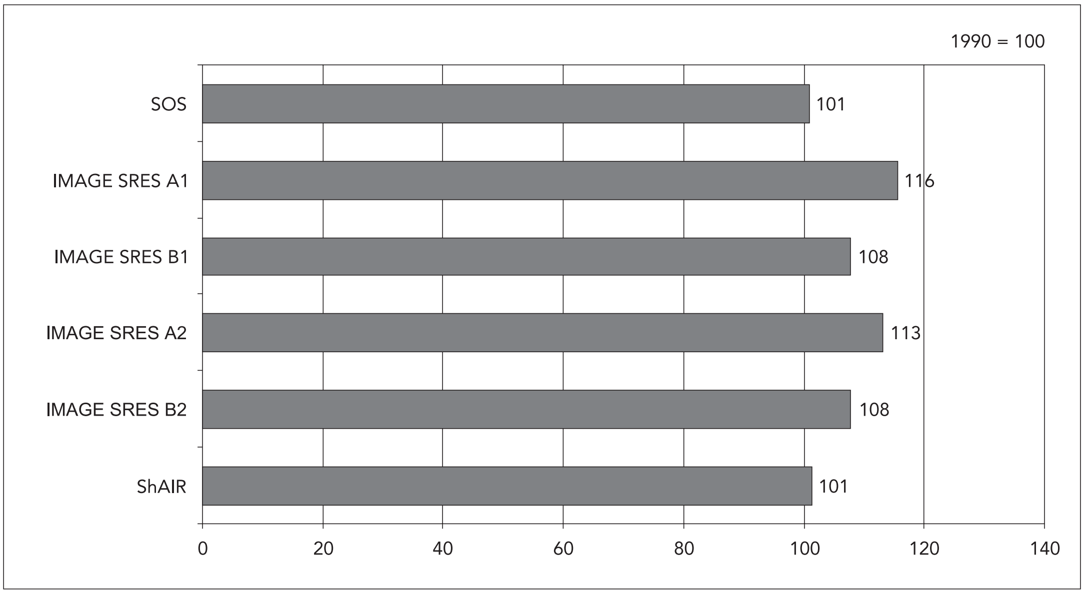
In this section we compare EU-wide projections for total GHG emissions for 1990 and 2010 (useful to evaluate the Kyoto target), followed by a comparison of EU-wide emission projections for energy related CO_2, CH_4 and N_2O.

4.3.1.1. Emission projections of total greenhouse gases

Only a limited number of the considered projections include all greenhouse gases (CO_2, CH_4, N_2O and fluorinated gases) necessary for computing the total GHG emissions, which is helpful in evaluating the trend towards the Kyoto target. These projections are based on applications of two different models. First, the SRES projections are based on the IMAGE 2.2 model, whereas the Primes model has been used within the SOS and ShAIR study.

The analysis shows that emission projections for 2010 differ considerably (Figure 38). Despite the differences, none of the projections meets the Kyoto target of the EU (8 % GHG reduction in 2010 compared with 1990). Thus additional climate policies are

EU-wide emission projections for total GHGs in 2010 Figure 38



Sources: IMAGE team (2001); Ecofys, NTUA, AEAT (2001a); EEA (2001).

necessary to achieve these targets. The emissions for 2010 in the SOS and ShAIR projection are comparable to 1990 emissions, whereas the SRES projections are 8 to 16 % above the 1990 level. The differences between the projections are mainly caused by higher emissions of CO_2 and CH_4 (see below).

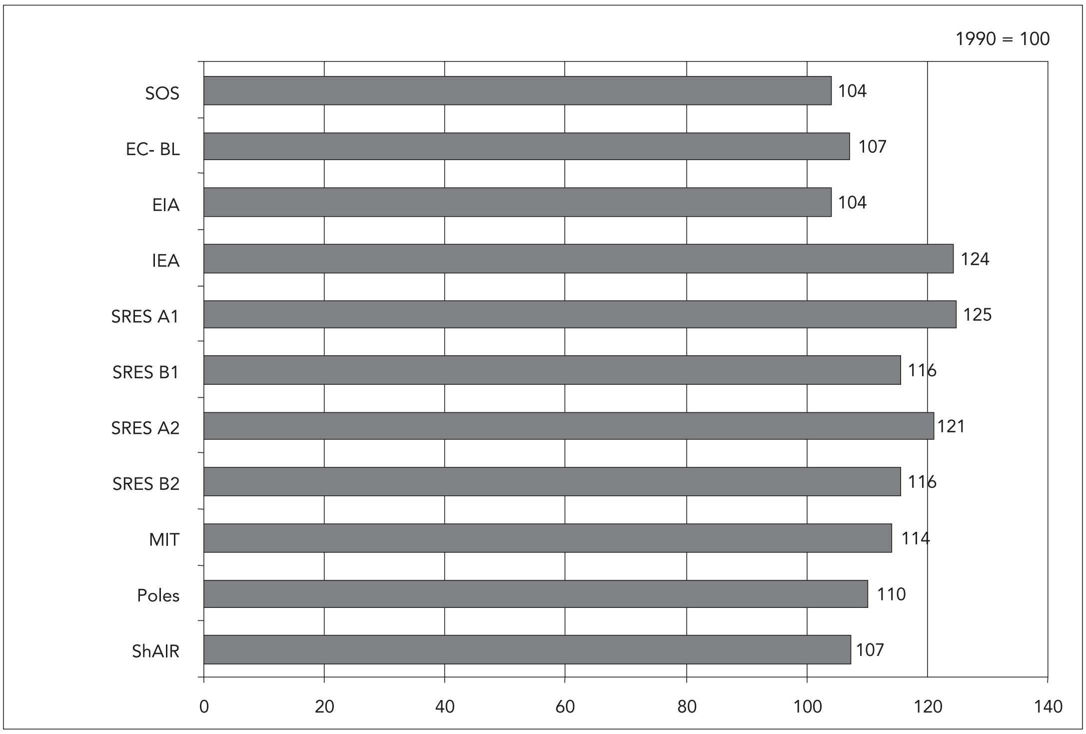
An evaluation of the contribution of the separate greenhouse gases to the total GHG emissions shows that, in the considered baseline projections, CO_2 will remain the most important GHGs, whereas the contribution of fluorinated gases is limited. The emissions of the non-CO_2 greenhouse gases CH_4 and N_2O are projected to stabilise or decrease, whereas CO_2 emissions will increase.

4.3.1.2. CO_2 emission projections from energy use

Figure 39 shows the various emission scenarios for carbon dioxide from energy use (carbon dioxide emissions are mainly caused by burning fossil fuels). All scenarios expect carbon dioxide emissions to increase, but the rate of change differs strongly. The SOS projection is at the lower end of the range, with an increase of 4 % between 1990 and 2010. The lowest alternative scenario, the reference scenario of the Energy Information Administration (EIA, 2001), indicates an emission increase that is nearly equal to the SOS (4 %). The IEA (1998) and SRES A1 (IMAGE team, 2001) scenarios show the highest increases of 24 and 25 % respectively. Further in this analysis, we will look at some of the different trends in the energy system that could be responsible for these differences.

Figure 39 **Various EU-wide emission projections for energy related CO_2 in 2010**

Sources: Ecofys, NTUA, AEAT (2001a); European Commission (1999); EIA (2001); IEA (1998); AEA Technology (2001); IMAGE team (2001); Viguier, L. et al. (2001), Criqui and Kouvaritakis (2000); EEA (2001).



