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Analysis of Greenhouse Gas Emissions of European Countries with regard to the Impact of Policies & Measures

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15. Zusätzliche Angaben

16. Kurzfassung

Die Studie untersucht die Klimapolitiken Europäischer Staaten und evaluiert deren bereits erzielten Beitrag zur Treibhausgasminderung wie auch den zukünftig prognostizierten. Sie basiert auf einer Dekompositionsanalyse, die es ermöglicht Triebkräfte der Treibhausgasemissionen zu identifizieren und zu vergleichen. Die Analyse wird unterstützt durch eine vertiefte Analyse ausgewählter Politiken (Erneuerbare Energiequellen, Kraft-Wärme-Kopplung, KWK und Abfall). Die Analyse zeigt, dass die Klimapolitik aller EU Mitgliedsstaaten an dem einen oder andere Punkt verbessert kann und dass Ansatzpunkte für eine weitere Untersuchung des Potenzial für Politikverbesserungen für alle EU Mitgliedsstaaten identifiziert werden können.

17. Schlagwörter

Treibhausgasemissionen, Politiken & Maßnamen, Emissionstrends, Emissionsprognosen, Kohlenstoffintensität, Energieintensität, Umwandlungseffizienz, Verkehr, Erneuerbare Energiequellen, Kraft-Wärme-Kopplung, KWK, Müll-Management, EU Mitgliedstaaten, Europa

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16. Abstract
The study investigates the climate policies of the European countries and evaluates their contribution to greenhouse gas reductions that have already been achieved as well as those which are projected for the future. It is based on a decomposition analysis which allows the driving forces of greenhouse gas emissions to be identified and compared. This analysis is supported by an in-depth analysis of selected policies (renewable energy supply, combined heat and power and waste). The analysis shows that the climate policies of all EU Member States can be improved at one point or another and that starting points for the further investigation of potential policy improvements can be identified for each EU Member State.

17. Keywords
Greenhouse gas emissions, policies and measures, emission trends, emission projections, database, decomposition analysis, carbon intensity, energy intensity, conversion efficiency, transport, renewable energy supply, combined heat and power, CHP, waste management, EU Member States, Europe

18.	19.	20.

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List of Abbreviations

AT	Austria
BE	Belgium
BMW	Biodegradable municipal waste
Cap	Capita
CH_4	Methane
CO_2	Carbon Dioxide
CRF	Common Reporting Format by UNFCCC [1]
CY	Cyprus
CZ	Czech Republic

[1] The CRF is reported according to Annex II to guidelines for the preparation of National Communications by Parties included in Annex I to the Convention, Part 1: UNFCCC reporting guidelines on annual inventories (following incorporation of the provision of decision 13/CP.9) (UNFCCC/SBSTA/2004/8)

DE	Germany
DH	District heating
DK	Denmark
DOC	Desolved organic carbon
EE	Estonia
ES	Spain
EU	European Union
EU-15	Member States of the European Union before May 2004
EU-9	New Member States of the European Union (except Malta) as of May 2004
F gases	Fluorinated gases
FI	Finland
FIT	Feed-in tariff
FPES	Fossil Primary Energy Supply
FR	France
GDP	Gross Domestic Product
GEC	Gross Electricity Consumption
GHG	Greenhouse Gas
GHGMM	Greenhouse Gas Monitoring Mechanism (EU Decision 280/2004/EC)
GR	Greece
HU	Hungary
IE	Ireland
IT	Italy
kg oe	Kilogramme of oil equivalent
LT	Lithuania
LU	Luxembourg
LV	Latvia
MBT	Mechanic and biological treatment
MER	Market Exchange Rates
MSW	Municipal solid waste
Mtoe	Million tonnes of oil equivalent

N_2O	Nitrous Oxide
NIR	National Inventory Report
NL	Netherlands
OECD	Organisation for Economic Co-operation and Development
pkm	Passenger Kilometres
PL	Poland
POP	Population
PPP	Purchasing Power Parities
PT	Portugal
RES	Renewable energy sources
SE	Sweden
SI	Slovenia
SK	Slovak Republic
SWDS	Solid waste disposal sites
TFC	Total Final Energy Consumption
TFCT	Total Final Energy Consumption in Transport
tkm	Ton Kilometres
TPES	Total Primary Energy Supply
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
VAT	Value added tax
WDI	World Development Indicators by World Bank
WRI	World Resource Institute

1 Introduction

The most recent progress report under the Greenhouse Gas Monitoring Mechanism (GHGMM)[2] shows that the EU Member States are at present considerably far off their target to reduce greenhouse gas (GHG) emissions by 8% compared to 1990 levels in the period between 2008 and 2012. According to this report, greenhouse gas emissions were reduced by 2.9% between 1990 and 2002. However, this reduction was mainly caused by reduced emission in the United Kingdom and Germany. The report shows that most Member States are far from their target path pursuant to the burden sharing agreement. Projections for the EU-15 Member States as a whole show that the greenhouse gas emissions of the community can at best be reduced by 1% with the existing domestic policies and measures. Additionally the report shows that the EU-15 Kyoto target cannot be achieved even with additional domestic policies and measures. Only if the planned use of Kyoto mechanisms of some Member States is taken into account will the EU-15 target be achieved.

In Kyoto and in the negotiation process thereafter, Germany and the European Union always emphasized the importance of domestic policies and measures for achieving the reduction targets of the protocol. They proposed, for example, introducing “ceilings” in order to limit the use of flexible Kyoto mechanisms for achieving the targets.

In 2005, Germany and the EU have to demonstrate their progress in implementing their commitments under the Kyoto Protocol (demonstrable progress pursuant to article 3.2 of the protocol). With regard to reporting demonstrable progress, the European Union and Germany underline in their statement to the climate secretariat that these reports should describe, above all, whether the implemented policies and measures contribute to achieving the target and to what extent additional measures will be necessary. According to the stance of the European Union, the evaluation of demonstrable progress should analyse the most recent emission trends and the projected emissions. In order to preserve the pioneer role which the European Union has played up to now in international climate policy, it is absolutely necessary that the Member States develop and implement convincing reduction policies and measures and that they demonstrate the effects of them.

Against this backdrop, we analyse in this report the climate policies of the European countries and evaluate the contributions that have already been made as well as those which are projected for the future.

As a basis for this analysis, a comprehensive database for GHG, energy and socio-demographic data, such as population and gross domestic product, was compiled and

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[2] Progress report under Council Decision 280/2004/EC concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol.

described in detail (chapter 2). This database contains both the historical trend data and the projected data of different time series. Based on this database a reference data set for the further analyses was selected and examined with regard to its data quality (sections 2.2 to 2.7).

In section 2.1 a set of representative driving forces for the GHG emission level have been identified by decomposing the development of GHG emissions. Based on these methodologies a comprehensive analysis of the development of the indicators was undertaken for each of the EU Member States (chapter 3). In addition, the developments of these indicators are compared internationally at the end of this chapter (section 3.25).

As the analysis on the macro level does not always provide a clear picture of the diverse influencing factors, an in-depth analysis of some of the most important factors influencing the greenhouse gas emission level was undertaken (chapter 4).

Chapter 5 provides an analysis of selected policies and measures applied by the Member States. The promotion of combined heat and power and renewable energies as well as the policies and measures in the waste sector were investigated in detail in the form of case studies (chapter 5).

Finally, in chapter 6, the results of the various analytical steps are summarized in such a way that a general conclusion for the improvements of policies and measures and their assessment can be provided.

2 Methodological aspects

Several methods are applied to analyse the impacts of policies and measures on greenhouse gas emissions: apart from a decomposition of the driving forces of greenhouse gas emissions, in-depth analyses for individual driving forces and case studies for policies and measures in selected sectors are applied.

All these analyses integrate past trend data with projections for the future development of the individual data. A reliable and consistent database is therefore essential for all these approaches. Correspondingly, the individual data source and their reliability are described and discussed in detail (sections 2.2 to 2.5) after the introduction of the more complex decomposition method in section 2.1.

2.1 Decomposition analysis

The analysis at the country level is based on a decomposition of the total greenhouse gas emissions of each Member State of the European Union in order to identify the driving forces for the development of total greenhouse gas emissions. This decomposition includes emission data as well as data on energy consumption, economic development, and population growth. It is based on the equation below:[3]

$$\frac{GHG}{POP} = \frac{GHG}{CO_2} \cdot \frac{CO_2}{TPES} \cdot \frac{TPES}{TFC} \cdot \frac{TFC}{GDP} \cdot \frac{GDP}{POP} \text{ with}$$

GHG *Total greenhouse gas emissions*

POP *Population*

CO_2 *CO_2 emissions*

TPES *Total primary energy supply*

TFC *Total final energy consumption*

GDP *Gross domestic product at constant 1995 prices*

Based on this equation five driving forces for the development of greenhouse gas emissions can be determined:

- *Carbon/GHG*: the first factor in the product describes the relation between greenhouse gas emissions and CO_2 emissions; we will use the reciprocal value of that factor, i.e. the share of CO_2 in total greenhouse gas emissions, as it is easier to interpret. A decreasing trend shows that the importance of CO_2 emissions for total greenhouse

[3] The formula is derived from OECD (1999, p. 29) and was slightly amended for the analysis of total greenhouse gas emissions.

gas emissions is abating. That is the case, for example, if measures to reduce CO_2 are more successful than measures to reduce other greenhouse gases.

- *Carbon intensity*: it is measured by the ratio of CO_2 emissions to total primary energy supply and indicates whether the primary energy structure has developed towards less carbon intensive fuels or not. A downward trend indicates that the fulfilment of energy needs can be increasingly met with less carbon intensive or carbon free sources, such as natural gas or renewables. Furthermore, it might be relevant for policy making to distinguish between these two options: improvements of the carbon intensity due to the introduction of carbon free energies like renewable energies and nuclear power on the one hand, and due to a shift to less-carbon intensive fossil fuels on the other hand. This aspect will be analysed and discussed in more detail within the sectoral studies (section 4.3).
- *Conversion efficiency*: the third factor is the conversion intensity of the respective economy, i.e. the total primary energy supply divided by the total final energy consumption. However, as this factor is more difficult to interpret, we will once again use the reciprocal value which is the conversion efficiency. An increasing trend of the conversion efficiency signifies that more final energy was or will be produced from less primary energy sources, or in other words, that conversion efficiency was or will be improved.
- *Energy intensity*: it is calculated by dividing the total final energy consumption by the gross domestic product at constant 1995 prices. It shows how much energy has been used to produce one unit of domestic production.
- *Economic development*: the final factor is represented by the MER-based gross domestic product per capita at constant 1995 prices. It gives an indication of the economic development of the respective country. An increasing trend points out that the economy has grown or will grow on a per-capita basis.

These driving forces will be used to identify causes for the development of the *greenhouse gas emissions* in each European country from a top-down perspective. As a basis for the analysis, two types of decomposition methods are applied:

- A decomposition of the driving forces in relative terms that means that the trends and projections of the driving forces are illustrated as indicators standardised in 1990 as 100. This approach is selected to provide an overview of the causes for the development of the *per-capita greenhouse gas emissions.* Per-capita greenhouse gas emissions are often mentioned in the context of equity. An increasing trend indicates that the greenhouse gas emission level rises on a per-capita basis. To facilitate comparability, the scaling of the ordinate was selected uniformly for all Member States.
- A decomposition of the driving forces by factoring the equation above on the basis of the LOG mean Divisa index decomposition method by Ang (2004). This type of method – the approach is described in detail in the box below – is selected in order to quantify the annual contribution of each driving force to the *greenhouse gas*

emission trend. The annual contribution of the driving forces to the greenhouse gas *emission* trend is illustrated in a differentiated manner for three periods (1990-1995, 1995-2002; 2002-2010). Four different types of scaling of the ordinate have been selected.

On this basis a detailed analysis of trends and projections can be carried out.

Index decomposition analysis

Index decomposition analysis is a widely accepted analytical tool for policymaking on national energy and environmental issues. The decomposition analysis is applied in order to find out where policy may have the most effect and to quantify the influence of driving forces to an aggregate.

An index decomposition analysis begins by defining a governing function relating the aggregate to be decomposed to a number of pre-defined factors of interest (driving forces). With the governing function defined, various decomposition methods can be formulated to quantify the impacts of changes of these factors on the aggregate. The method of factorizing is mathematically based on a series expansion of order one of an aggregate, in this case the greenhouse gas emission level. As there are various possibilities for choosing the variables, the expansion does not yield a unique result.

An important difference between decomposition methods is whether or not they are *complete*. An incomplete method does not assign the entire change in a variable to the factors included in the analysis. The result is a residual which is sometimes substantial. For most methods, a revised version can be derived which attributes the residual to the other factor and turns an incomplete method into a complete method (Sun 1998).

For this study the Log Mean Divisa Index (LMDI) (additive) method was selected which uses a log mean weight function. It is recommended for general use by Ang (2002). The advantages of this method are that it provides a complete decomposition and the decomposition formula takes a rather simple form, irrespective of the number of factors considered in the composition. The LMDI method (additive) is based on the following formula:

$\Delta V_{x_k} = \sum_i L(V_i^T, V_i^0)\ln(\frac{x_{k,i}^T}{x_{k,i}^0})$ where function L(a, b) is the logarithmic average of two positive numbers a and b given by $L(a,b) = \frac{a-b}{\ln a - \ln b}$ *for* $a \neq b$ *and* $= a$ *for* $a = b$.

Further description of the method can be found in Ang (2004).

2.2 Data sources

The database for the analysis of greenhouse gas emissions with regard to the impact of policies and measures has to fulfil numerous requirements. First of all, it should comprise the following reference data:

- Population (POP)
- Gross domestic Product (GDP)
- Total Primary Energy Supply (TPES)
- Total Final Energy Consumption (TFC)
- Total Greenhouse Gases (GHG)
- CO_2 Emissions (CO_2)

The time series of this reference data set should be accurate and consistent on the one hand, and complete for all EU Member States and for all years in the past on the other hand. The projections within the database should – in addition – be compatible with the historic data and comparable with the projections provided by the Member States. The database was compiled according to these criteria. As one single data source does not meet all these demands, the database is based on different data sources. The following databases are taken into account for the analysis of greenhouse gas emissions of European Countries:

- **National Inventory Reports and Common Reporting Format tables submitted in April 2005 (UNFCCC 2005)**

  Annex I Parties to the Convention submit their national greenhouse gas inventories of anthropogenic emissions by sources and removals by sinks to the UNFCCC and review – if necessary – their historic emissions annually. The reporting comprises the Common Reporting Format (CRF) and the National Inventory Report (NIR). The CRF provides actual data on greenhouse gases, which are covered by the Kyoto Protocol (CO_2, N_2O, CH_4, F-gases and total greenhouse gases). The National Inventory Report gives inter alia a detailed overview in accordance with which methods are used to calculate the emissions in the CRF. Within the European Union, the European Environment Agency compiles those reports for an inventory report of the European Union.

- **Third National Communications**

  In the National Communications, Annex I Parties report on the steps they are taking to implement the Convention. The National Communications should be submitted in intervals of about three years. Most of the EU Member States submitted their third National Communications by 2004, the deadline for the 4^{th} submission is 1 January 2006. The content of these documents is entered into a database for projections of all greenhouse gases covered by the Kyoto Protocol. The structure of the projections in the National Communications is usually not uniform; some EU Member States break down their projections by gas and others do it by sector or by both categories. In general, EU Member States indicate projected greenhouse gas savings resulting from key policies. The projections can be categorized into "with existing domestic measures", which include all measures fully implemented on a certain date and "with additional domestic measures", which include planned or adopted policies and measures.