4.3.1.3. Emission projections of non-CO_2 greenhouse gases

EU-wide emission projections for CH_4 and N_2O for various studies are presented in Table 10. The projections in the ShAIR study are based on earlier studies by Ecofys and AEA Technology (1999/2000). These studies were afterwards refined through more detailed analysis, which resulted in the sectoral objectives study (SOS). The changes in the SOS compared with ShAIR are as follows. For CH_4, the main update was to include measures to reduce emissions from landfills and, for N_2O, small adjustments to overcome differences in base year figures and new assumptions about driving forces were made. The emissions for the SRES projections are based on various calculations with the IMAGE 2 model.

Using the IPCC categories, the main sources of CH_4 in all projections are agriculture (which accounts currently for about 50 % of the EU methane emissions), landfills (around 25–30 %) and fugitive emissions from fossil fuel production and distribution (around 15–20 %).

Considerable differences between the projections have been found for CH_4. The SRES projections show a clear increase, while the SOS and ShAIR projections show a considerable emission reduction of CH_4 by 2010 (Table 10). One important reason for the differences is the inclusion of current policy measures in the SOS and ShAIR projections. For example, measures are assumed to have been implemented (partly) to control emissions from landfills (e.g. landfill directive), leakage from gas distribution systems and emissions in coal mining in SOS and ShAIR. The absence of such policies in the SRES projections leads to the projected increase of CH_4 emissions. The differences are also caused by differences in underlying factors of the activities that contribute to the CH_4 emissions. For agriculture, for example, differences in livestock numbers and emission factors might contribute to the overall differences in CH_4 emissions (see next section).

The projections for N_2O emissions are more comparable, all indicating a decrease by 2010. The smallest decrease is found in the SRES A2 projection, in which economic interests are combined with, among others, limited global interest and a large population increase (see next section).

Comparison of EU-wide total CH_4 and N_2O emission projections Table 10

	% change 1990/95–2010	
	CH_4	N_2O
SOS	– 18	– 16
ShAIR	– 26	– 14
SRES A1	+2	– 15
SRES B1	– 2	– 18
SRES A2	+ 5 (– 4)	– 7
SRES B2	+ 5 (– 7)	– 11

Sources: IMAGE team (2001); Ecofys, NTUA, AEAT (2001a); EEA (2001).

4.3.2. Analysing underlying factors in SOS and other EU-wide projections

In the previous section, substantial differences in the emission projections of the various greenhouse gases have been identified. As to which main factors can be identified as causing these differences, first, we will look at two main driving forces, namely the projections for population and gross domestic product (GDP).

Population and GDP changes in 2010, compared with 1990 Table 11

	Population	GDP	
	% change (1990=100)	% change (1990=100)	Annual change (%)
SOS	105	155	2.2
EC 1999-BL	105	147	1.9
EIA 2001	103	149	2.0
IEA 1998	103	146	1.9
SRES A1	108	147	1.9
SRES B1	108	147	2.0
SRES A2	109	135	1.5
SRES B2	106	141	1.7
MIT 2001	102	158	2.3
Poles 2001	108	140	1.7
ShAIR	105	144	1.9

Sources: IMAGE team (2001); Criqui and Kouvaritakis (2000); EIA (2001); IEA (1998); European Commission (1999); Ecofys, NTUA, AEAT (2001a); AEA Technology (2001); Viguier, L. et al. (2001); EEA (2001).

The development of population and GDP growth are shown in Table 11. The population projections differ only marginally (2 to 9 % population increase by 2010), even taking into account the relatively high population growth in some of the SRES scenarios that assume a high immigration rate. A larger deviation is found in the projections for GDP growth (21). All scenarios expect GDP to grow, with average growth rates over a 20-year period varying between 1.5 and 2.3 % per year. (In the course of the 1990s, growth rates in Europe have been around 1.6 % per year.) The question is whether these differences in driving forces can explain the differences for CO_2 emissions (Figure 39). Differences in population assumptions are relatively small and thus are not a very important factor in the explanation of the differences in emission projections. Although the differences in GDP growth rates are considerable, they cannot explain all the differences in emission projections. In fact, there is no direct correlation between the GDP and emission growth rate (e.g. the EC 1999-BL and SRES A1 show similar growth rates for GDP, while the emission growth rates differ strongly).

The main trends in the energy system can be characterised by two indicators (key factors), the energy intensity (i.e. the ratio of the primary energy supply per unit of GDP) and the carbon intensity (i.e. the ratio of CO_2 emissions per unit of primary energy supply) (Table 12).

Table 12 **Changes in the energy system in 2010, compared with 1990**

Sources: IMAGE team (2001), Criqui and Kouvaritakis (2000); EIA (2001); IEA (1998), European Commission (1999); Ecofys, NTUA, AEAT (2001a); AEA Technology (2001), Viguier, L. et al. (2001), EEA (2001).

	Energy intensity (Primary energy supply per unit GDP)	**Carbon intensity (CO_2 emission per unit primary energy supply)**
	1990 = 100	1990 = 100
SOS 2001	78	82
EC 1999	76	91
EIA 2001	81	84
IEA 1998	86	96
SRES A1	85	93
SRES B1	79	93
SRES A2	88	93
SRES B2	85	92
MIT 2001	76	93
Poles 2001	79	93
ShAIR 2001	83	83

The energy intensity improves continuously in most scenarios, with rates varying between 0.7 % and 1.3 % decrease per year. This is comparable to historic trends in energy intensity. The differences of the energy intensity trends between the scenarios are relatively large. The scenario with the slowest improvement is the *World energy outlook 1998*. The fastest improvement occurs in the MIT scenario and the shared analysis study. The energy intensity improvement rate in the SOS projection is within the range of the other projections, but at the optimistic end.

The second indicator (ratio) is the carbon intensity. In all projections, the carbon intensity has improved (decreased), caused by a lower market share of carbon intensive fuels, either due to the use of more natural gas instead of oil or coal or due to a larger share of non-fossil based energy sources. This is also called 'decarbonisation'. Many of the scenarios included in this comparison have relatively high decarbonisation rates. These high decarbonisation rates are largely a result of the declining use of coal in the UK and Germany since 1990. The decarbonisation rates are highest in the sectoral objectives study, the ShAIR baseline and the Energy Information Administration's *International energy outlook* projections (EIA, 2001). In the other baseline scenarios, decarbonisation rates are more modest (Van Vuuren et al., 2001).