- **EEA's (2004) trends and projections report**

  This report is an indicator-based assessment of the emission trends, emission projections and existing and proposed policies and measures for reducing greenhouse gas emissions by 2010 in the European Community and acceding and candidate counties. The report presents an assessment of the actual and projected country-specific progress (by 2010) towards achieving the emission targets under the Kyoto Protocol and is updated annually. It is based on National Inventory Reports and National Communications. In addition, it takes into account information provided by the countries under the EU Greenhouse Gas Monitoring Mechanism (GHGMM). Since the National Communications are not updated year by year, they are often somewhat outdated. In these cases, Member States submit under the EU GHGMM additional data on updated projections to the European Commission. The European Environment Agency reports both the historic trends and projections in this comprehensive report.

- **Eurostat's New Cronos Database (2004b)**

  The New Cronos Database contains macroeconomic and social statistics data of all EU Member States. All European Member States submit national statistics to Eurostat on a regular basis. The relevant environment and energy database covers historic energy data and general indicators on the impact of population on energy consumption. This data source does not, however, include projections.

- **European Energy and Transport Trends to 2030 (EC 2003)**

  This report presents key issues of likely economic, energy, transport and CO_2 trends in the period between 1990 and 2030 for current EU Member States, and EU candidate and neighbouring countries. This database contains detailed sectoral energy and CO_2 emission data as well as trends of the main driving forces behind energy demand. Both historic data and projections are indicated at intervals of 5 years. The quantitative analysis of the projections was compiled with the use of the PRIMES and ACE models. PRIMES is a partial equilibrium model for the European Union energy system and is used for the EU-15 Member States. The Accession Countries Energy (ACE) Model is an energy demand and supply model. Both are developed by and maintained at the National Technical University of Athens. Eurostat data (PRIMES, ACE) and OECD data (ACE) were used as the main data source for the latest versions of the models. The baseline projection was compiled on the basis of current market trends and existing policies at the end of 2002. The baseline should serve as a reference for additional policy-relevant scenario analysis.

There is a lack of consistency between the coverage and disaggregation of the database by EC (2003) and the data indicated by the Parties to UNFCCC (National Communications). The differences arise mainly in the sectoral coverage and level and type of breakdown and in the type of greenhouse gas included.[4]

Table 2.1 Reporting structure of Primes baseline and Member States projections

	CO_2
Primes Baseline 1. Energy supply 1.1 Electricity generation 1.2 Heat generation 1.3 Refineries 2. Energy demand 2.1 Industry 2.2 Transport 2.3 Tertiary 2.4 Households	

	CO_2	CH_4	N_2O	F gases
MS Projections (Common Reporting Format) 1. Energy A. Fuel Combustion 1. Energy industries 2. Manufacturing industries and construction 3. Transport 4. Other sectors 5. Other B. Fugitive emissions from fuels 2. Industrial processes 3. Solvent and other product use 4. Agriculture 6. Land-use change and forestry 6. Waste 7. Other				

Source: EC (2003); Common Reporting Format

Due to the deviating reporting structure, projections can only be compared – yet with some restrictions – in the transport section and the overall projection for the EU. An analysis of the differences between the DG Tren database EC (2003) and the Member State projections can be found in EEA (2004).

- **Electricity Information (IEA 2004)[5]**

  The Electricity Information contains comprehensive information on the OECD electricity sector. It provides detailed data on GDP, population, Total Primary Energy Supply and Final Energy Consumption for all OECD countries. In addition, projections for the IEA Member States are provided.

- **World Development Indicators (World Bank 2003)**

  The World Development (WDI) Indicators is an annual compilation of data about development. It includes socio-demographic data such as population, gross domestic product (GDP), etc.

- **The ShAIR scenario (EEA 2002)**

  The ShAIR study evaluates and assesses the experience in environmental projections. In this regard sensitivity and uncertainty analysis of a baseline scenario were undertaken. Furthermore relevant indicators for prospective analysis and policy

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[4] The DG TREN database (EC 2003) covers only CO_2 emissions from fuel combustion, the process related emissions are not taken into account.

[5] As in the Electricity Information by IEA (2004) projections are not indicated, the version of 2002 is selected for further analysis.

evaluation were identified and accessible methodologies, information flows and tools for integrated assessment were improved and developed. The report focuses primarily on scenario construction for the assessment of air and climate change policies.

2.3 Reference data

Below we describe which data set was selected as *reference data* for the in-depth analysis of greenhouse gas emissions of European countries with regard to the impact of policies and measures:

Historic greenhouse gas emission trends are based on the CRF. It is assumed that the CRF data are the most accurate GHG emission data available as they are reviewed by the UNFCCC and updated regularly by the Parties according to recent country-specific findings. In addition, the CRF tables are available for all EU Member States. CO_2 emission data, however, could alternatively derive from the Primes database (EC 2003), as very detailed and uniform historic and projection data are available in this database. Nonetheless, this emission database was not taken into consideration, as the historic times series are not complete for all years between 1990 and 2000 and only CO_2 data are provided.

Projections of greenhouse gas emissions are derived from the National Communications of the Parties to the Kyoto Protocol and the latest EEA Trends and Projections Report (EEA 2004). The latter comprises all available updates of emission projections under the GHG monitoring mechanism.

Historic energy data have been taken from the “New Cronos Database (Energy)” of Eurostat (2004b). *Projections* on Total Primary Energy Supply and Final Energy Consumption derive entirely from EC (2003). They are highly consistent with the historic reference data (Eurostat 2004b) as historic time series by EC (2003) are based on Eurostat as well. Furthermore, they provide comprehensive data from all EU Member States.

Historic socio-demographic data, like GDP and population development, originate from the New Cronos Database (Eurostat 2004b). If any data were missing, however, the “World Development Indicator” databases of the World Bank (2003), the European Energy and Transport Trends to 2030 (EC 2003) and the Electricity Information by IEA (2002) were used to close remaining gaps.

Data filling procedure for GDP development

Data on GDP was missing in the New Cronos Database (Eurostat 2003; Eurostat 2004b) for Germany (1990), Estonia (1990-1992), Hungary (1990), Poland (1990-1995) and Slovakia (1990-1991). In order to close these data gaps, the development of the GDP between 1990 and 2000 from other data sources (EC 2003; EEA 2003; IEA 2002; World Bank 2003) is taken into consideration. The missing data was determined by transferring the relative mean GDP development between 1990 and 2000 from all other data sources on the GDP time series of the New Cronos Database.

Although the EEA (2004) *projections on GDP and population* are not complete for all EU Member States, we decided to take them as reference projections as this data source is updated with regard to the most recent Member States projections available. Moreover, the data source consistency of emission projections and socio-demographic factors can be guaranteed. For some of the EU Member States, however, if data by EEA (2004) are not available, projections by EC (2003) are taken into account.

Market exchange rates versus purchasing power parities:

In the database, GDP values are indicated in Market Exchange Rates (MER) in constant 1995 prices and in purchasing power parities (PPP)[6].

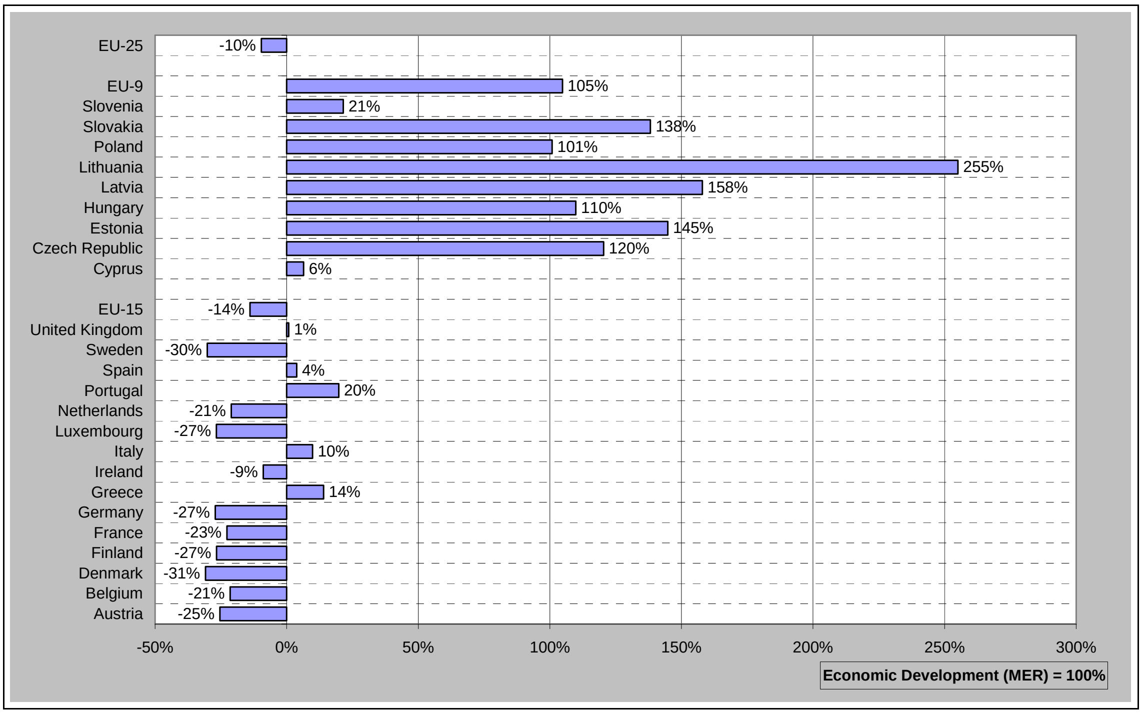
There is a debate in the scientific community whether GDP in PPP or in MER reflect more adequately the real GDP – especially in emission scenarios (Holtsmark et al. 2004). Holtsmark et al. (2004) come to the conclusion that the use of MER-based economic development implies an overestimation of the economic growth. However, at the same time, it represents a corresponding overestimation of the potential for energy efficiency improvements in less developed countries. In other words, the use of MER overvalues the energy efficiency improvements that will take place in the less developed countries in a process where the emission-intensity gap (TFC/GDP) is narrowed.

In spite of certain advantages of PPP-based GDP values, we took MER-based GDP values into account as reference data. The fact that GDP projections based on PPP are not available was crucial to our decision. Nevertheless we analysed exemplarily the effect of both approaches on GDP, on the results of the decomposition analysis and on the GDP related indicator energy intensity (section 2.1).

Figure 2.1 provides an overview of the deviation of PPP-based GDP from MER-based GDP in the individual EU Member States. It can easily be seen that the relative deviation between the two approaches are largest in the new EU Member States – on average by +105%. In all new Member States, the PPP-based GDP is higher than the one based on MER. In the EU-15 Member States differences between the two approaches are evident as well but the deviations are much smaller, on average by -14%. In only a few EU Member States is the PPP-based GDP higher, in the majority of Member States however, the PPP-based GDP is lower than the MER-based one.

6 In economics, PPP is a method used to calculate an alternative exchange rate between the currencies of two countries. The PPP measures how much a currency can buy in terms of an international measure (usually dollars), since goods and services have different prices in some countries than in others. http://en.wikipedia.org/wiki/Purchasing_power_parity (1. July 2005)

Figure 2.1 Deviation of PPP-based GDP from MER-based GDP in the EU Member States in 2002



Source: Eurostat (2004b); World Bank (2004)

It should be stressed that the deviation of the GDP values illustrated in Figure 2.1 originates from two different effects. First of all, as already mentioned, the more important effect is that the GDP values are based on different approaches – PPP and MER, in the following "approach effect". This effect, however, is overlapped by the fact that the GDP values are derived from two different data sources, the "data source effect": the MER-based GDP values are taken from Eurostat (2004) and the PPP-based GDP values derive from World Bank (2004). In the latter data source the corresponding MER-based GDP values to the PPP-based GDP values are indicated and differ from those provided by Eurostat (2004b).

Table 2.2 Deviation of MER-based GDP values by World Bank from those by Eurostat

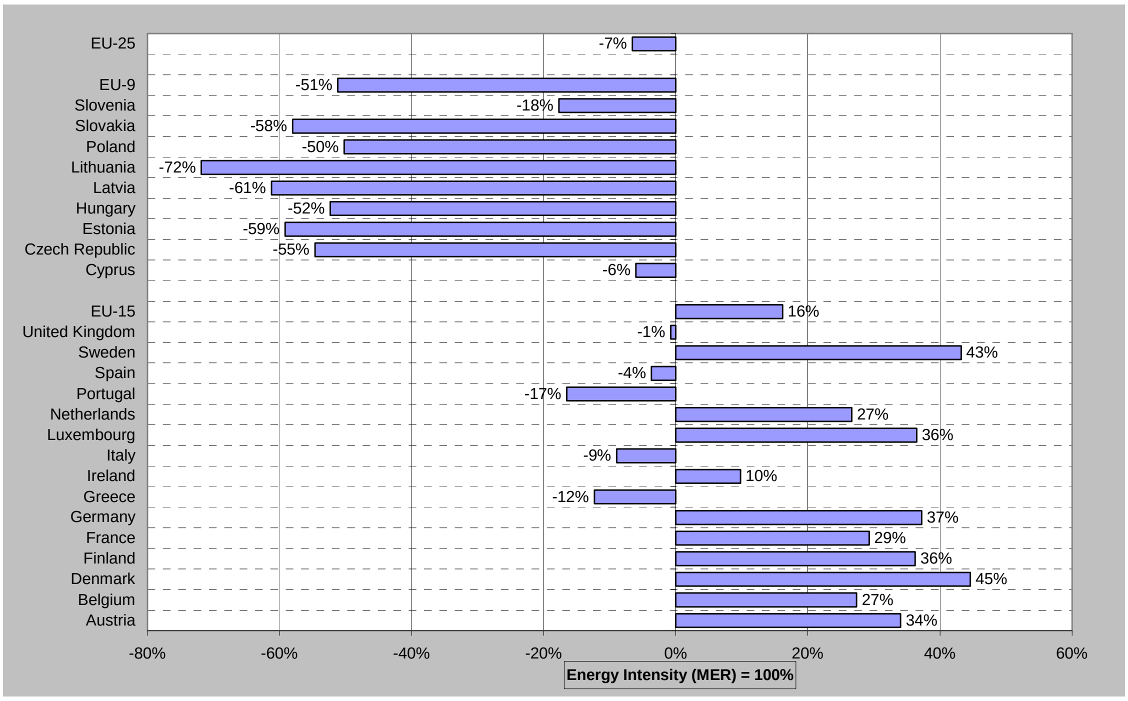
Year	Cyprus	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Poland	Slovakia	Slovenia	EU-9	EU-15
2002	97%	94%	104%	100%	97%	115%	81%	98%	94%	97%	100%
1990-2002	102%	104%	92%	100%	101%	87%	122%	100%	107%	102%	100%

Source World Bank (2004); Eurostat (2004b)

In Table 2.2 the deviation of GDP values by World Bank (2004) from Eurostat (2004b) are indicated individually for the new Member States and for EU-9 and EU-15 as average values. In the EU-15 Member States, the “data source effect” is negligible. On average the 2002 GDP values by World Bank (2004) agree with those by Eurostat (2004b) although for a few Member States they deviate by a maximum of 3%. In the new Member State the “data source effect” is more significant; for the 2002 value, it varies between 81% and 104%, for the average value of 1990 to 2002, it varies between 87% and 122%. However, compared to the “approach effect” and to the total effect of deviation, illustrated in Figure 2.1, the “data source effect” is rather negligible.

As already mentioned the MER-based GDP implies an overestimation of economic growth necessary to close or narrow the income gap and a corresponding overestimation of the potential for energy efficiency improvements in less developed countries in which the deviation between the two approaches is largest. As can be seen in Figure 2.2, the level of energy intensity based on PPP GDP in the new Member States is only half as high as the energy intensity measured in MER GDP while the one in EU-15 Member States is even larger than the one in MER GDP. Thus, using the PPP approach, the potential for energy improvements in the new Member States seems to be even smaller than if the MER GDP was selected.

Figure 2.2 Deviation of energy intensity based on PPP GDP from the one based on MER GDP in the EU Member States in 2002



Source: Eurostat (2004b); World Bank (2004)

Independently from the choice of GDP value in the reference data, the influence of the choice on the analysis results will be investigated exemplarily later on.

Table 2.3 summarises the possible data source and our section for the compilation of the database. The data reliability of the selected data sources will be discussed in detail in sections 2.4 and 2.5.

Table 2.3 Overview of possible and selected data sources

data base	Trends 1990 - 2002	Projections 2002 - 2010
	Driving Forces for Energy Demand: GDP, Population	
possible	Eurostat (2004), IEA (2004), EEA (2003), World Bank (2004), EC (2003)*	EC (2003), IEA (2002), EEA (2004);
selected	GDP: generally Eurostat (2004) GDP (1990): IEA (2002), EEA (2003), EC (2003), World Bank (2004)***	GDP: EEA (2004) EC (2003)
selected	Population: Eurostat (2004)	Population: EEA (2004) EC (2003)
	Total Primary Energy Supply and Total Final Energy Consumption	
possible	Eurostat (2004), IEA (2004), EEA (2002) (TPES), EC (2003)*	EC (2003)
selected	Total Primary Energy Supply: Eurostat (2004), Final Energy Consumption: Eurostat (2004)	Total Primary Energy Supply: EC (2003); Final Energy Consumption: EC (2003)
	Emission data: CO_2, CH_4 N_2O, F-Gases, Total Greenhouse Gases	
possible	Common Reporting Format (UNFCCC 2005), EC (2003)*/**	National Communications/ GHGMM (EEA 2004), EC (2003)**
selected	Common Reporting Format (UNFCCC 2005)	National Communications/ GHGMM (EEA 2004)

* only for the years 1990, 1995, 2000
** only CO_2
*** Data filling procedure for GDP development is described in the main text

Source: Own illustration

Finally, a comprehensive reference database was compiled, which facilitates analysing the impacts of policies and measures on greenhouse gas emissions. However, we were not able to close all gaps. Malta, for example, provided neither greenhouse gas emissions nor energy data. As a result, it has been excluded completely from the analysis.

2.4 Assessment of trend data

Data reliability is an important criterion for assessing the quality of a database. While projection data from different data sources – according to the assumptions made – may deviate to a great extent, the variation of different data sources covering historic trend data should generally be lower. In this section, the data reliability of the reference data will be assessed by comparing the reference data on Population (POP, Gross Domestic Product (GDP), Total Primary Energy Supply (TPES) and Total Final Energy Consumption (TFC) with other data sources exemplarily for the years 1990 and 2000.[7] The reference data mainly derives from Eurostat (2003)[8], while the data for comparison derive from IEA (2002), EEA (2003) and EC (2003).

The method applied to assess the reliability is based on the assumption that the more data sources correspond to each other, the more reliable the data sources are. In other words, the more deviations that can be identified among data sources, the more the reliability of the data must be called into question.

The deviations from the reference data are analysed in more detail by identifying the outliers and determining the standard deviations according to the formula below:

$$\sigma_x = \sqrt{\frac{1}{N}\left(\sum_{i=1}^{N}(x_i - x_{Reference})^2\right)}$$

With σ_x*:* *Standard deviation*

N: *Number of countries*

$x_{Reference}$*:* *Reference data for relevant country*

x_i*:* *Data i in the data set considered*

i: *enumerator*

In those cases in which one deviation is much larger than all the others, the standard deviation is also determined by neglecting the outlier. All the findings are described in the relevant sections. In addition, a final overview of the identified outliers and determined standard deviations is provided in section 2.7.

The structure of deviations, i.e. a trend toward positive or negative deviations, is examined by comparing the values of the different data sources for 1990 and 2000, both for individual countries and for the data set as a whole. Finally, whether the structure of deviation is comparable in all data sources considered is verified.

2.4.1 Population

In Figure 2.3 and Figure 2.4 the deviations of other data sources from the reference data on population are illustrated for the years 1990 and 2000. That the data on population in 1990 do not on average vary a great deal with the exception of Cyprus (EC 2003) and France (EC 2003; IEA 2002) can be clearly seen. The large deviation of Cyprus might be explained by different approaches to defining the Cyprian population. That is, some

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7 The reliability of data on carbon dioxide and total greenhouse gases cannot be compared since only one data source is available for the latter (CRF) and the data sources for carbon dioxide (EC 2003; EEA 2003) are not directly comparable with each other. However, the conclusion which can be drawn by comparing the data sources is summarized in EEA (2004).

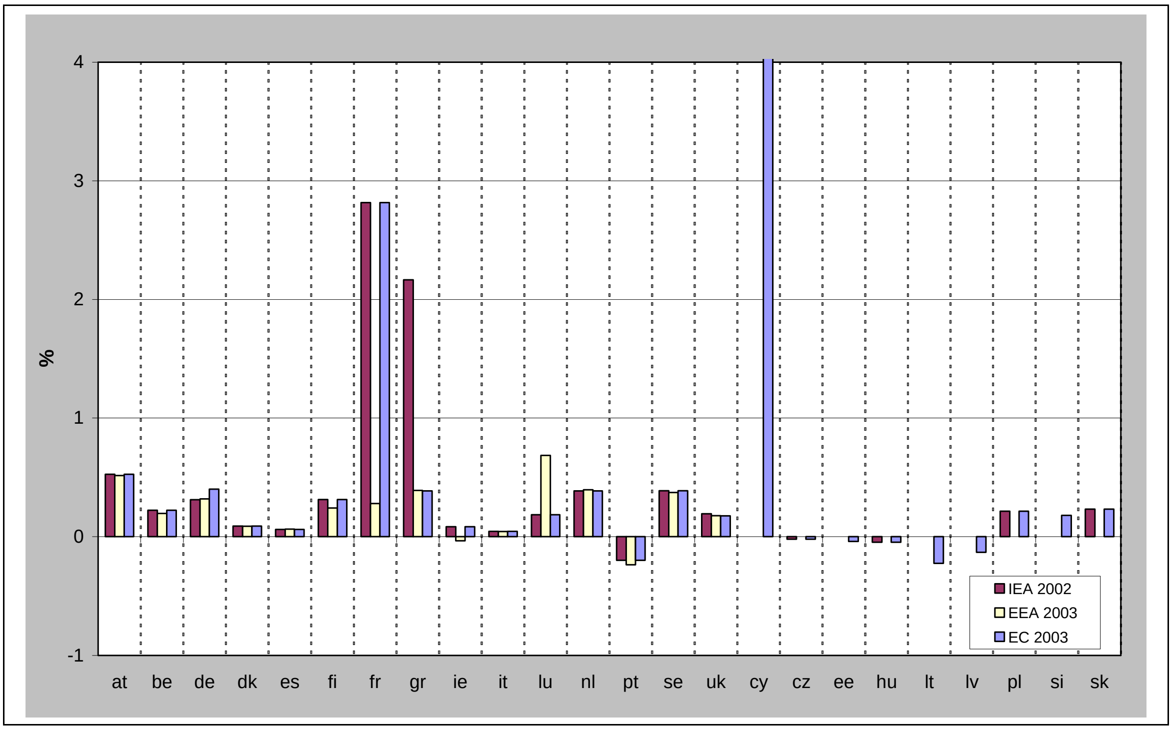
8 The reference data is based on Eurostat (2004b) with exempting figures on GDP for 1990 for Germany, Estonia, Hungary, Poland and Slovakia. They are calculated by the Oeko-Institut on the basis of all available data sources.

statistics include the population of both parts of the country, the Turkish and the Greek part; others consider only the Greek population. While the Cyprian outlier cannot be affirmed by another source, the deviation of the population data of France as reported by IEA (2004) is within the same range as reported in the data of EC (2003). A possible explanation for the deviation of the French population could be that the population of the overseas territories (Territoires d'Outre Mer) are included in EC (2003) and IEA (2002) as well, while they are ignored in Eurostat (2003) and EEA (2003). The standard deviations are rather low. Neglecting the Cyprian value the standard deviation of EC (2003) accounts for 0.6 %, while that of IEA (2002) – considering all values – adds up to 0.8 %, and that of the EEA (2003) amounts to 0.3%.

In 2000, again – similar to 1990 – the highest deviation can be identified with the French and Cyprian population data from EC (2003). In 2000, the deviation for many countries is much smaller than in 1990 but there are some larger negative deviations and additional parallel deviations of two data sources (EEA 2003; IEA 2002). As data by EEA (2003) are not available for 2000, a direct comparison cannot be made. Neglecting the Cyprian value, a standard deviation of 3.3% for EC (2003) can be determined, the standard deviation of all population data from IEA (2002) amounts to 0.9%.

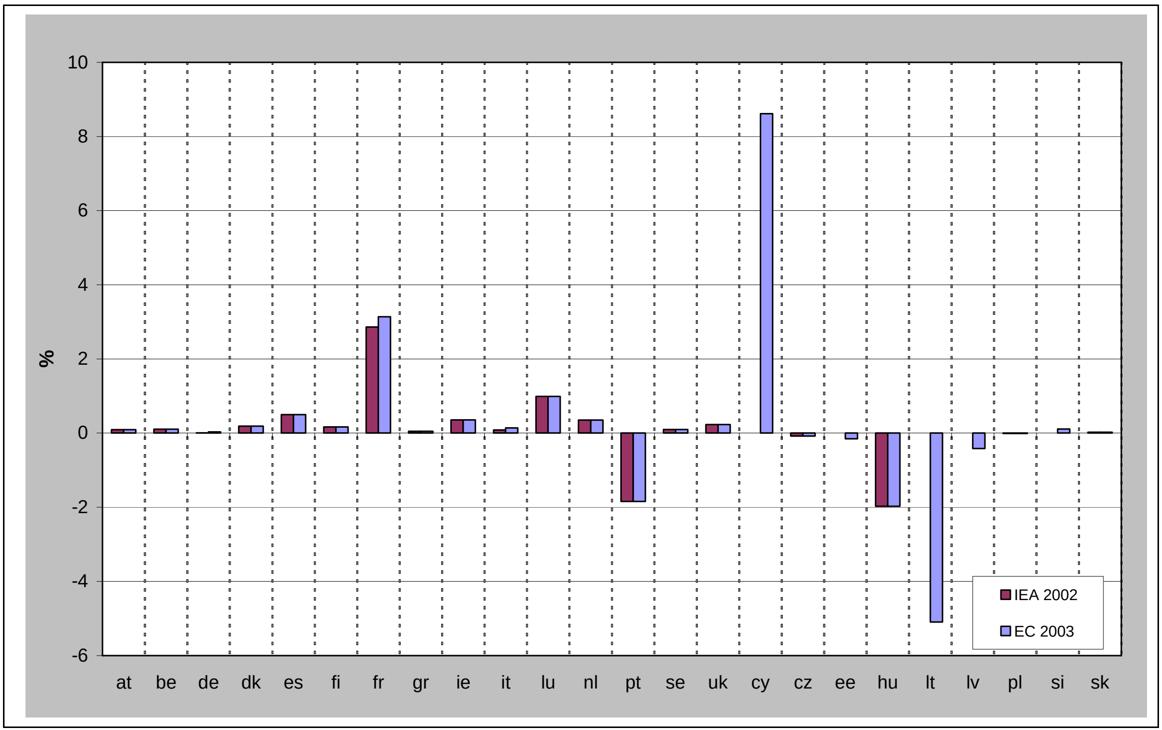
The parallel deviation of the two data sources (France, Portugal, Hungary and Luxembourg) hint to the fact that the reference data are not completely concordant with the real population figures. Furthermore, it should be mentioned that – at least in 1990 – the reference data on population tend to be in a lower range as most of the other population data turn out to be higher. Nevertheless, the standard deviations of data on population from other data sources are so small that they do not have a significant influence on the analysis results. Overall, the reliability of the reference data on population can be assessed as fairly good.

Figure 2.3 Deviation of different population data from Eurostat data for 1990



Source: Eurostat (2003), IEA (2002), EEA (2003) and EC (2003); own calculations

Figure 2.4 Deviation of different population data from Eurostat data for 2000



Source: Eurostat (2003), IEA (2002); EC (2003); own calculations

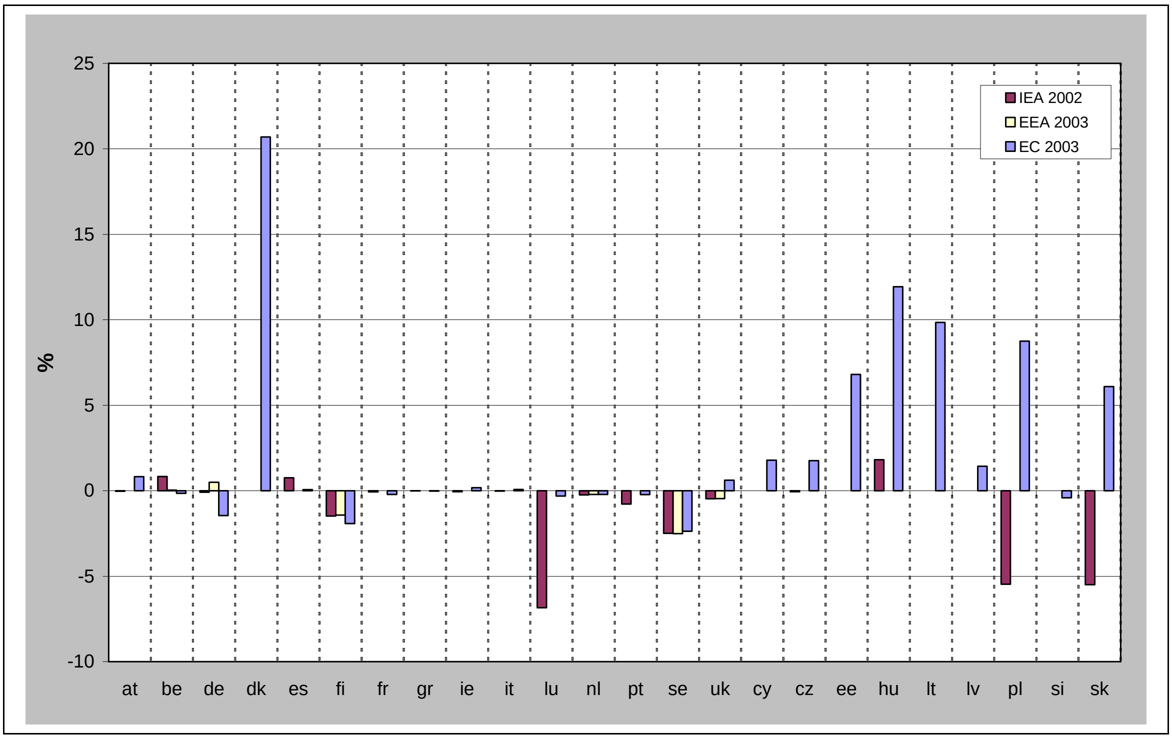
2.4.2 Gross Domestic Product

Figure 2.5 and Figure 2.6 provide an overview of the deviation of other data sources from the Eurostat data on GDP in 1990 and 2000. The dimension and the structure of deviations are similar for both years. In both years, the GDP of Denmark, according to EC (2003), deviates the most by far (almost 21%), but this deviation is not supported by the GDP given in IEA (2002).

The standard deviation in 1990 and 2000 amounts to about 5% for EC (2003), to 0.8-2.2% for IEA (2002) and to less than 1% for EEA (2003). Furthermore, it is apparent that for 1990 as well as for 2000 especially the GDP data for the new Member States given in EC (2003) are on average higher than the reference data. However, at least for the new Member States, for which IEA (2002) data are available, the assumption that the GDP is actually higher than the reference data has not been affirmed. On the contrary, for two of the three countries for which IEA (2002) data are available, Poland and the Slovak Republic, there is a significant negative deviation. These findings give the impression that data for the new Member States in particular are not as reliable as that for the EU-15.