It is also possible to trace back the trends in carbon intensity to the underlying energy mix. An important factor, for instance, includes the different assumptions for coal use in the next decade. Almost all scenarios

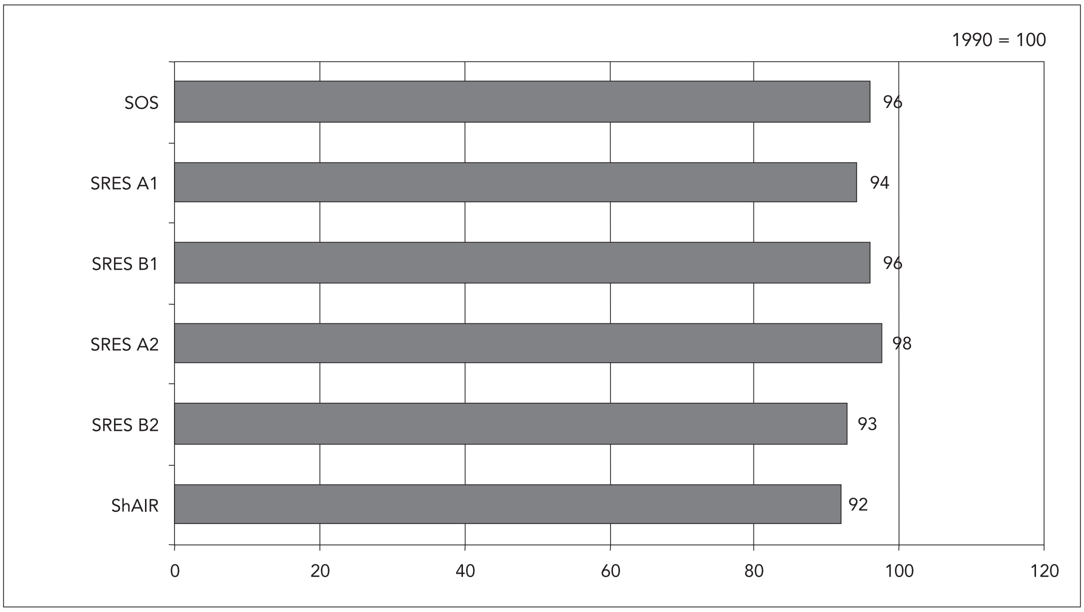
(21) For projections which are based on integrated energy-economy models, GDP growth is not an input parameter but a simultaneously calculated result of the model which considers the impact of restrictions and system boundaries as well as different policies and measures on the economy.

expect a continuation of the current decline in coal consumption, with the *World energy outlook* (IEA, 1998) being the only exception, with a relatively low decarbonisation rate. The EIA projection, on the other hand, assumes the fastest rate in further decline in coal consumption (about a 25 % decline in coal consumption between 2000 and 2010), which causes a relatively high decarbonisation rate. Non-fossil fuels such as nuclear and solar/wind could also strongly influence decarbonisation rates. However, the shares of solar and wind energy are still relatively low (although rapidly increasing in all scenarios) and, as regards nuclear power, all scenarios appear to agree on a stabilisation at 2000 levels until 2010.

Regarding carbon dioxide emissions from energy use, it can be concluded that differences in energy intensity and the decarbonisation rate and, to a lesser extent, economic growth all appear to play an important role in causing differences among the scenarios. It appears that baseline scenarios that assume relatively high (or low) energy intensity improvement also assume relatively high (or low) decarbonisation rates.

Finally, we analysed one variable that possibly contributes to the considerable differences in CH_4 emission projections. The variable was the projection for livestock numbers, using the number of cows as an example. The special attention paid to livestock numbers is given by the fact that livestock is the most important source of CH_4. This indicator is used in the SOS projections, the four SRES projections and the ShAIR analysis. Figure 40 depicts the differences between the projections with respect to livestock. All projections show a decrease in the number of cows in Europe by 2010. However, the differences are relatively small. The smallest decrease can be seen in the SRES A2 projection (2 %) and the largest in the ShAIR analysis (8 %). The differences in changing livestock numbers cannot explain the large differences in CH_4 emissions. Therefore other factors, such as differences in emission factors (e.g. defined as the emission per unit of feed) and in particular the inclusion of policies to reduce emissions per animal, are more likely causes to account for the differences in CH_4 emissions.

Change in livestock numbers between 1990 and 2010 (in number of cows) Figure 40



Source: IMAGE team (2001); Ecofys, NTUA, AEAT (2001a), EEA (2001).

4.3.3 Summary and conclusions of the comparison of EU-wide projections

The following conclusions can be drawn from the above analysis.

- Large differences between the EU-wide projections exist, with increases of EU total GHG emissions ranging from 1 to 16 % in 2010 compared with 1990. None of the baseline projections meet the Kyoto target of the EU.

- The different scenarios and underlying assumptions provide different backgrounds against which climate change mitigation policies can be evaluated.

- The sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) is within the range of emissions scenarios of other studies — but at the lower end of projected increases.

- Important factors that determine the differences between the projections are the differences in carbon emission intensity (CO_2 emission per unit of primary energy supply) and energy intensity (primary energy supply per unit of GDP) and the emission factors for methane. Although economic growth (GDP) rates differ considerably between the projections, no direct correlation has been found between GDP growth rates and emission projections.

- In addition, differences in the degree of policy action also contribute to the differences between the projections/ scenarios. This includes policies that are not explicitly oriented towards climate change, such as, for instance, energy and agricultural policies.

- Some differences between the projections can also be caused by the use of different definitions (for example for sectors) and different coverage of countries (since some projections that were considered cover more countries than the EU).

- Lack of information on several of the emission projections/scenarios considered (e.g. socioeconomic background and certain policy measures) made analysis and comparison difficult.

5. Comparison of EU-aggregated national emission projections with EU-wide emission projections

5.1. Results of comparisons and key differences

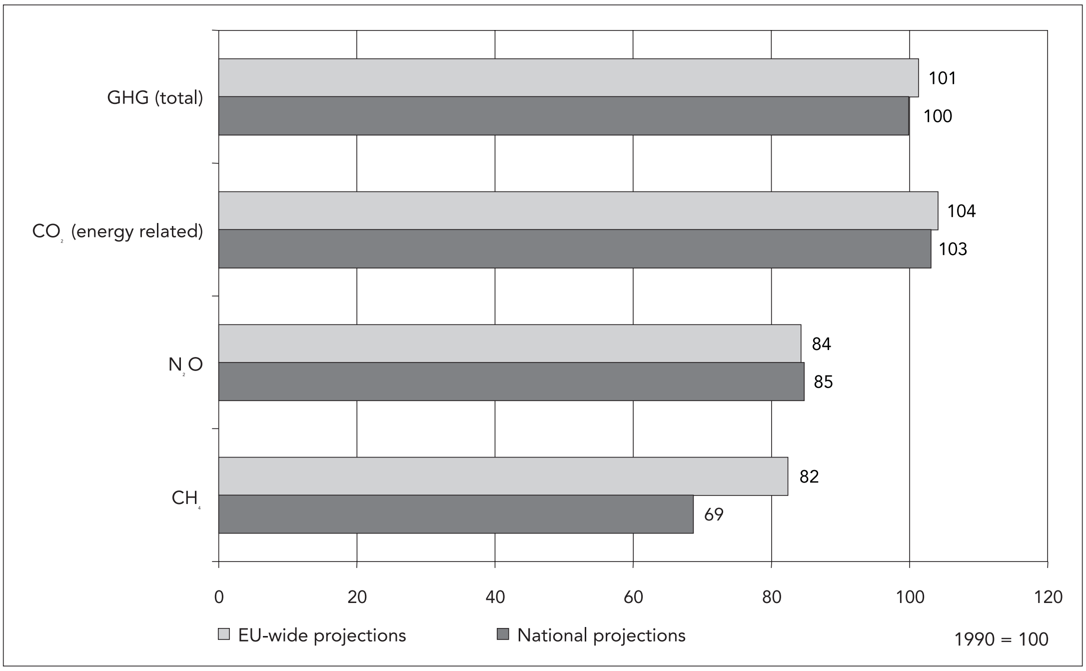
Both approaches for emission projections for the EU — EU-aggregated emission projections produced by aggregating national projections provided by Member States and EU-wide emission projections from the SOS — show similar results for all greenhouse gas emissions by 2010, except for methane. However, the comparison by sectors and by Member States shows substantial differences in some cases. Lack of information has made analysis and comparison difficult in several cases.

National emission projections provided by Member States and EU-wide emission projections from the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) are only partially comparable. Due to different disaggregation with respect to the greenhouse gases and sectors in the national emission projections, it is not possible to compare the results for all greenhouse gases and for all sectors. In particular the F-gases have not been assessed separately in all national emission projections. In addition, the disaggregation of industry, services and households is not homogeneous in all national emission projections. Thus, these sectors and also the sources emitting F-gases cannot be compared with the EU-wide emission projections of the SOS.

On an aggregated level both approaches show quite similar results although differences can be identified with regard to individual sectors or gases (Figure 41). In 2010, total GHG emission projections will be more or less on the same level as emissions in 1990. The emission projections for energy related CO_2 and N_2O emissions differ only by 1 %. Only the projection for methane (CH_4) shows substantial differences. According to the SOS, EU-wide CH_4 emissions are projected to decrease by 18 %, whereas the aggregation of the national emission projections results in a reduction of CH_4 emissions by more than 30 %.

Comparison, by gases, of EU-aggregated national emission projections and the EU-wide emission projection for EU-15 in 2010

Figure 41

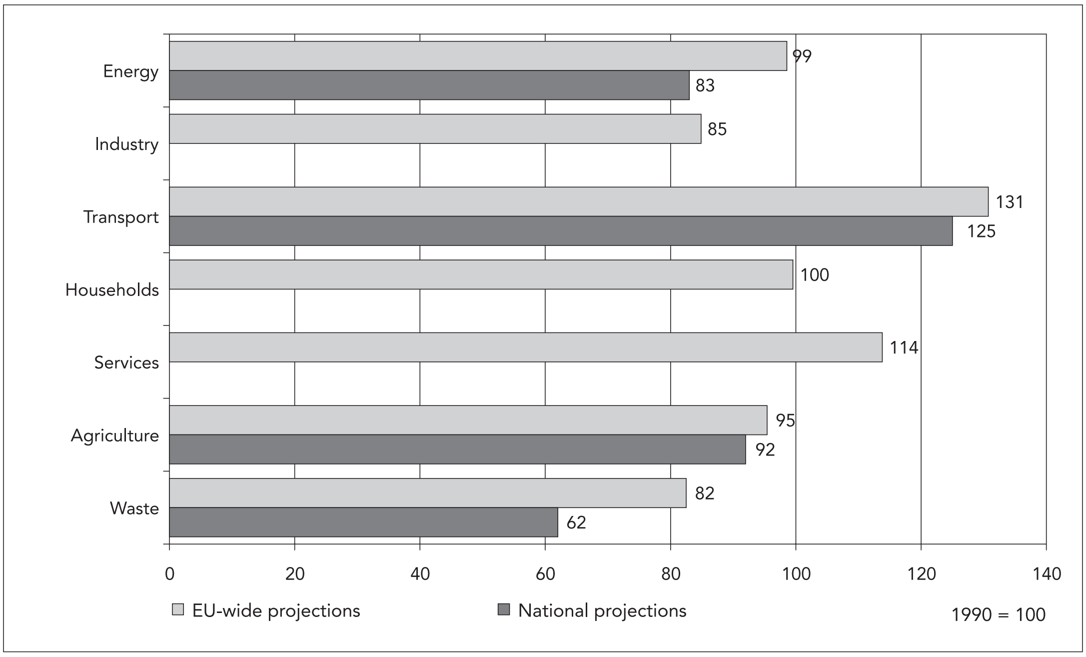


Sources: EU-wide projections: Ecofys, NTUA, AEAT (2001a); national projections: AEA Technology (2001).

Figure 42

Comparison, by sectors, of EU-wide national emission projections and the EU-wide emission projection for total GHGs for EU-15 in 2010

Sources: EU-wide projections: Ecofys, NTUA, AEAT (2001a); national projections: AEA Technology (2001).



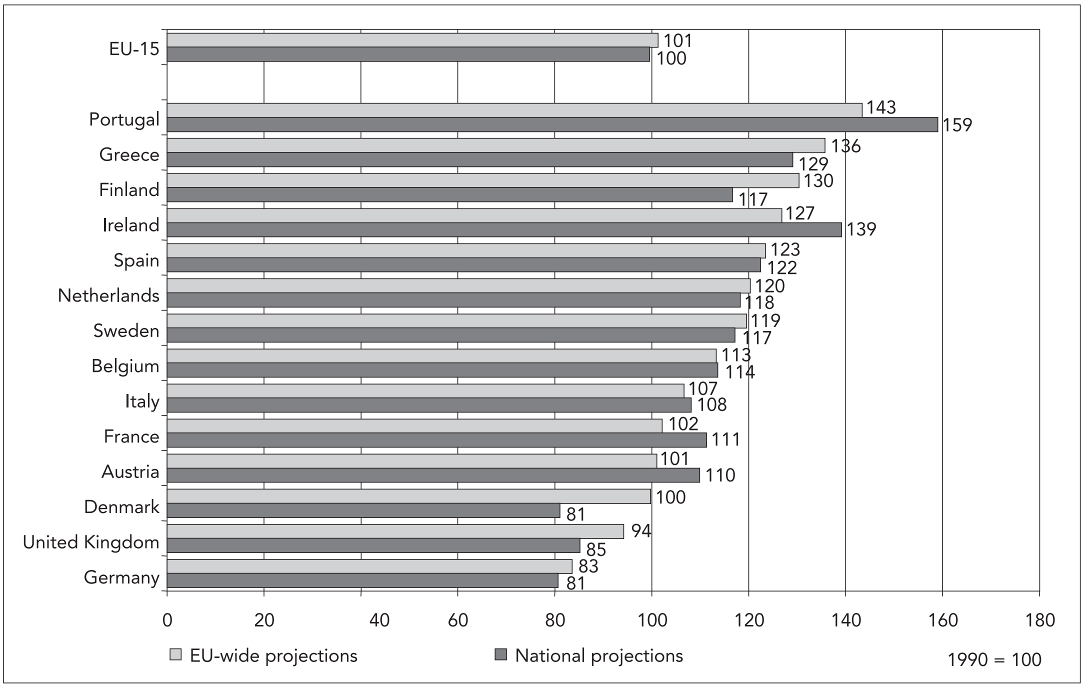
However, on the sectoral level the comparison of emission projections shows a rather different picture. The results of the national emission projections in the sectors that can be compared are systematically lower than in the SOS (Figure 42). The difference is relatively small for agriculture (3 %) and the transport sector (6 %).

Both approaches differ remarkably in their projections for waste (20 %) and the energy sector (16 %) ([22]).

Figure 43

Comparison of national emission projections and the EU-wide emission projection, disaggregated for Member States, for total GHGs in 2010

Sources: EU-wide projections: Ecofys, NTUA, AEAT (2001a); national projections: AEA Technology (2001).



(22) The energy sector in this report includes 'energy industries' (1A1) and 'fugitive emissions from fuels' (1B), as defined under the UNFCCC.

Considering the rather similar projection for total GHG emissions, this can only be explained by substantially higher national emission projections for the remaining sectors, services, households and industry, which however cannot be compared here due to inadequate sectoral disaggregation, mainly in the national projections.