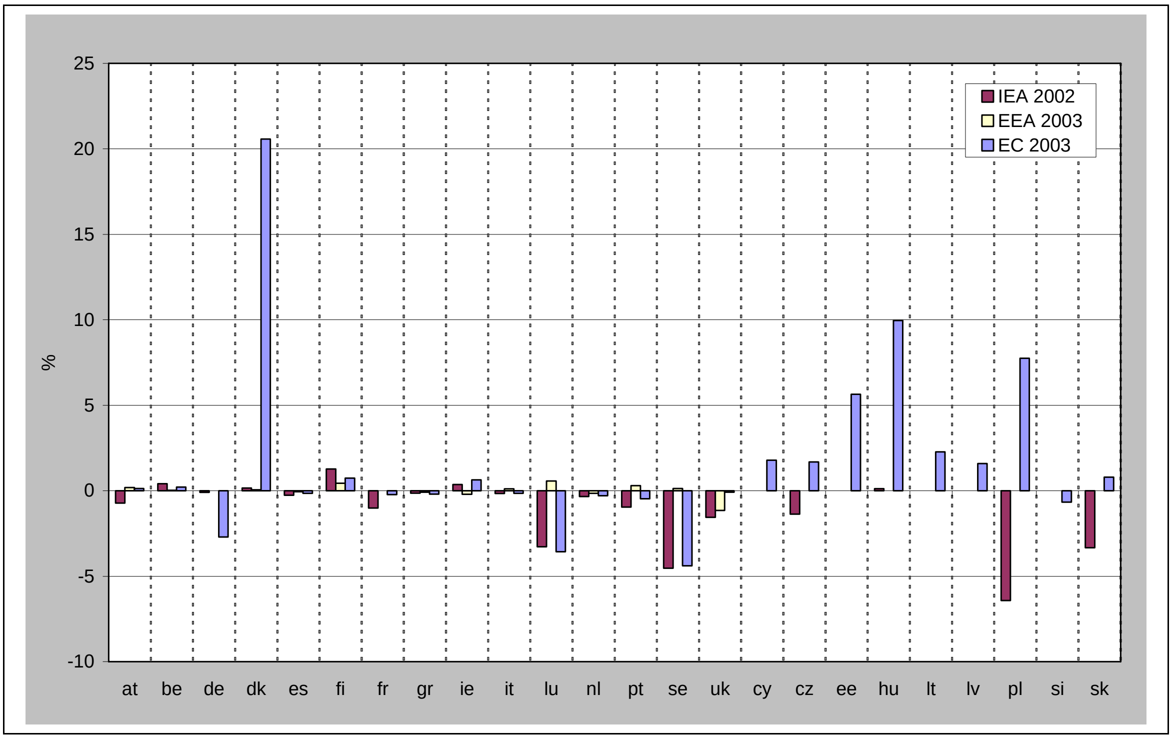
Although the standard deviation of data on GDP is higher than the one of population data, the reliability of the reference data on GDP seems to be adequate as the standard deviations are still rather small and most of the significant deviations of the data given in EC (2003) are not affirmed by IEA (2002) data.

Figure 2.5 Deviation of different GDP data from Eurostat data for 1990



Source: Eurostat (2003), IEA (2002), EEA (2003) and EC (2003); own calculations

Figure 2.6 Deviation of different GDP data from Eurostat data in 2000

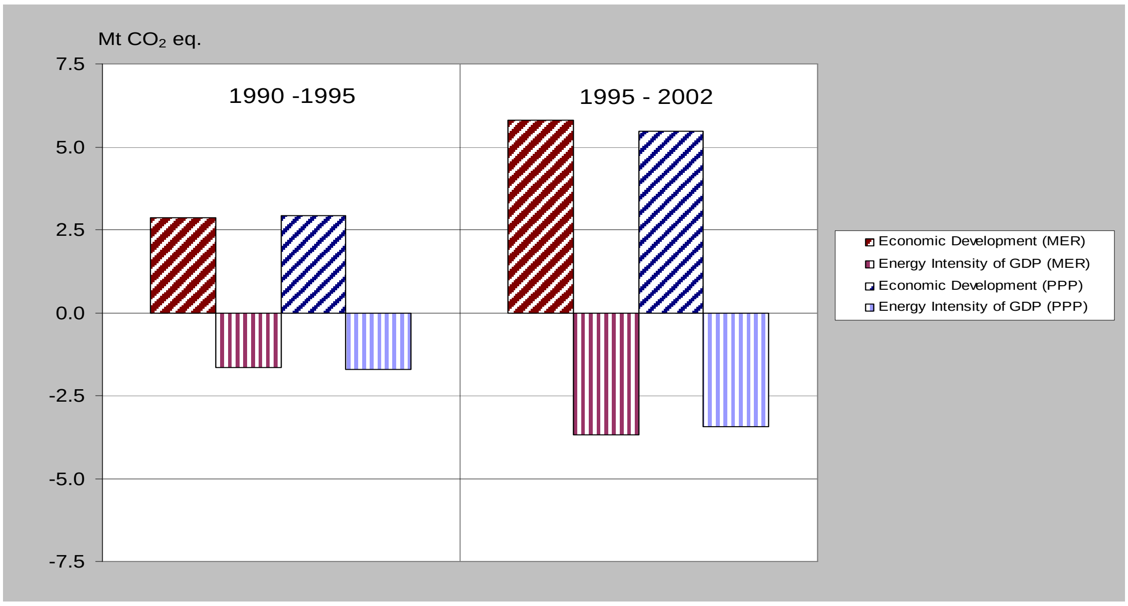


Source: Eurostat (2003), IEA (2002), EEA (2003) and EC (2003); own calculations

Effect of PPP-and MER-based approaches on the results of the LMDI decomposition analysis

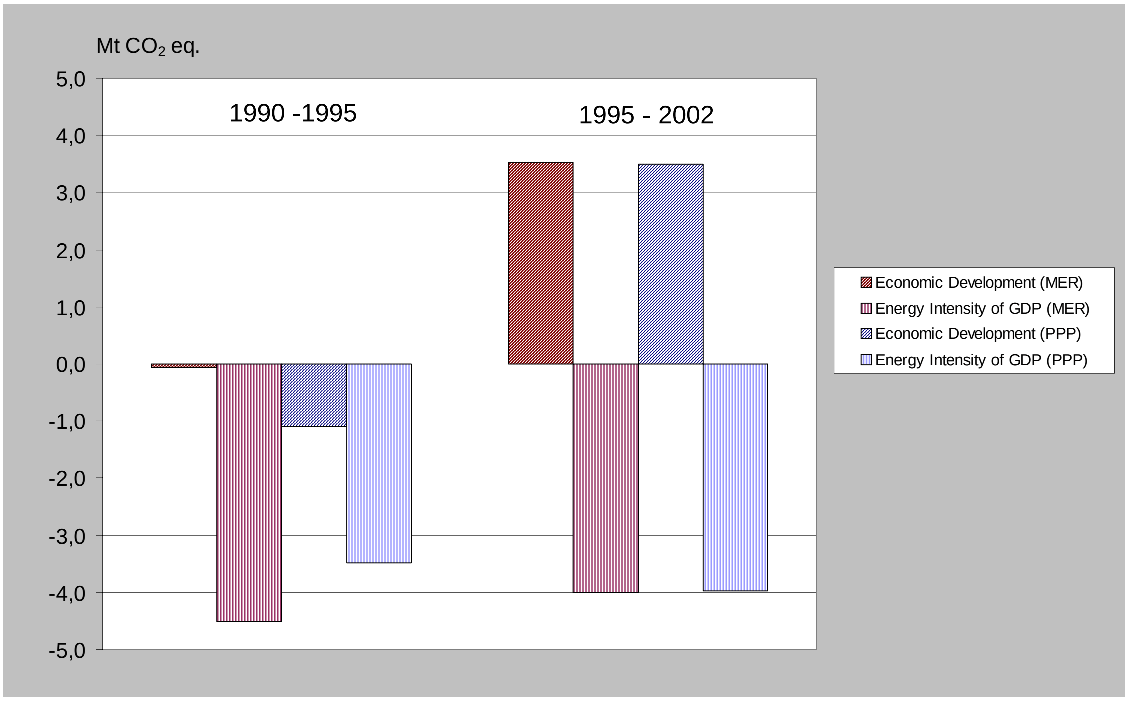
In Figure 2.7 and Figure 2.8 the effects of a PPP or MER-based GDP on the results of the LMDI decomposition analysis (section 2.1) are illustrated exemplarily for the EU-15 Member States and the new Member States. Obviously the choice of GDP influences the annual contribution of the driving forces GDP and energy intensity, but the deviation of the PPP-based approach from the MER-based approach influence only marginally the key message of the decomposition results.

Figure 2.7 Annual contribution of GDP and energy intensity to the GHG emission trends and projections in EU-15 based on MER and PPP approach



Source: Eurostat (2004b), World Development indicators (2004); Ang (2004); own calculations

Figure 2.8 Annual contribution of GDP and energy intensity to the GHG emission trends and projections in EU-9 based on MER and PPP approach



Source: Eurostat (2004b), World Development indicators (2004); Ang (2004); own calculations

2.4.3 Total Primary Energy Supply

Figure 2.9 and Figure 2.10 provide an overview of deviations of other data sources from the TPES reference data (Eurostat 2004b) in 1990 and 2000.

In 1990, EC's (2003) TPES data deviate in some cases to a great extent, both positively and negatively. The highest deviations can be found with TPES from Latvia which amounts to 54%; the corresponding figure by IEA (2002) is not available. Neglecting the TPES of Latvia[9] the standard deviation of EC (2003) accounts only for 4.2%.

TPES data of IEA (2002) and EEA (2002) are on average lower than the reference data for almost all EU-15. But the deviations of those two data sets are usually not in the same magnitude if individual countries are considered. The standard deviation of EEA (2002) adds up to 8.3%, that of IEA (2002) to 4.6%.

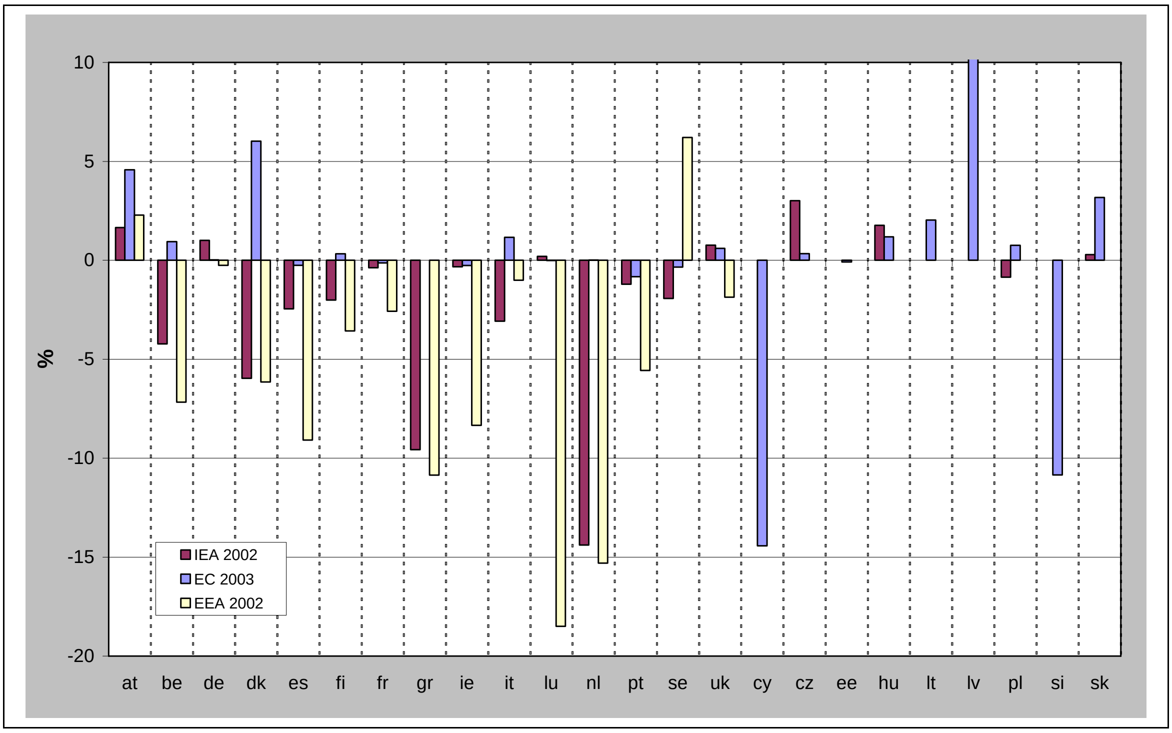
For 2000, EEA (2002) TPES data are not available for most of the countries. The EC (2003) data deviate, particularly in some of the new Member States, from the reference

9 Latvia's 1990 TPES value in Eurostat's database seems to be wrong. This fault can be traced back to the TPES of liquid fuels which is roughly 4 Mtoe lower in Eurostat's database than in other data sources (EC 2003, CRF data submitted in 2005). We have therefore corrected our database and have increased Latvia's liquid TPES in 1990 by 4 Mtoe.

data up to 5.9 %, but in general the deviations are much smaller than for the year 1990 (standard deviation of 2.2%).

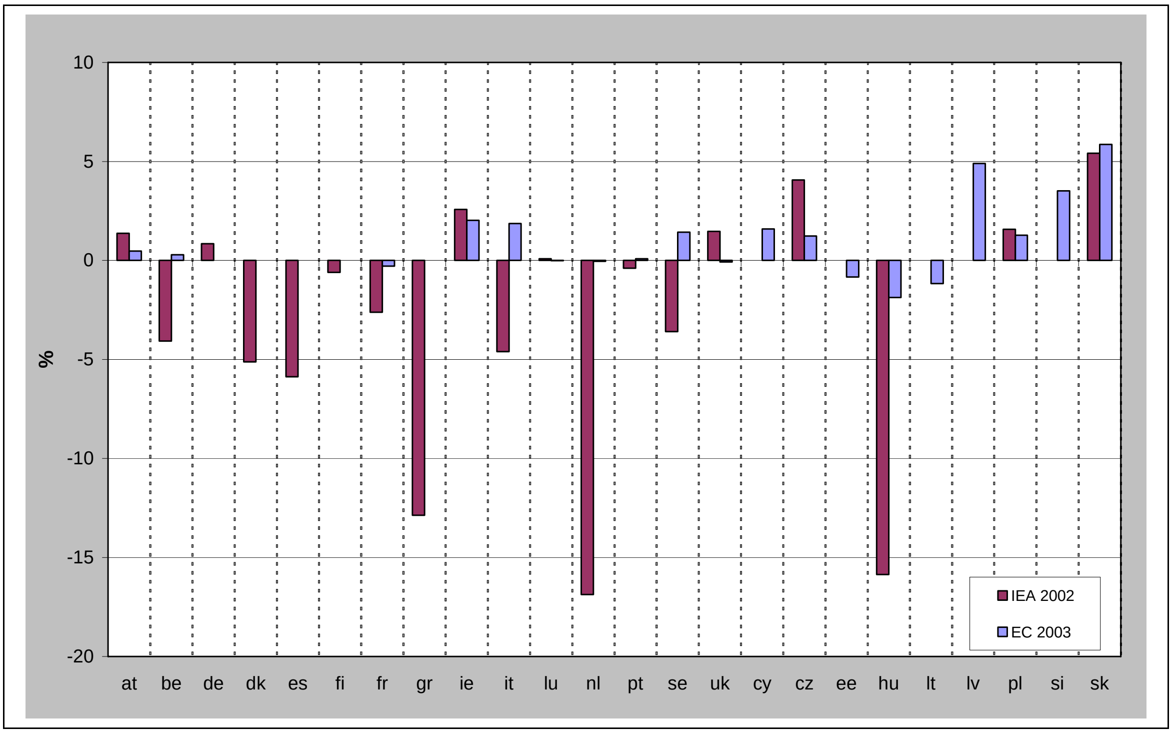
Data on TPES in several EU-15 Member States as reported by IEA (2002) are significantly lower than the reference (up to 16.9% for the Netherlands). For other countries, the TPES figures are either similar or, for some of the new EU Member States, slightly higher (up to 5.4%). The standard deviation of data as reported by IEA (2002) in 2000 (6.8%) are comparable with that reported in 1990 (4.6%).