Figure 43 shows a comparison at the Member State level of the national emission projections and the disaggregated EU-wide emission projections. Although the trend for the EU as a whole is similar for the two approaches, there are marked differences for some Member States. This relates in part to differences in assumptions in the projections, for example regarding the factors mentioned in Chapter 4, such as carbon emission intensity and energy intensity, but mainly to the policies and measures included in the analysis. The sectoral objectives study concentrated on EU-wide policies and measures and did not include specific policies and measures in Member States. For example, in the UK the national emission projection includes the effect of policies and measures introduced after Kyoto and thus this emission projection is lower than the emission projection for the UK from the SOS. In Austria, France, Ireland and Portugal, the national emission projections are for higher emissions in 2010 than the disaggregated EU-wide emission projections from the SOS. This relates to assumptions about sector growth as well as assumptions about the effectiveness of EU policies.

5.2. Comparison of sectoral projections

In the subsequent sections, the results of the national emission projections are compared with the EU-wide emission projections resulting from the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) on a sectoral level. However, due to different disaggregation of the national emission projections in industry, services and households, these sectors could not be included in this comparison.

5.2.1. Energy sector

The EU-aggregated national emission projection for total GHG emissions from the energy sector (23) **is 16 % lower than the EU-wide emission projection from the sectoral objectives study. This can probably be partly explained by the more detailed analysis of domestic policies and measures in the national projections, whereas the sectoral objectives study focuses mainly on EU-wide policies and measures. However, due to lack of information it was difficult to provide clear conclusions. Other possible explanatory factors should be explored further.**

The EU-aggregated national emission projection for the energy sector, for those countries that provided information, is 16 % lower than the EU-wide emission projection of the SOS. However, for some Member States the projections differ even more. For Denmark and Sweden, the national emission projections are about 40 or 80 % lower, respectively, than disaggregated EU-wide emission projections of the SOS.

The national emission projections for the United Kingdom (31 %), Austria (21 %) and Ireland (13 %) are, in contrast, much higher than the disaggregated EU-wide emission projections of the SOS. The national emission projections for GHG emissions of the energy sector are more or less in line with the disaggregated EU-wide emission projections of the sectoral objectives study only in France and Germany.

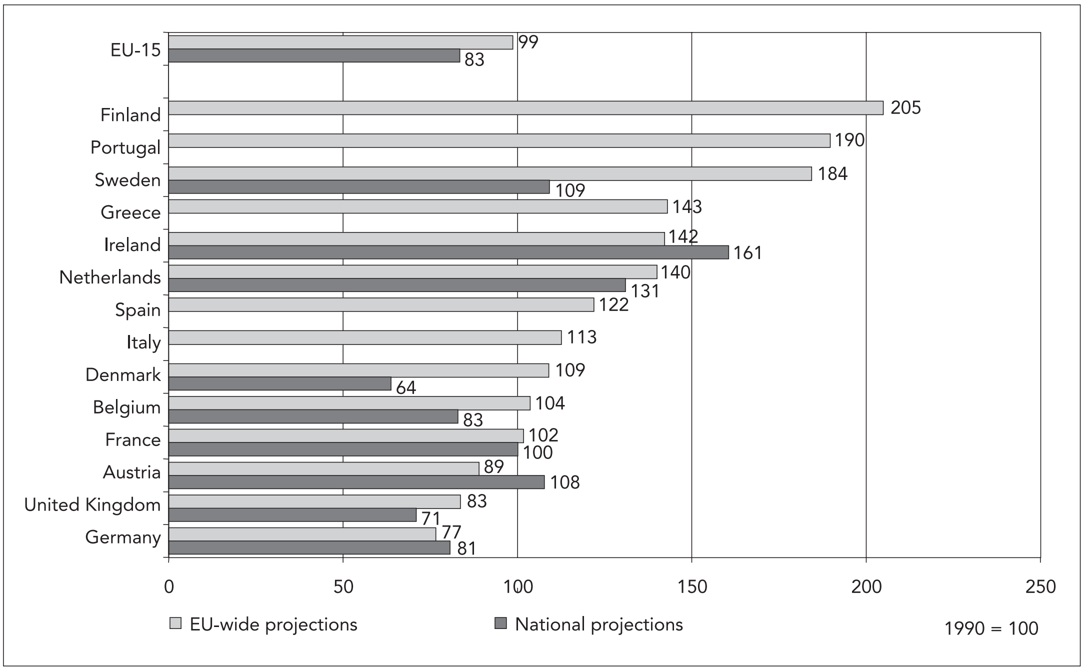
In the SOS baseline scenario, emissions from electricity and steam generation — which cause the main share of greenhouse gas emissions in the energy sector — are projected with consideration to the existing developments at the end of the 1990s in the three policy categories ‘renewable energy’, ‘nuclear energy’ and ‘changes in fuel mix and cogeneration’. The trends, shares and energy supply structures assumed there as driving forces for GHG emissions should be compared with the assumptions used in the national emission projections to identify possible key factors explaining differences in projections.

(23) The energy sector in this report includes ‘energy industries’ (1A1) and ‘fugitive emissions from fuels’ (1B), as defined under the UNFCCC.

Figure 44

Comparison of national emission projections and the EU-wide emission projection, disaggregated for Member States, for total GHGs in 2010 for the energy sector

Sources: EU-wide projections: Ecofys, NTUA, AEAT (2001a), national projections: AEA Technology (2001).



However, due to the lack of figures on the structure of energy supply for electricity and steam generation from the national emission projections, it is almost impossible to detect any key factor for the differences between EU-aggregated national and EU-wide emission projections clearly. On a general level it can be assumed that national emission projections consider domestic policies and measures, such as promotion schemes for renewables, nuclear phase out, increased energy standards for buildings or CHP promotion, etc. (see Table 2), in more detail than EU-wide projections. This is most likely one of the main reasons for differences between national and EU-wide projections in the energy sector. However other possible explanatory factors should be explored further.

5.2.2. Transport

The EU-aggregated emission projection for the transport sector and EU-wide emission projection from the sectoral objectives study are reasonably comparable. However, projections for individual countries differ substantially between both approaches, mainly due to the fact that EU-wide projections focus mainly on EU-wide measures, such as the ACEA agreement with the car industry to reduce CO_2 emissions from new passenger cars, whereas the national projections considers domestic policies and measures such as taxes and speed limits in more detail.

The EU-aggregated national emission projection for the transport sector, for those countries that provided information, is fairly similar to the EU-wide emission projection of the SOS (a difference of less than 5 %). Differences in the results of the national emission projections and disaggregated EU-wide emission projections of the sectoral objectives study on the Member State level are much larger (Figure 45). Projections for the Netherlands, Italy, Sweden and Finland are between 26 and 9 % below the disaggregated EU-wide emission projections of the sectoral objectives study for these countries.

National emission projections for Ireland, Austria, Denmark and France are substantially higher than the projection of the sectoral objectives study for those countries (between 65 and 8 %). Only the national emission projections of the United Kingdom and Germany are more or less comparable to the sectoral objective study projection for the transport sector for those countries.

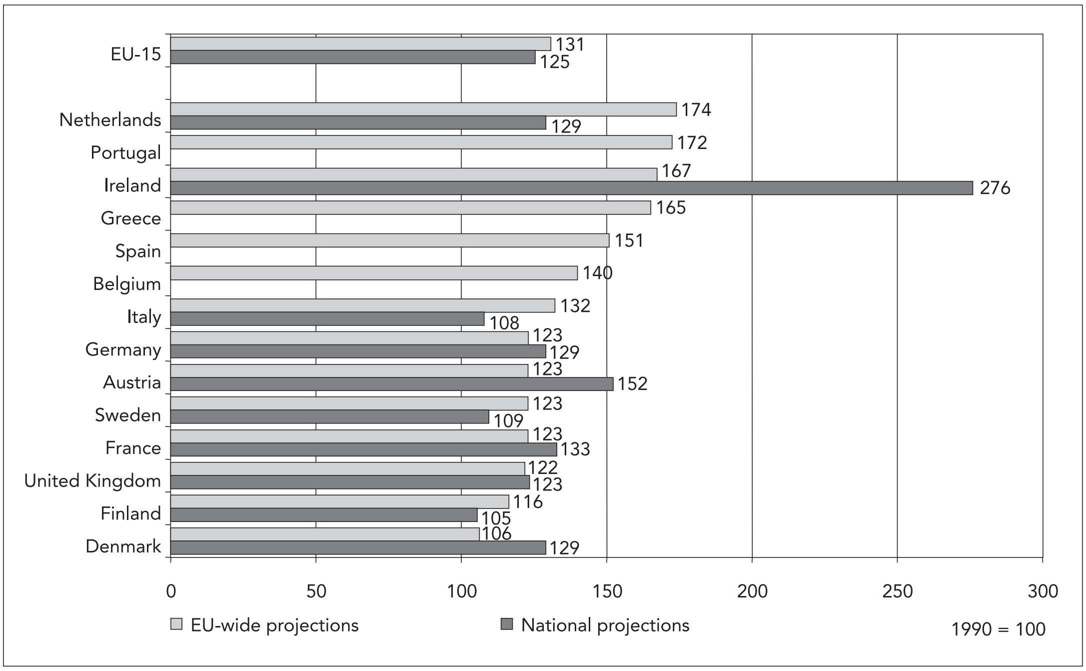
The projections from the sectoral objectives study are based on assumptions given below.

- Increased mobility growth rates up to 2010 will be comparable to the period between 1990 and 1995.

- A shift in the modal split from cars to trains and aviation.

Comparison of national emission projections and the EU-wide emission projection, disaggregated for Member States, for total GHGs in 2010 for the transport sector

Figure 45



Sources: EU-wide projections: Ecofys, NTUA, AEAT (2001a); national projections: AEA Technology (2001).

- Substantial improved fuel efficiency for trains and aeroplanes, although aviation remains the less fuel-efficient mode of transport — about three times the average for passenger transport.

As regards fuel efficiency for cars, the voluntary so-called ACEA agreement with European (ACEA), Japanese (JAMA) and Korean (KAMA) car manufacturers to reduce CO_2 emissions from new passenger cars has been reflected in the baseline assumptions for the sectoral objectives study. According to this agreement, the fuel efficiency of the car fleet should increase from the current 186 g CO_2 emissions per kilometre to 130 g CO_2 emissions per kilometre in 2010 (European Commission, 2001c). This is equivalent to an improvement of 3.6 % per year or 30 % between 2000 and 2010 (Capros et al., 2001, pp. 43 ff).

National emission projections, in contrast, do not explicitly consider the ACEA agreement, although it can be assumed that it has been taken into account implicitly in most Member States. These projections focus more on national policies and measures such as taxes (car, carbon, fuel, mineral oil etc.), speed limits or infrastructure improvements (see Table 5). On the other hand, the national policies and measures mentioned above do not seem to be included explicitly in the SOS baseline scenario.

Thus, the most likely major reason for differences in the emission projections of the transport sector is that national emission projections consider more precisely national policies and measures while the EU-wide projections focus on EU-wide policies and measures, such as the ACEA agreement with the car industry to reduce CO_2 emissions from new passenger cars.

5.2.3. Agriculture

The EU-aggregated emission projection for the agricultural sector and EU-wide emission projection from the sectoral objectives study are similar. However, most likely due to different country-specific assumptions of driving factors, such as livestock numbers, projections for some Member States differ substantially between both approaches.

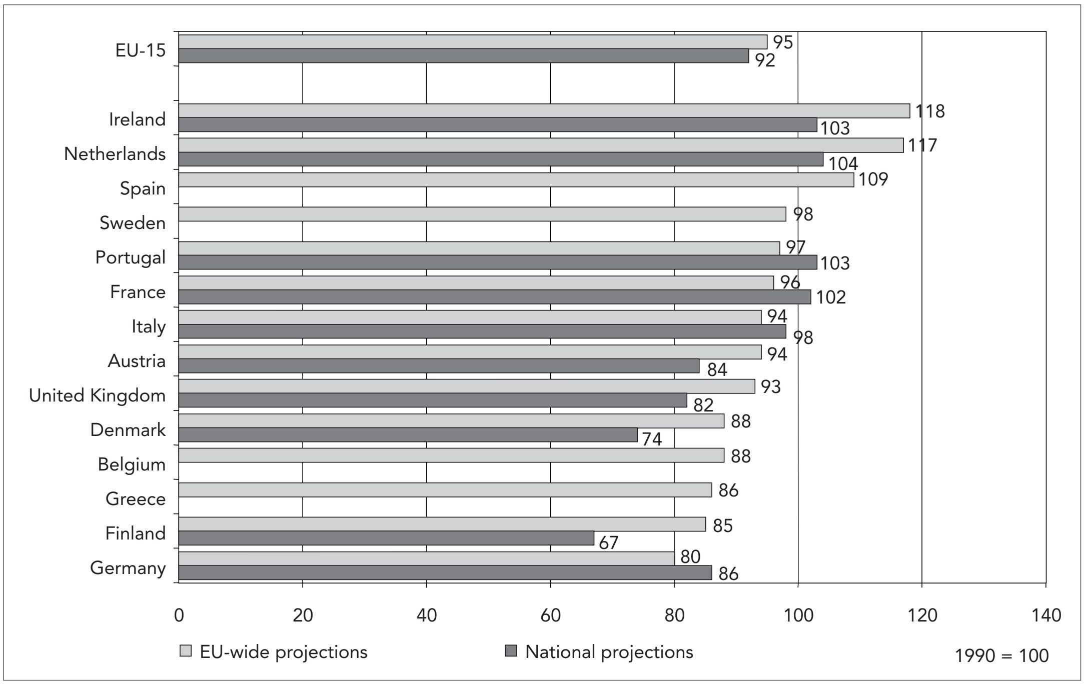
Figure 46 shows a comparison of the national emission projections, for those countries that provided information, and the EU-wide emission projections of the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) for the agricultural sector. The overall trends for the EU are similar for both projections.

For most Member States, the disaggregated EU-wide emission projections indicate smaller decreases or larger increases, i.e. the effect of measures is smaller. This can be expected, as the SOS includes EU-wide measures but does not include all the policies and measures in individual Member States.

The exceptions are France, Germany, Italy and Portugal, where the disaggregated EU-wide emission projections of the SOS appear to show, in contrast, a greater effect of measures. In the case of Germany, the larger emission reduction is likely to be due to more optimistic assumptions about reducing the nitrogen surplus and a larger assumed reduction in livestock numbers, although this cannot be confirmed as no details of this underlying information are given in the German national emission projections. In the case of France, agricultural emissions were relatively stable from 1990 to 1997 and it is assumed that this trend will continue; whereas, in the SOS, changes in livestock numbers and fertiliser use are assumed. The Italian national emission projections assume that fertiliser use will still be at 1990 levels by 2010 (rather than lower as in the SOS) and that there will be greater numbers of some livestock. (Livestock projections are based on data used by IIASA in the RAINS model.) No details of the agricultural trends assumed by Portugal are available, so a reason for the divergence in the projection cannot be established.