Figure 2.9 Deviation of different TPES data from Eurostat data in 1990



Source: EEA (2002), IEA (2002), EEA (2002) and EC (2003); own calculations

Figure 2.10 Deviation of different TPES data from Eurostat data in 2000

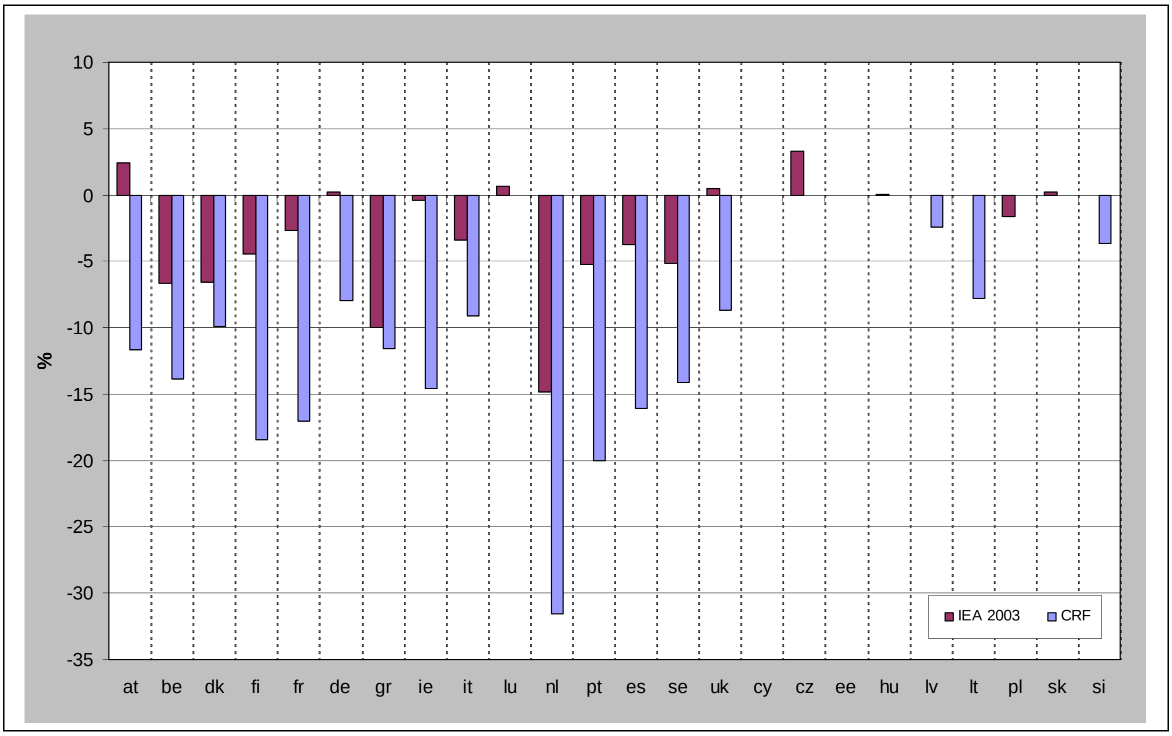


Source: IEA (2002) and EC (2003); own calculations

Altogether, the reliability of the TPES reference data seems to be not as good as the reliability of the population and GDP data, as there are more – and more significant – deviations from other data sources. The data reported by IEA (2002) and EEA (2002) point to lower values of the TPES data. Therefore we investigated if there are other indications that the TPES data provided by Eurostat (2003) and EC (2003) overestimate the TPES and to what extent lower TPES values could influence the analysis results.

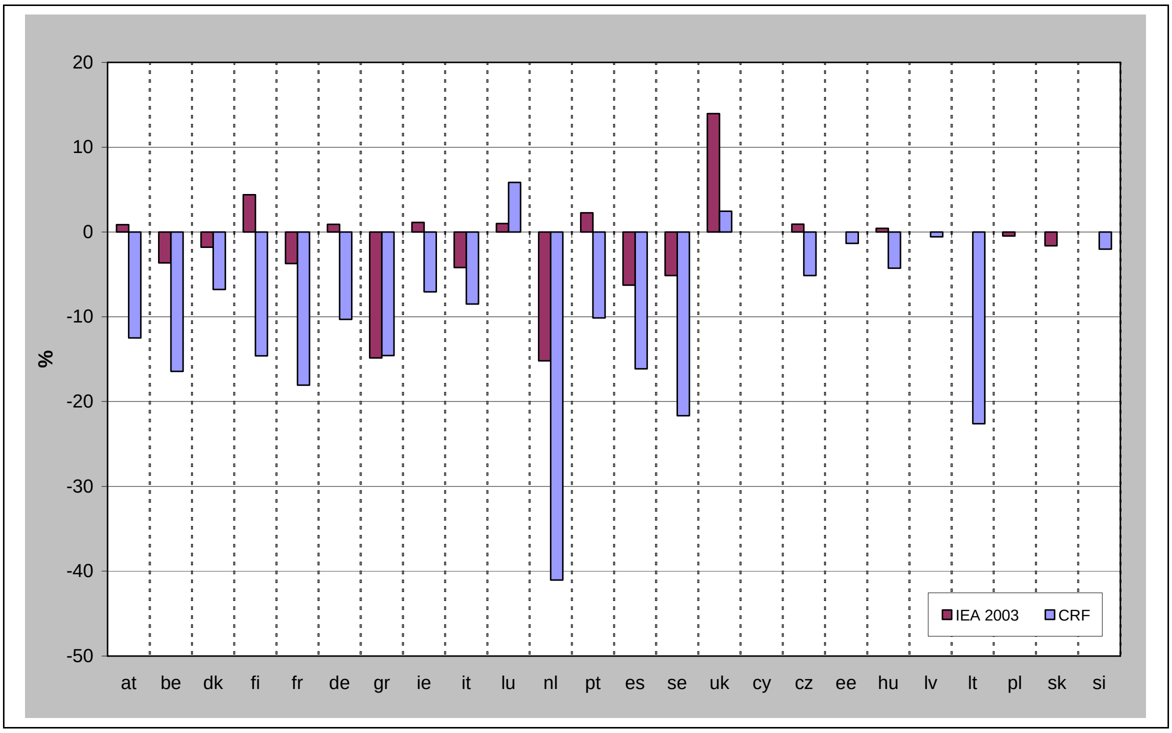
Another source of primary energy supply data are the CRF tables submitted under the United Framework Convention on Climate Change (UNFCCC 2005). However, since these tables are designed to report the greenhouse gas emissions of the parties to the Climate Convention, only data on fossil primary energy supply (FPES) are included. Figure 2.11 provides an overview of the deviations of the IEA (2003) and the UNFCCC (2005) FPES data from the Eurostat (2004b) FPES data in 1990. As can be easily seen, the deviations of the UNFCCC (2005) data are even more significant and, in most of the Member States, go in the same direction as the ones provided by IEA (2003). FPES data according to UNFCCC (2005) is significantly lower than FPES data provided by Eurostat (2004b).

Figure 2.11 Deviation of different FPES data from Eurostat data in 1990



Source: IEA (2003); Eurostat (2003); UNFCCC (2005); own calculations

Figure 2.12 Deviation of different FPES data from Eurostat data in 2002



Source IEA (2003); Eurostat (2003); UNFCCC (2005); own calculations

In 2000, a similar structure of deviation is apparent. Although there are some more positive deviations from the Eurostat values, UNFCCC (2005) and IEA (2003) FPES data are on average significantly lower than the Eurostat (2004b) data.

However, the FPES data provided by IEA (2003) and by CRF (2005) – similar to TPES in 2000 by IEA (2002) and EEA (2002) – are incomplete and are not available for several Member States. In addition, the alternative data sources also deviate from one another so that there is no evidence as to which of the data sources is most reliable.

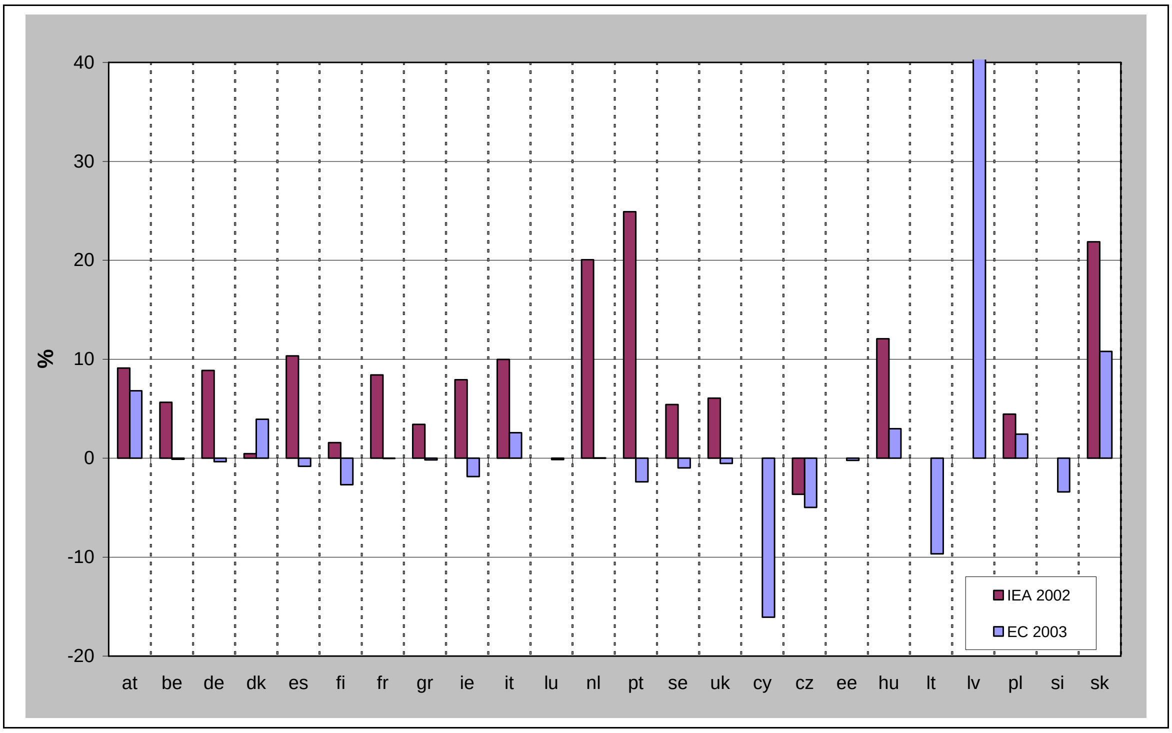
Against this background, and taking into account the requirement to base the analysis on a complete data set for all Member States which is also compatible with the data source for the Final Energy Consumption, we decided – in spite of the fair data reliability – to use Eurostat's TPES data as reference data.

2.4.4 Final Energy Consumption

Figure 2.13 and Figure 2.14 show deviations of the Total Final Consumption (TFC) data reported by EC (2003) and IEA (2002) from the reference data (Eurostat 2004b). The structures of the deviations in 1990 and 2000 are similar. The TFC data provided by IEA (2002) are significantly higher for most of the countries than the values given in Eurostat (2004b). The standard deviation by IEA (2002), neglecting the value of Portugal and the Slovak Republic, amounts in 1990 to 9.6% and in 2000 to 10.1%, but the deviations for the individual countries are not within the same range.

While data on TFC reported by IEA (2002) are consistently higher than the reference data for 1990 and 2000, the picture is quite different if the reference data is compared with EC (2003). The TFC values reported by EC (2003) are available for all countries considered and are – with some exceptions – quite comparable to the reference data. The exceptions are the TFC for Latvia which EC (2003) provides for 2000, which deviates by 56.3% and the TFC for the Slovak Republic in 2000, which deviates by 26.7% from the reference data. Neglecting the outliers[10], the standard deviations add up to 4.9% for 1990 and to 1.5% for 2000.

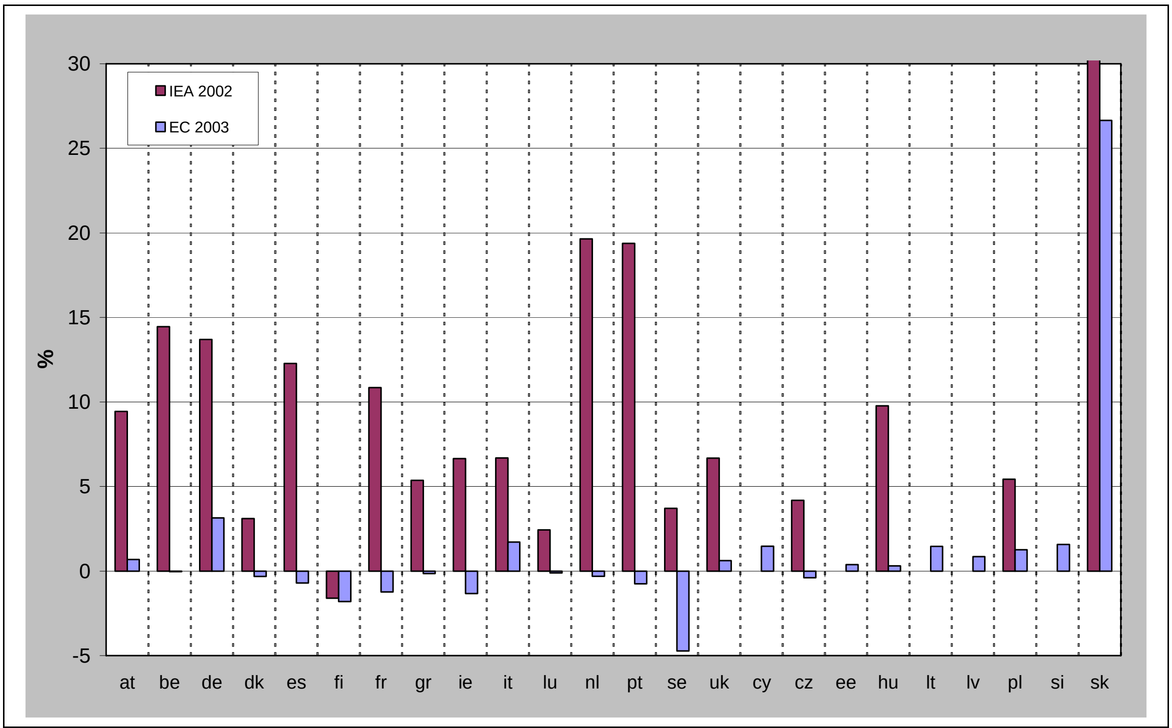
Figure 2.13 Deviation of different TFC data sources from Eurostat data in 1990



Source: Eurostat (2003), IEA (2002) and EC (2003); own calculations

10 The exceptions are the TFC for Latvia which EC (2003) provides for 2000, which deviates by 56.3% and the TFC for the Slovak Republic in 2000, which deviates by 26.7% from the reference data.