Figure 46 **Comparison of national emission projections and the EU-wide emission projection, disaggregated for Member States, for total GHGs in 2010 for the agricultural sector**

Sources: EU-wide projections: Ecofys, NTUA, AEAT (2001a); national projections: AEA Technology (2001).



5.2.4. Waste

The EU-aggregated national emission projection for total GHG emissions from the waste sector is 21 % lower than the EU-wide emission projection from the sectoral objectives study. For most countries, national emission projections show larger decreases of emissions than in the EU-wide emission projections disaggregated for Member States. This can be explained by a larger effect of the landfill directive, assumed by Member States. Larger increases shown in national emission projections for some Member States appear to be due to assumed increase of per capita waste generation and waste incineration.

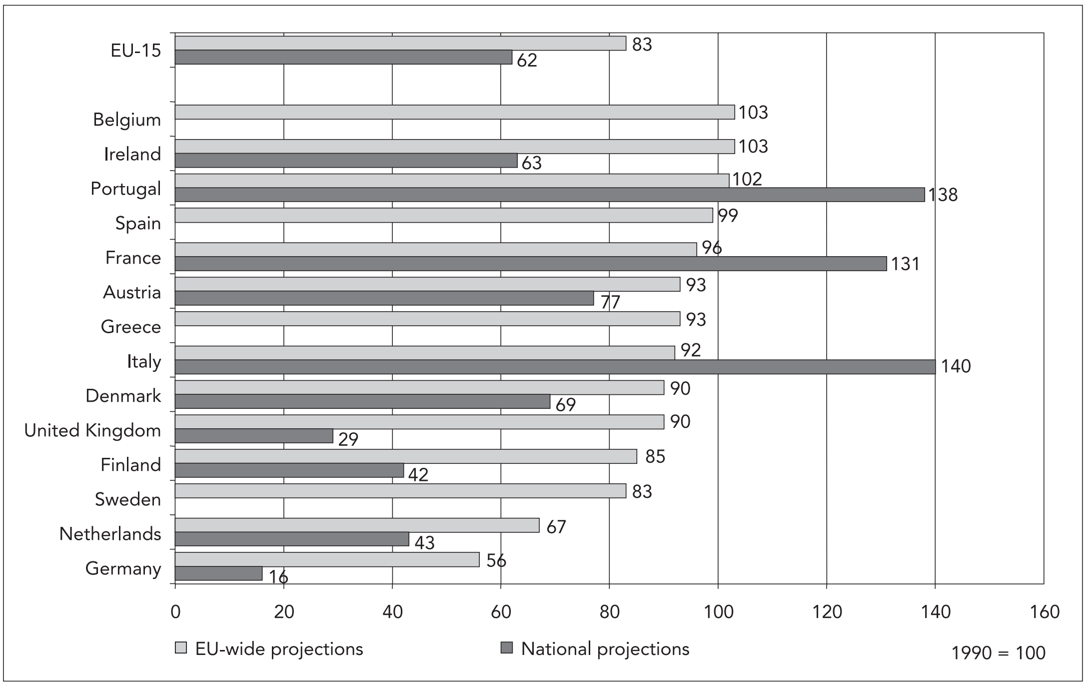
In Figure 47, comparison is made, for the waste sector, between the national emission projections for those countries that provided information and the EU-wide emission projections of the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a). It shows that national emission projections, for those countries that provided information, is 21 % lower than the EU-wide emission projection of the SOS

As with agriculture, most of the national emission projections include a greater effect of measures, in particular in the UK and in Germany. The exceptions are France, Italy and Portugal. Although France's projection includes a large (80 %) reduction in CH_4 emissions due to the diversion of waste from landfill, increased waste production leads to increased incineration of waste, which, together with an increasing plastics content of waste, leads to an increase in CO_2 (and N_2O) emissions. This more than offsets the reduction in CH_4 emissions. In contrast, the SOS assumes no increase in per capita waste generation or change in waste composition. Furthermore, CO_2 emissions from the additional incineration of waste were not specifically calculated in the waste sector projections, as alternative routes for the diversion of waste were not quantified.

The Italian national emission projections do not assume full implementation of the landfill directive, and this, together with assumptions that waste generation per capita will increase, gives an increase in emissions.

No details are available on the Portuguese national emission projections, so the reason for the difference in projections cannot be clarified.

Comparison of national emission projections and the EU-wide emission projection, disaggregated for Member States, for total GHGs in 2010 for the waste sector Figure 47



Sources: EU-wide projections: Ecofys, NTUA, AEAT (2001a); national projections: AEA Technology (2001).

6. Conclusions, recommendations and future work

6.1. Comparison of national and EU-wide projections

The two approaches for arriving at projections of GHG emissions for the EU — aggregating national emission projections and the EU-wide emission projection from the sectoral objectives study (Ecofys, NTUA, AEAT, 2001a) based on modelling the EU as a single region — show similar results for total GHG emissions by 2010 but major differences for some of the Member States, gases and sectors.

The reasons for these differences could not be identified with much certainty in this study, due to lack of information, mainly in the national emission projections provided by the Member States (see below). However, some attempts to explain differences have been made.

- **Energy sector** (24)
  The EU-aggregated national emission projection for total GHG emissions from the energy sector is 16 % lower than the EU-wide emission projection from the sectoral objectives study. This can probably be partly explained by the more detailed analysis of domestic policies and measures in the national projections, whereas the sectoral objectives study focuses mainly on EU-wide policies and measures. Underlying assumptions on the scenarios for renewable energies, nuclear energy and changes in fuel mix and cogeneration are well identified and shown in the EU-wide sectoral objectives study, but much less in the national projections which make comparison very difficult.

- **Transport sector**
  The EU-aggregated emission projection for the transport sector and EU-wide emission projection from the sectoral objectives study are reasonably comparable. However, projections for individual countries differ substantially between both approaches, mainly due to the fact that EU-wide projections focus for the main part on EU-wide measures such as the ACEA agreement with the car industry to reduce CO_2 emissions from new passenger cars, whereas the national projections consider domestic policies and measures such as taxes and speed limits in more detail.

- **Agricultural sector**
  The EU-aggregated emission projection for the agricultural sector and EU-wide emission projection from the sectoral objectives study are similar. However, most likely due to different country-specific assumptions of driving factors such as livestock numbers, projections for some Member States differ substantially between both approaches.

- **Waste sector**
  The EU-aggregated national emission projection for total GHG emissions from the waste sector is 21 % lower than the EU-wide emission projection from the sectoral objectives study. For most countries, national emission projections show larger decreases of emissions than in the EU-wide emission projections disaggregated for Member States. This can be explained by a larger effect of the landfill directive, assumed by Member States. Larger increases shown in national emission projections for some Member States appear to be due to assumed increase of per capita waste generation and waste incineration.

However, the basic problems which prevent identification of explanations for differences in emission projections between the two approaches stand out clearly.

- **Information on projections provided by several Member States is not transparent and complete**
  Information on underlying scenarios for driving forces for each sector and other projection assumptions is for several Member States lacking or incomplete.

- **Projection methods differ among the Member States**
  For some sectors, the information given on disaggregation of the sector is insufficient.

(24) The energy sector in this report includes 'energy industries' (1A1) and 'fugitive emissions from fuels' (1B), as defined under the UNFCCC.

For services, households and industry a sectoral comparison between the aggregated national emission projections and the EU-wide emission projections was even impossible. This is particularly troublesome since these sectors appear to account for many of the differences in the results.

- **Assumptions on policies and measures and their effectiveness are likely to differ**
  The assumed effectiveness of policies and measures, in terms of avoided emissions of greenhouse gases, could be the key factor in explaining the differences between national emission projections and EU-wide emission projections. However, due to lack of information in the national projections, this aspect could only be taken into analysis to a limited extent.

- **Specific policies and measures are difficult to identify in the EU-wide model results**
  The top-down model approach used in the sectoral objectives study is not very detailed in its presentation of the specific policies and measures that are assumed to be in place in the emission projection, although this approach has the advantage of consistent model assumptions for all sectors, gases and Member States.

6.2. Recommendations towards good practice for projections

The quality of the Commission's annual assessment of progress of the EU towards reaching the Kyoto Protocol and EU Member States' burden sharing agreement targets under the EU GHG monitoring mechanism depends much on the quality of the greenhouse gas inventory data, the emission projections and the information on policies and measures provided by Member States. For that purpose, the Monitoring Committee has developed guidelines, based on UNFCCC guidelines, for the reporting of such information by Member States to the Commission.

For the reporting of annual greenhouse gas inventories under the monitoring mechanism the specific guidelines are very detailed and require the use of a common reporting format (with a fixed split and definition of sectors) and the use of detailed specific IPCC guidelines for the methodologies to be used for the compilation of the inventories. The guidelines for inventories are aimed at improving all aspects of **quality of GHG inventories**:

- completeness (e.g. inclusion of all important source and sink categories);
- comparability (e.g. harmonisation of definitions and methods);
- consistency (e.g. use of the same methodologies for all years in the time series);
- transparency (providing all necessary background and underlying information).

The Commission aims at improving the quality of all reported information from Member States, but in particular on policies/measures and projections. However, the **current guidelines for policies/measures and projections are not very detailed** and appear to leave some possibilities for different interpretations for the compilation and reporting of emission projections and the effectiveness of policies and measures.

Within the UNFCCC, the recently adopted Marrakesh Accords include further detailed requirements on the reporting of annual greenhouse gas inventories as a prerequisite for a country to be allowed to use the Kyoto Protocol ('flexible') mechanisms. The quality of the inventories will also be important to assess compliance with the Kyoto Protocol commitments for 2008–12. However, not much further detailed requirements were agreed in Marrakesh on the reporting of policies/measures and projections.

The European Community, as a regional economic integration organisation and a party to the protocol, also needs to report information on annual inventories and on policies/measures and projections to the UNFCCC. Currently, the 'national' communication of the European Community is focused mostly on EU-wide common and coordinated policies/measures and thus the European Commission, which developed the third EC communication to the UNFCCC (due 30 November 2001), focused mostly on EU-wide 'top-down' emission projections, which include these policies and measures, and less on the national policies and measures. The EU Member States focus on national policies and measures in their national communications and/or national programmes under the monitoring mechanism and these are often the same.

The two different approaches (EU-wide projections versus aggregated national projections) will continue to be needed and are to quite some extent complementary. EU-wide approaches are needed to identify (current and) new common and coordinated policies, while national approaches can take better national circumstances and policies/measures into account.

Within the monitoring mechanism the EU-wide projections can be used as a comparison tool aimed to identify the main areas (e.g. sectors) where improvements are required both at EU-wide and national level. This is also one of the main aims of this report.

The following aspects of **quality of emission projections** need to be improved further:

- completeness (inclusion of all important source and sink categories);
- comparability (harmonisation of definitions, in particular for sectors, and also of methods for preparing sectoral projections and of assumptions such as GDP development);
- consistency (e.g. use of the same methodologies for the base year of the projection and for the target year, usually 2010);
- transparency (providing all necessary background and underlying information, especially for the national projections much of which is lacking, in particular on the assumed effectiveness of packages of policies and measures).

The comparability of national and EU-wide projections could be enhanced by more detailed guidelines on both the reporting format (e.g. in a similar way as the reporting format for inventories) and on the harmonisation of methodologies.

The improvement of the quality of projections on all aspects (completeness, comparability, consistency and transparency) will have to be addressed in the EU and also at UNFCCC level. However, arriving at timely solutions is an urgent issue for the EU as a signatory to the framework convention. Therefore, improving the quality of information within the EU might offer the EU a prominent international role in the process of improvement of the quality of projections at UNFCCC level as well.

6.3. Future work

Improving emission projections on all aspects as outlined above (Section 6.2) will not easily be reached in a single step. As part of the ongoing work under the EU GHG Monitoring Mechanism Committee, the following steps are proposed.

- Further comparing the methods, both for individual national emission projections provided by Member States and for EU-wide emission projections, with the aim of further identifying key factors that determine the main differences.
- Organising workshops for specific sectors with both national and EU-wide modelling experts, to further identify key factors that determine main differences, and discussing the feasibility of developing more detailed guidelines for reporting emission projections and policies/measures and for methodologies for compiling emission projections. (A workshop on energy related GHG emission projections will take place on 27 and 28 February 2002.)
- Based on the outcome of the above steps, developing of additional guidelines for a common reporting format for emission projections and for policies/measures and additional guidelines for methodologies for compiling emission projections.

Such EU monitoring mechanism guidelines might also serve as EU input into the international UNFCCC process.

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8. Glossary

ACEA	European Automobile Manufacturers Association (EU-wide agreement with ACEA and, similarly, with Japanese (JAMA) and Korean (KAMA) car manufacturing industries)
BSA	Burden sharing agreement
CCGT	Combined cycle gas turbine
CHP	Combined heat and power generation
CH_4	Methane
CO_2	Carbon dioxide
EEA	European Environment Agency
EFMA	European Fertiliser Manufacturers Association
EIA	Energy Information Administration (US)
ETC/ACC	European Topic Centre on Air and Climate Change
EU	European Union
GDP	Gross domestic product
GHG	Greenhouse gas
HFC	Hydrofluorocarbon
IIASA	International Institute for Applied Systems Analysis
IEA	International Energy Agency
IMAGE	Integrated model to assess the global environment
IPCC	Intergovernmental Panel on Climate Change
KP	Kyoto Protocol
Maraccas	Model for the assessment of regional ammonia cost curves for abatement strategies
MS	Member States
Mt CO_2 eq.	Mega (million) tonnes of CO_2 equivalents
N_2O	Nitrous oxide
NP	National projections
OECD	Organisation for Economic Cooperation and Development
PAM	Policies and measures
PFC	Perfluorocarbon
RAINS	Regional air pollution information and simulation model
RIVM	Rijksinstituut voor Volksgezondheid en Milieu (National Institute of Public Health and the Environment), the Netherlands
SAP	Shared analysis project for energy scenarios (European Commission, 1999)
SF_6	Sulphur hexafluoride
ShAIR	The shared baseline scenario for air pollution up to the year 2020 (EEA 2001)
SOS	Sectoral objectives study (Ecofys, NTUA, AEAT, 2001a)
SRES	Special report on emissions scenarios (for IPCC)
UNFCCC	United Nation Framework Convention on Climate Change
US	United States

Annex 1: List of tables

Annex 2: List of figures