Figure 2.14 Deviation of different TFC data sources from Eurostat data in 2000

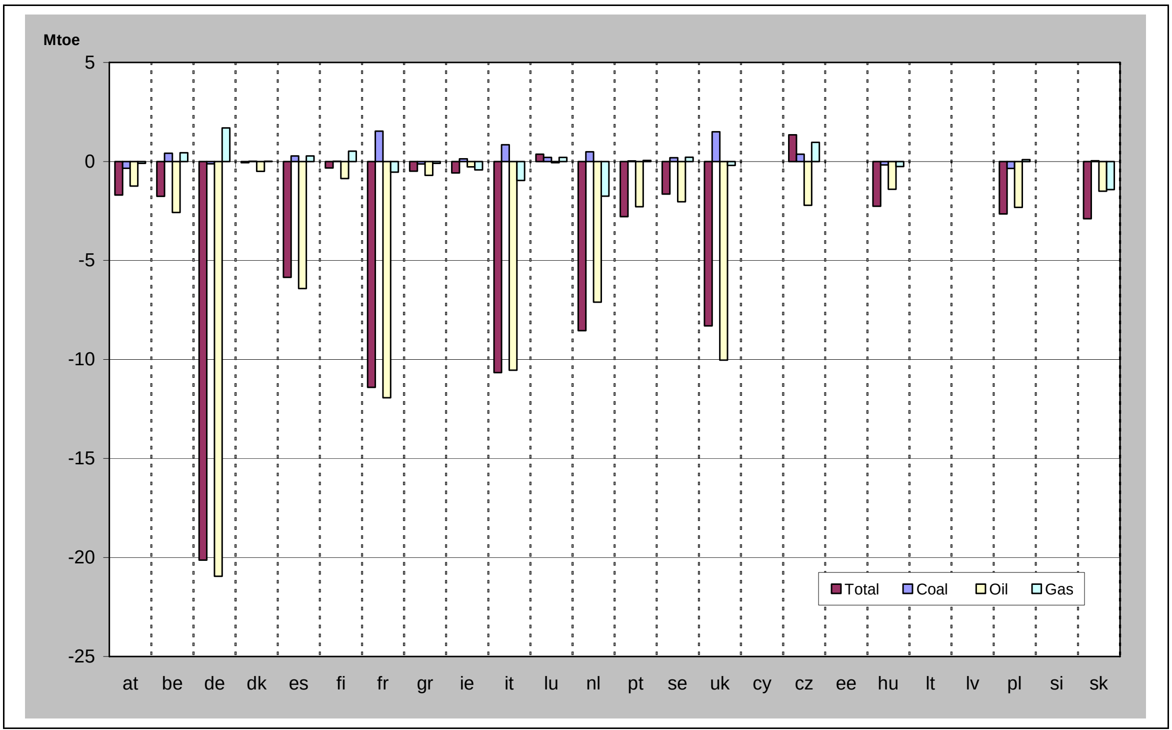


Source: Eurostat (2003), IEA (2002) and EC (2003); own calculations

In spite of the deviations of the IEA (2002) data, the reliability of the TFC reference data can be assessed as fairly good. In most cases the reference data are concordant with the TFC reported by EC (2003).

No similar patterns of deviations between the data different sources can be identified if the analysis results for the TFC and the TPES data are compared. While the TPES reported by IEA (2002) is, for example, on average smaller than the reference data, data on TFC reported by the same source are higher. A major reason for this deviation is the difference in the definition of TFC: In IEA (2002) the use of oil as feedstock is accounted as final consumption of the chemical industry. In Eurostat (2003), however, the feedstocks are not included in the TFC. Figure 2.15 reveals that the deviations of the TFC data provided by IEA (2002) from the Eurostat (2004b) derive predominantly from different oil consumption figures which, in turn, derive from the different coverage of the feedstocks.

Figure 2.15 *Deviation of the total final coal, oil and gas consumption provided by IEA (2004) from Eurostat in 1990*



Source *IEA (2004), Eurostat (2004b), own calculations*

As a conclusion, the deviations of TFC data provided by IEA (2002) from the Eurostat (2003) data derive from different classifications. The data reliability of the reference data can be assessed as good, in particular if one takes into account that the exclusion of oil used for feedstocks is more appropriate in analyses which focus on energy efficiency and greenhouse gas emissions.

2.5 Assessment of projection data

Projections play an important role for the assessment of policies and measures. As all European Countries have an obligation to reduce or limit their greenhouse gases under the Kyoto Protocol, it is of great importance to assess whether the emission targets will de facto be achieved. In order to be able to evaluate the progress and impacts of policies and measures, both sound baselines projection and adequate assumptions regarding the impact of measures and measures are indispensable.

Generally, the type of projected data must be differentiated. The socio-economic data of GDP and population are independent from measures taken to reduce greenhouse gases. In contrast, the TPES, TFC and GHG are directly influenced by energy and climate policies. Thus, for evaluating the projections, it is important to consider which policies and measures are included in the baseline. In this section the projections of GDP, TPES and TFC from different data sources (EC 2003 and IEA 2002) are compared. Population, one of the driving forces for energy demand, is not considered further as population data can be predicted in a relatively reliable manner. In addition, the growth or shrinkage of a population is a slow process compared to, for example, the variability of GDP. Moreover, projections on GHG cannot be compared as there is only one comprehensive data source on greenhouse gas emissions available. Much like the assessment of reliability of historic data, the relative deviations between projections are visualised.

The comparisons of projections are not discussed in great detail. In contrast to the previous section in which data quality is assessed by analysing the deviations, the quality of projections can only be evaluated by also reviewing the assumptions and modelling approaches used for the projections to which the deviations can be attributed.

2.5.1 Objective and assumptions of the projections

In section 2.2 some assumptions and model description of the different projections are already outlined. In the following, some additional information on the assumptions of the projections/models are provided, but the all-embracing details must be reviewed in the relevant reports and databases (EC (2003); EEA (2003), IEA (2002)).

- European Energy and Transport Trends up to 2030 (EC (2003))

  The baseline scenario in this report includes existing trends and the effects of policies in place and of those in the process of being implemented by the end of 2002 whereas tax rates reflect the situation of July 2002 in the EU Member States. No additional policies to reduce greenhouse gases (e.g. in view of the Kyoto targets) are included in the baseline. In particular, no attempt has been made to forecast how the EU Member States might endeavour to fulfil their Kyoto commitments.

  The economic outlook for both the EU-15 Member States and new EU Member States is based on a number of underlying assumptions. For example, despite the recent economic slowdown – caused among other things by the terrorist attack of September 11th 2001 – GDP growth is assumed to remain generally positive. In addition, the EU is projected to benefit from economic and monetary unifications as well as from a continued increase in world trade, as barriers continue to fall. The Baseline scenario draws on the macroeconomic and sectoral projections from several different sources, including the European Commission's Directorate-General for Economic and Financial Affairs, Member States' stability programmes and long term projections, the results of a study performed under contract by WEFA[11] and the results of GEM-E3 model[12].

[11] WEFA is an economic consultancy company which in 2001 delivered a consistent macro-economic and sectoral forecast over the horizon to 2020 for the EU Member States and, at a more aggregate level, for candidate countries and EU neighbouring countries. This study has been used as a benchmark (EC 2003).

[12] The GEM-E3 model has been constructed under the co-ordination of the National Technical University of Athens within projects supported by DG Research (EC 2003).

The Baseline projections as regards the evolution of international fuel prices are based on the assumption that global energy markets will remain well supplied at a relative modest cost until 2030. These projections derive from the output of the POLES model which is a global sectoral model of the world energy system.[13]

- Electricity Information (2002)

  The projections in the Electricity Information are obtained from the 2001 annual cycle of submission from the Member countries to the IEA. These country submissions include national projections of energy trends and descriptions of energy policies. However, in some cases, elements of projections have been developed by the IEA Secretariat in order to be able to construct national energy balances for the projection years. Not all IEA Member countries revise their national projections each year and accordingly do not submit revised projections to the Secretariat each year. The older the projection, the more out of line it may become with recent trends in energy supply and demand in the country concerned (IEA 2002).[14] Energy data are submitted in a common reporting format and methodologies to allow for international comparisons to be made.

- Submissions under GHG Monitoring Mechanisms (EEA 2003)

  The EEA obtains the projections on GHG emissions and corresponding projections for GDP, population etc. as well as the assumptions used in projections models from the National Communications and from queries under the GHGMM. The projections and assumptions are updated by the EEA according to the following procedure: In preparation of the Commission’s progress report, the EEA compiles a draft country profile with GHG projections, assumptions used etc., based on National Communications, information provided by the Member States and previous country profiles. These drafts are sent to the Member States’ focal points for authorisation. If available, the focal points update the drafts with more recent data or projections and submit it to the EEA (via the Commission). Therefore, the EEA reports usually take into account the most recent projection data available.

By reviewing the projections and the underlying assumptions it can be easily explained why the projections might differ. The objectives of the projections vary significantly. While the baseline reported by EC (2003) should serve as a reference for additional policy-relevant scenario analysis, the projections reported by EEA (2003) should reflect the

[13] The development of the POLES model has been partially funded by the European Commission. Since 1997 the model has been fully operational and can produce detailed long term (2030) world energy and CO_2 emission outlooks with demand, supply and price projections by main region. The model splits the world in 26 regions.

[14] The year in brackets refers to the year when the data were submitted to the Secretariat by the IEA Member country concerned (IEA 2002): Austria (1996), Belgium (1996), Czech Republic (2001), Denmark (2001), Finland (2001), France (1999), Germany (2001), Greece (2001), Hungary (2001), Ireland (2001), Italy (2001), Luxembourg (1993), Netherlands (2001), Portugal (2001), Spain (2001), Sweden (2000) and United Kingdom (2001).

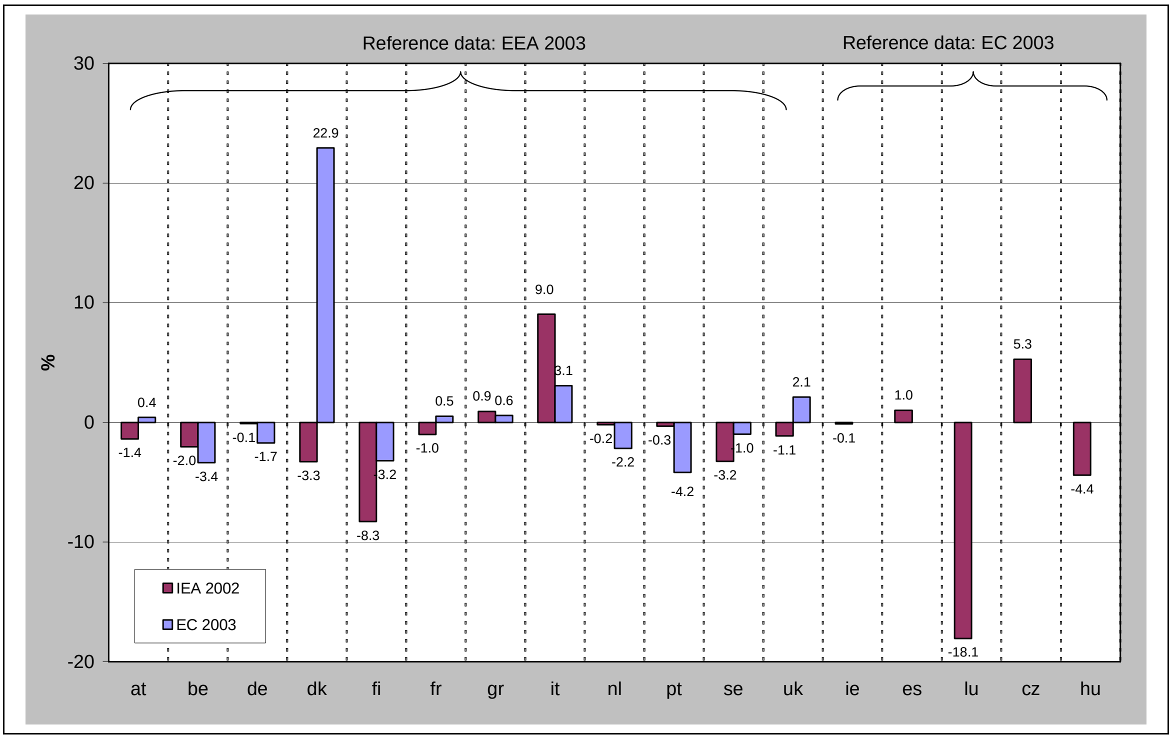
actual circumstances taking into account recent measures taken. Thus, they are regularly updated. The projections by IEA (2002) should also reflect the actual developments but they are not as up-to-date as the projections by EEA (2003).

2.5.2 Deviations of projections

The TPES and TFC projections provided by EC (2003) are selected as reference projections. For the GDP projections we followed a mixed approach: we selected, when available, the projections provided by EEA (2003) as reference projections. However, for Luxembourg and the new Member States these projections are not reported. In these cases we, therefore, fell back on the GDP projections provided in EC (2003).

Figure 2.16 illustrates the relative deviations of projections on GDP in 2010 of IEA (2002) and EC (2003) from the reference data. It shows relative deviations from -18% for Luxembourg (IEA 2002) up to +23% for Denmark (EC 2003) compared to the reference data. The deviation of Denmark seems to be a structural problem as Denmark was already identified as an extreme outlier in the historic data of EC (2003). Luxembourg's status as an outlier, however, can be explained by the fact that the IEA projection for that country is outdated, originating as it does from 1993 (compare also footnote 14).

Figure 2.16 Deviation of GDP projections from reference projections in 2010



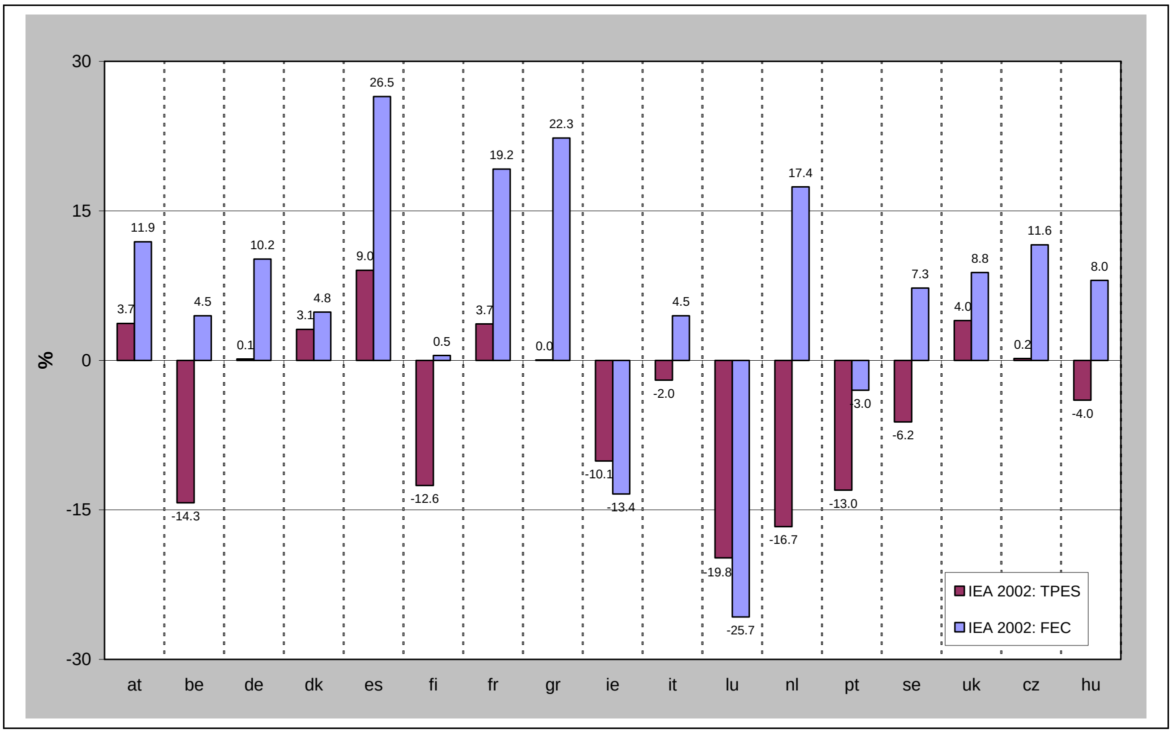
Source: IEA (2002), EEA (2003) and EC (2003); own calculations

Regarding the deviations in absolute terms, Italy shows the largest deviation with € 110 billion (IEA 2002), followed by Denmark with € 44 billion (EC 2003), Germany with -€ 43 billion (EC 2003) and the United Kingdom with € 27 billion (EC 2003). It can easily be seen that a small relative deviation in the projection of a country with a strong economy might be far more relevant than a relatively large deviation of a country with a small economy i.e. the relative deviation of Germany amounts only to -2% while the absolute deviation adds up to the same absolute deviation of Denmark, which could be identified as an outlier in relative terms. In general, if projections are compared in detail, it is advisable also to take into account the deviation in absolute terms.

Figure 2.17 illustrates the relative deviation of projections on TPES and TFC in 2010 as reported by IEA (2002) and EC (2003). In general, the TFC varies according to the development of the energy demand (demand side) while the TPES is influenced by the TFC on the one hand and by changes in conversion efficiency and supply systems (renewable energies, nuclear power, fossil fuels) on the other hand (supply side).

Much like the historic data, analogies regarding the deviation of TPES and TFC can be recognized. Although both the TFC and the TPES deviate positively and negatively and not inevitably in the same direction if individual countries are regarded, on average there is a trend that the TFC by IEA is higher than the reference data – inter alia due to the inclusion of feedstocks – and a negative deviation of TPES by IEA from the reference data. The reference data is not Eurostat but the secondary data source EC (2003) which is at least more or less based on Eurostat data in the past.

Figure 2.17 Relative deviation of projections on TPES and TFC in 2010 from reference projections



Source: IEA (2002), and EC (2003); own calculations

In conclusion, a uniform deviation structure of another data source from the reference projection cannot be identified for the socio-demographic; for the energy related projections there are similar structures as in the past.

Finally, it is not possible to determine which projections best reflect the real development in the future; uncertainty of the data persists. As expected, the different projections vary more significantly than the historic data did. In general, one should be aware of the fact that projected data and the related indicators are more uncertain and less reliable than historic data.

The assessment of data reliability and the comparison of the projections underline that the selected reference data are rather reliable; however, attention should be paid to the data quality of TPES data. Indications cannot be found as to why another data source should be more adequate. Important criteria for the selection of the reference database like accuracy, consistency, completeness and up-to-datedness have been largely considered but compromises had to be made as one data source does not meet all demands.

2.6 Combination of data from different sources

Since not all the data necessary for our analysis are provided by one data source, we inevitably had to compile our database from different data sources. The combination of different data sources might, however, undermine the reliability of the database if these different data sources are not fully compatible and consistent.

Some of the driving sources in our decomposition analysis are not affected by this problem, as they are calculated with data from the same source: the share of carbon in total greenhouse gases (carbon/GHG) is entirely calculated from UNFCCC (2005) data. The same applies to the conversion efficiency (TPES/TFC) which is calculated from EC (2003) data. For the calculation of other indicators, two different data sources are necessary. But for indicators which include population data (GHG/capita, GDP/capita), consistency problems do not emerge because the population data is rather reliable and does not deviate much between the different sources.

We have identified such consistency problems mainly with regard to the carbon intensity indicator (CO_2/TPES). The development of this indicator describes whether policies to reduce the energy related CO_2 emissions were successful or not. An extension of the share of renewables or nuclear sources, as well as efficiency improvements in energy conversion (mainly electricity generation) and fuel shifts from carbon intensive fuels (coal) to less carbon intensives fuels (natural gas), would improve this indicator. As long as this indicator is analysed on the macro level, we cannot identify consistency problems, since the calculation is based on just one data source for the TPES (EC 2003). But such incompatibilities of data become obvious if we leave the macro level and focus the analysis on the CO_2 emissions from fossil energy sources (CO_2/FPES). The reliability analysis (section 2.4.3, Figure 2.11 and Figure 2.12) has shown that the FPES data from UNFCCC (2005) is much below the Eurostat (2004b) data for several Member States. Moreover, the deviation of the UNFCCC from the Eurostat data is significantly different for each Member State. Correspondingly the vertical comparison of this indicator between different countries should be interpreted cautiously.

For this reason we have calculated the carbon intensity of the FPES with both data sources and have compared their development over time. A first observation is that for most Member States the time series which is calculated with data from UNFCCC (2005) for both the CO_2 emissions and the FPES, does not oscillate as much as the time series which is calculated with CO_2 emissions data from UNFCCC (2005) and FPES data from Eurostat (2004b). But this difference disappears if the linear trends of these time series between 1990 and 2002 are compared. These linear trends are almost identical for Austria, Denmark, Germany, Hungary, Italy, the Netherlands, Portugal, Slovenia and Spain and almost identical (i.e. parallel but slightly shifted) for Finland, France, Greece and Ireland. Only for Belgium, Latvia, Sweden and the United Kingdom do these linear trends of the carbon intensity deviate significantly and provide inconsistent results.[15]

[15] The Czech Republic, Estonia, Lithuania, Luxembourg, Poland and Slovakia do not provide FPES data in their CRF tables (UNFCCC 2005). It was, therefore, not possible to carry out this analysis for these Member States.

As a result, we conclude that it is possible to combine different data sources in our analysis and that the selection of the data source does not significantly affect the development over time. As a consequence we prefer to base the analysis of the carbon intensity on FPES data provided by Eurostat (2004b), also because this data set is more complete with regard to Member States and available years. However, the inconsistencies identified in the cases of Belgium, Latvia, Sweden and the United Kingdom have to be taken into account for the interpretation of the development of their carbon intensity.

2.7 Summary and conclusion

After having analysed the differences between the different data sources for trend data, it is impossible to identify a data source which is more adequate and at the same time complete for all Member States than the selected reference data (Eurostat 2003). The comparison of the different data sources does not reveal a homogenous picture, neither in regard to the deviation of individual data sources nor regarding country groups.

Table 2.4 Summary of standard deviations and outliers against Eurostat data (2003)

	Standard Deviation		Standard Deviation without outlier		Outlier			
	1990	2000	1990	2000	1990		2000	
	%	%	%	%	%	Country	%	Country
POP								
IEA (2002)	0.8	0.9						
EEA (2003)	0.3							
EC (2003)	3.9	2.2	0.6	3.3	18.7	Cyprus	8.6	Cyprus
GDP								
IEA (2002)	0.8	2.2						
EEA (2003)	0.8	0.4						
EC (2003)	5.9	5.3	4.3	3.3	20.7	Denmark	20.6	Denmark
TPES								
IEA (2002)	4.6	6.8						
EEA (2002)	8.3							
EC (2003)	11.8	2.2	4.2		54.3	Latvia		
TFC								
IEA (2002)	11.3	13.4	9.6	10.1	24.9	Portugal	39.5	Slovak Republic
EC (2003)	12.5	5.6	4.9	1.5	56.3	Latvia	26.7	Slovak Republic

Source: Own calculations

It can be summarized that for all data (POP, GDP, TPES and TFC) there are individual outlier countries which deviate substantially from the reference data. For most of the data sources used for comparison with the reference data, the standard deviation can be significantly reduced by excluding these outliers. Furthermore, most of the significant deviations are not affirmed by a second data source. In other words, data of the alternative data source also deviate from another. Correspondingly, there are no clear indications as to which of the data sources are more or less reliable than others. We believe, therefore, that basing our analysis predominantly on the reference data described above is justified, particularly since it is more complete than alternative data sources both with regard to years and to Member States.

In general, data for 1990, the base year of our analysis, are more difficult to generate than for other years, as fundamental structural economic changes took place during this period, particularly in the new Member States. Furthermore, the data collection in the new Member States might be more challenging as the documentation of data is often not as elaborated as it is in the EU-15 Member States. Due to the latter reason, data for the new Member States are often not available in their entirety.[16] All these aspects contribute to some of the deviations.

Nevertheless, the reliability of the reference trend data can be assessed as being fairly good in general, although the reliability of the TPES data is somewhat weaker. The deviations of other data from the reference data depend also on the characteristics of the considered data category: Population data do not vary strongly from one year to the next; correspondingly the deviations of the different data sources are, in general, also minor. GDP values, in contrast, fluctuate more intensively than population data; thus one has to generally accept larger deviations among different data sources. Regarding the energy data, the reliability of TFC is to a great extent acceptable. The TPES data, however, have to be interpreted more cautiously.

Projection data is basically more uncertain and less reliable. Correspondingly, the comparison of the different projection data for GDP, TPES and TFC has shown that the differences between the different data sources are more pronounced. It is, therefore, even more difficult to determine which data source is more appropriate than the other. But since the comparison did not reveal any indication that the selected reference projections are less adequate than others, we consider it justified to use these reference projections in our further analyses.

The analysis of the reliability of the reference data has revealed that different sources provide different values for individual countries in a single year. Correspondingly the international comparison between individual Member States might be difficult if the data for a single country deviates significantly. However, apart from this vertical comparison, our analysis is mainly focused on the analysis of the development over time of individual indicators within a country. In a horizontal analysis within a single country the deviations between different data sources often disappear if the deviations are more or less constant over time. For our horizontal analysis of the impact of policies and measure within a country, the deviations of different data sources are accordingly less important. But vertical comparisons between different Member States are more affected by these deviations and correspondingly have to be interpreted more carefully.

[16] The IEA (2002) database, for example, comprises only data from some of the new Member States.

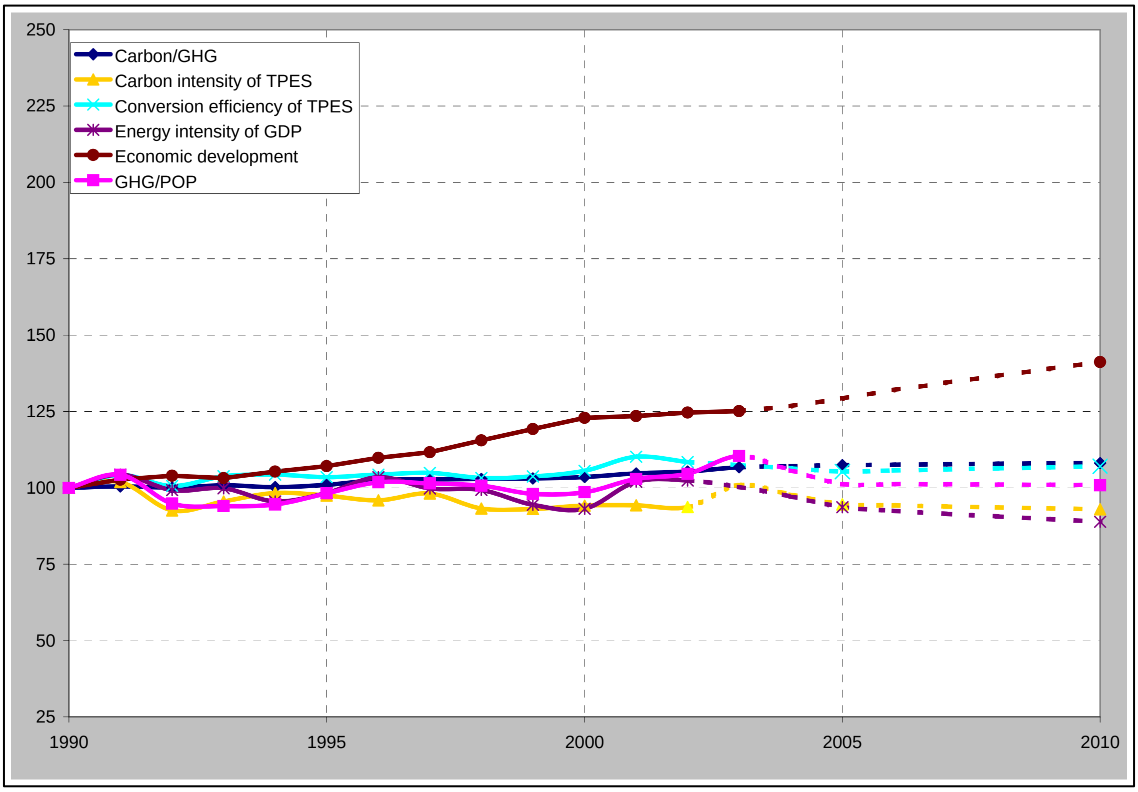
3 Results of the decomposition analysis

3.1 Austria

Austria's share of carbon dioxide (CO_2) in total greenhouse gas emissions has increased slightly in the second half of the nineties and is expected to continue to increase (Figure 3.1). In 2010 the share of CO_2 emissions will be almost 10% higher than in 1990. This points to the fact that policies to mitigate greenhouse gases other than CO_2 have been and will be more effective than CO_2 mitigation measures.

The carbon intensity of Austria's energy sector has oscillated in the past and is not expected to decrease substantially below the levels it already achieved in 2002. Since Austria has one of the lowest levels of carbon intensity in the EU, policies and measures that have the intention of decreasing the carbon intensity might not be very effective in Austria.

Figure 3.1 Driving forces of Austria



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency has slightly improved between 1990 and 2002 but will remain at that level until 2010. However, since Austria's conversion efficiency is already one of the highest in Europe, it will be difficult to increase substantially.

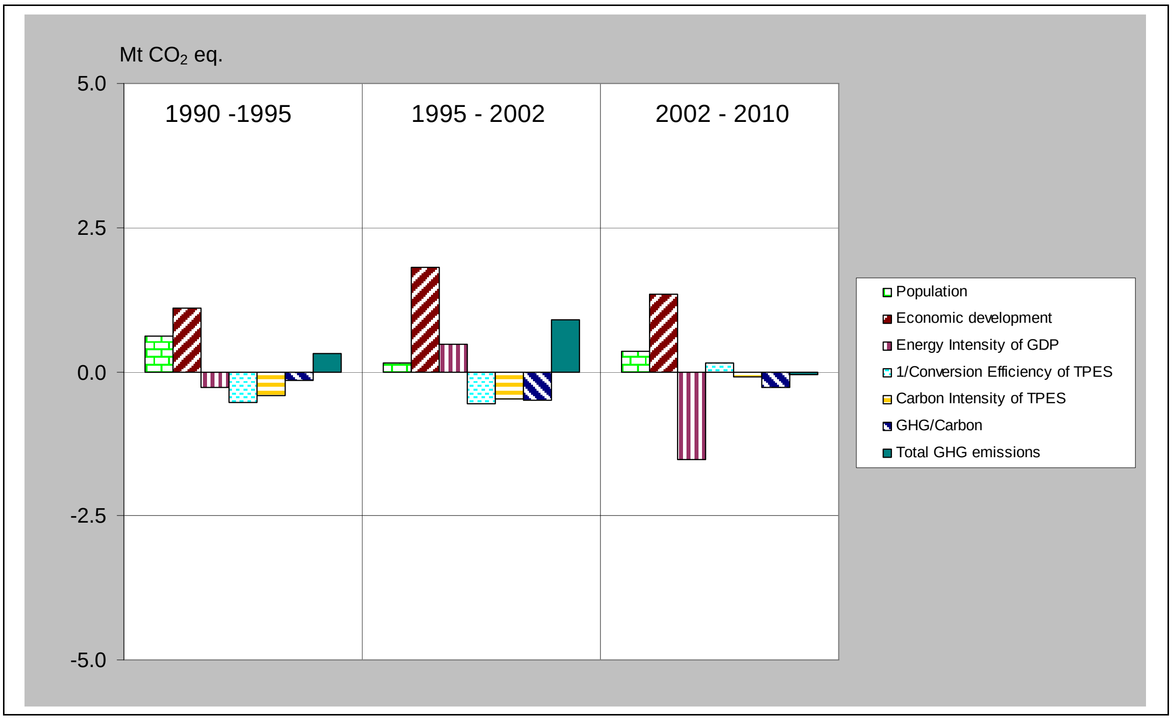
The energy intensity has improved continuously and is projected to increase further. In 2010, Austria's economy will consume 10% less energy on average than in 1990 to produce the same product. Its development is quite similar to the development in the EU as a whole, although Austria's energy intensity is slightly lower than the EU average.

The economic indicator increased almost constantly although at a lower rate in the early nineties and after the beginning of the new millennium. In 2010 the per-capita GDP in real terms will be almost 50% above the 1990 value. Since CO_2 and greenhouse gas emissions are projected to decrease further, the Austrian economy has decoupled significantly. In 2010 Austria will emit 20% fewer CO_2 and 30% fewer greenhouse gases to produce the same products as in 1990.

In the nineties, the per-capita greenhouse gas emissions in Austria increased and decreased several times. In the first years it is mainly influenced by the ups and downs of the carbon intensity, in the mid-nineties changes in the energy intensity of GDP exchange the influence of the carbon intensity. In 2000, the same ratio and in 2010 a slightly higher ratio of greenhouse gas emissions to population figures is attained or, respectively, projected.

Figure 2.3 shows that changes in carbon intensity – one of the lowest in Europe – and the conversion efficiency – one of the highest in the EU – did not contribute much to emission changes in the past and also up until 2010 no potentials are expected in this regard. Energy intensity, however, is projected to positively influence the greenhouse gas emission level in future although it had an increasing effect between 1995 and 2002. Therefore the trend reversal regarding energy intensity must be addressed by policies and measures.

Figure 3.2 Annual contribution of driving forces to the GHG emission trends and projections in Austria



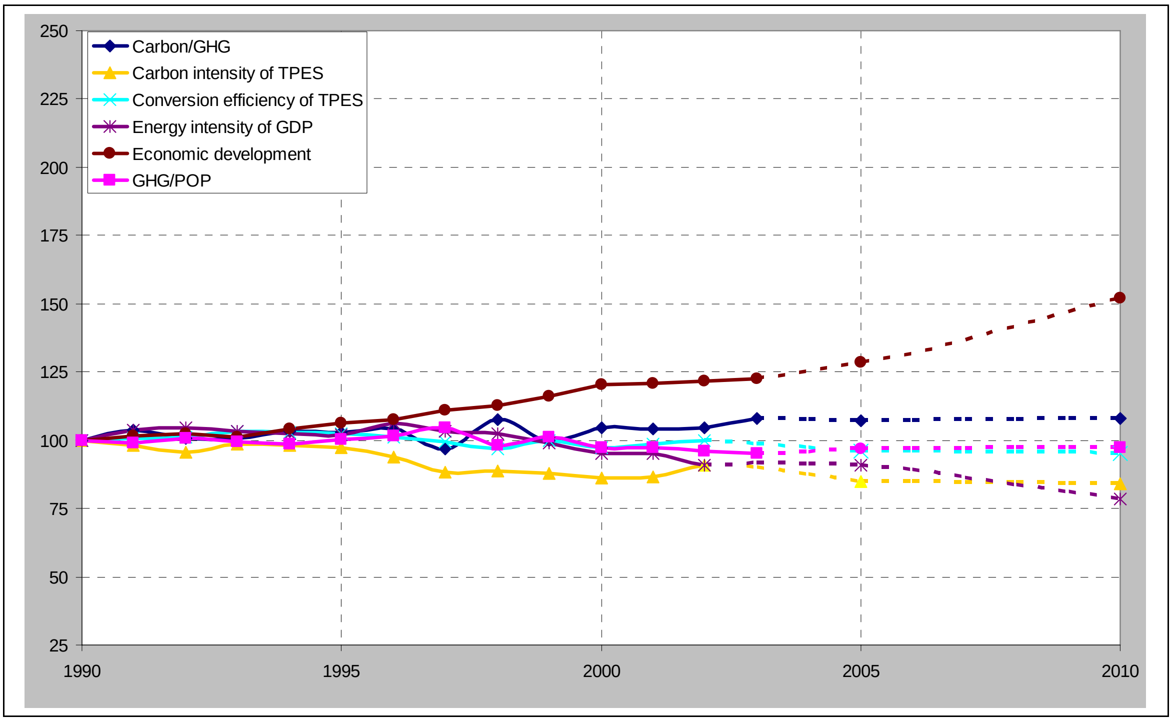
Source EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

3.2 Belgium

In the past the share of CO_2 in total greenhouse gases in Belgium remained almost constant (Figure 3.3). In the future it will increase only slightly since efforts to mitigate CO_2 and other greenhouse gases seem to be equally effective.

The carbon intensity of the Belgium energy sector has decreased above all in the second part of the nineties by about 10%. According to the projections it will continue to improve in the future although at a slower pace. In 2010, it will be more than 15% below the 1990 value. This is almost identical to the value of the EU as a whole.

Figure 3.3 Driving forces of Belgium



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency of the energy sector was improved slightly after 1990 but deteriorated once again thereafter. According to the energy and emission projections, it will decrease further and will be 5% below the 1990 level in 2010. This is clearly a sign that Belgium should adopt policies and measures that help to increase the conversion efficiency.

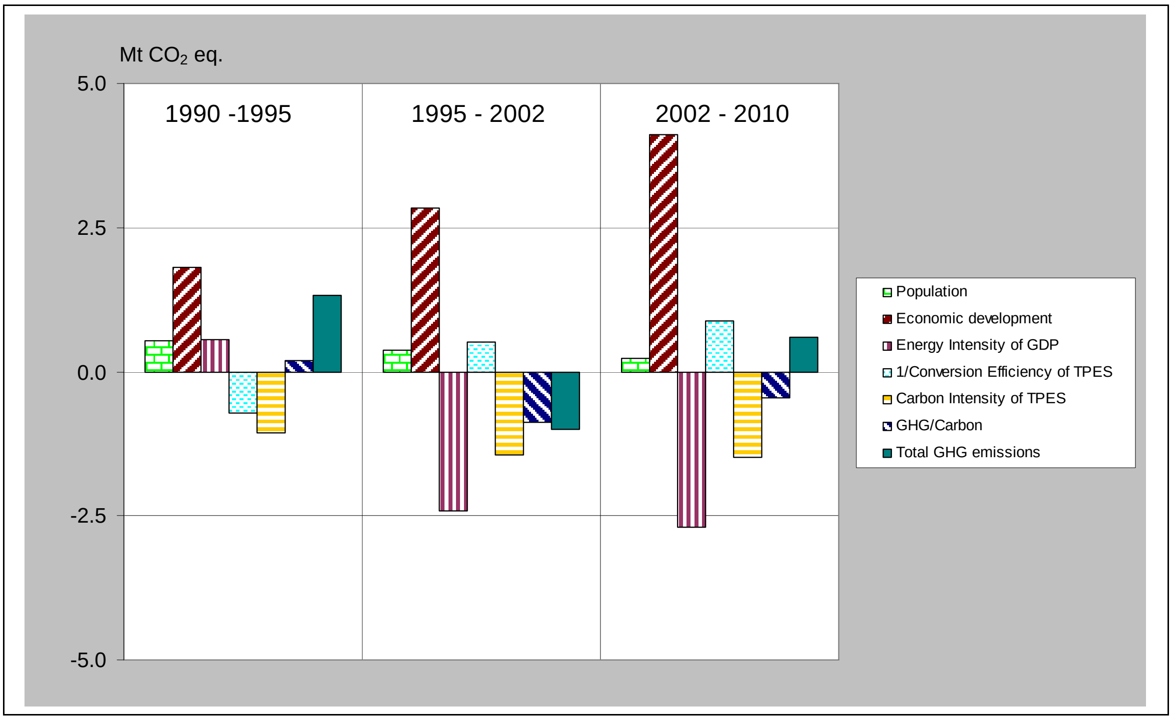
The energy intensity did not decline until 1998. However, since then it has decreased by about 7% until 2002 and is expected to improve further. In 2010 it will be more than 20% below the 1990 level, which is almost the same improvement that the EU as a whole is expected to achieve.

The economy developed much like the economies in most EU countries: slower growth rates or even a recession in the early nineties and after the year 2000, but more or less continuous growth in all other years. In 2010 the real gross domestic product per capita will be more than 50% above the 1990 value. At the same time, greenhouse gas emissions have decreased and are projected to decrease further. In 2010 greenhouse gas emissions per unit of GDP per capita will be a third lower than in 1990.

Greenhouse gas emissions per inhabitant in Belgium increased slightly in the beginning and decreased again at the end of the nineties; in 2000 the value of 1990 was almost reached again. This driving force is projected to be more or less stable at the 1990 value until 2010.

Figure 3.4 shows that the largest positive contribution to emission reduction at the end of nineties was achieved by energy intensity improvements which are projected to continue with a slightly higher annual contribution up until 2010. The deterioration of the conversion efficiency as well as the improvement of carbon intensity which started in the nineties are projected to continue up until 2010.

Figure 3.4 Annual contribution of driving forces to the GHG emission trends and projections in Belgium

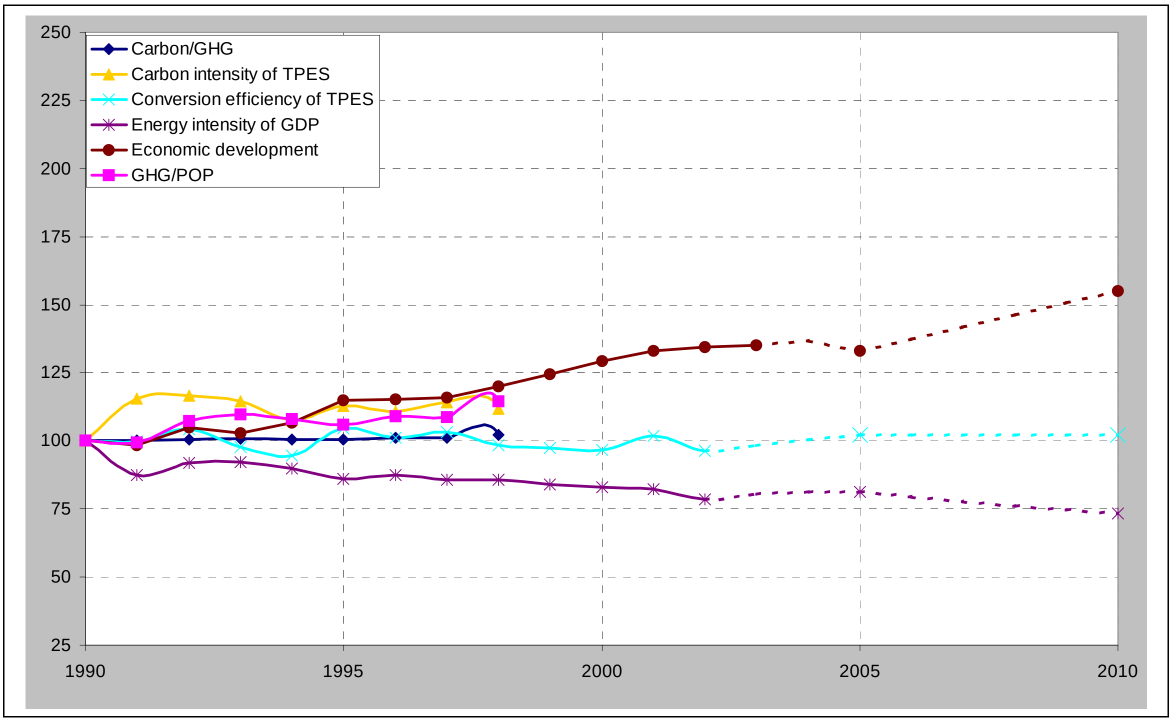


Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

3.3 Cyprus

Cyprus has provided neither a greenhouse gas inventory report nor greenhouse gas projections. Accordingly, only the energy indicators can be assessed. Figure 3.5 shows the conversion efficiency varied slightly in the past but remained more or less constant and is also not expected to improve substantially in the future. Thus, additional policies and measures that address the conversion efficiency might be quite effective.

Figure 3.5 Driving forces of Cyprus



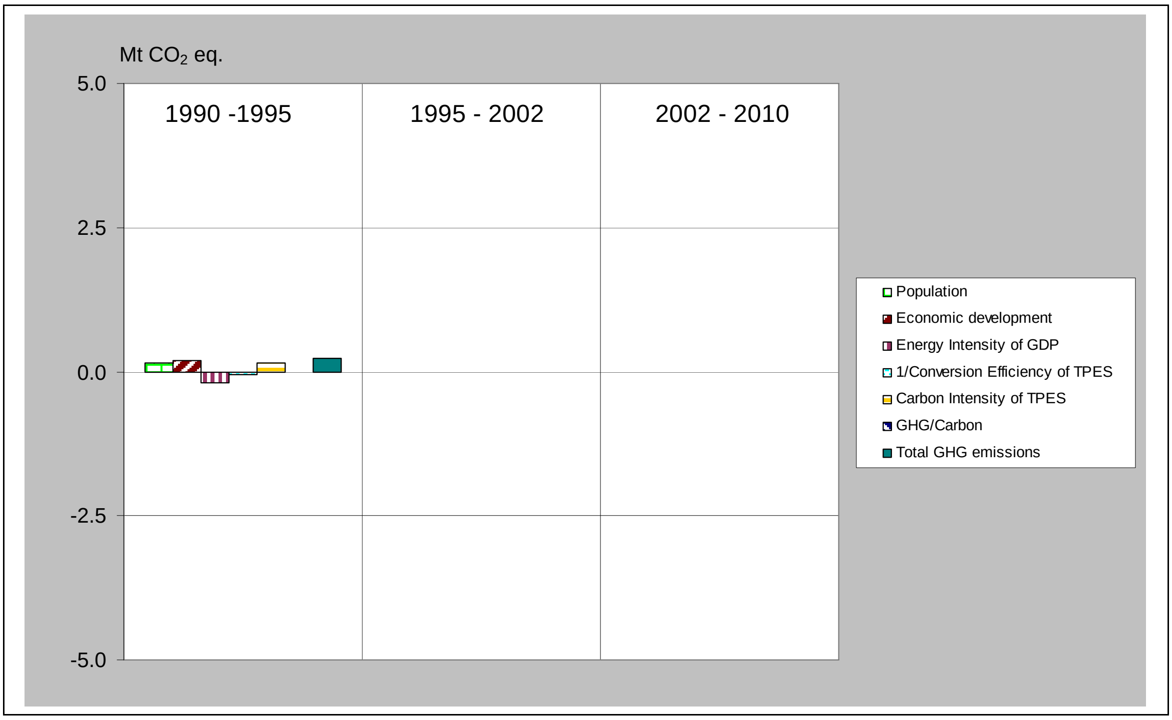
Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

The energy intensity was improved in the early nineties by about 10%. Since then it has improved only slightly but nevertheless continuously and is projected to improve further. In 2010 it will be more than one quarter below the level in 1990. The same product can then be produced with more than 25% less final energy than in 1990.

The economic development in Cyprus was more unstable than in most of the other European countries. The economy decreased in 1991, 1993 and 2002 and showed slow growth in 1996, 1997, 2002 and 2003 but grew substantially in the remaining years. According to the projections, growth will continue and will surpass the 1990 level by 2010 by about 55%. Since the growth is slightly stronger than the EU average, Cyprus can catch up a little with the EU average. Although data for greenhouse gas emissions are not available, it is very likely that greenhouse gas emissions decoupled parallel to the decrease of the energy intensity resulting from economic development.

Due to a lack of data and the small size of the country, the annual contribution of driving forces to the GHG emission trends and projections does not reveal significant insights.

Figure 3.6 *Annual contribution of driving forces to the GHG emission trends and projections in Cyprus*



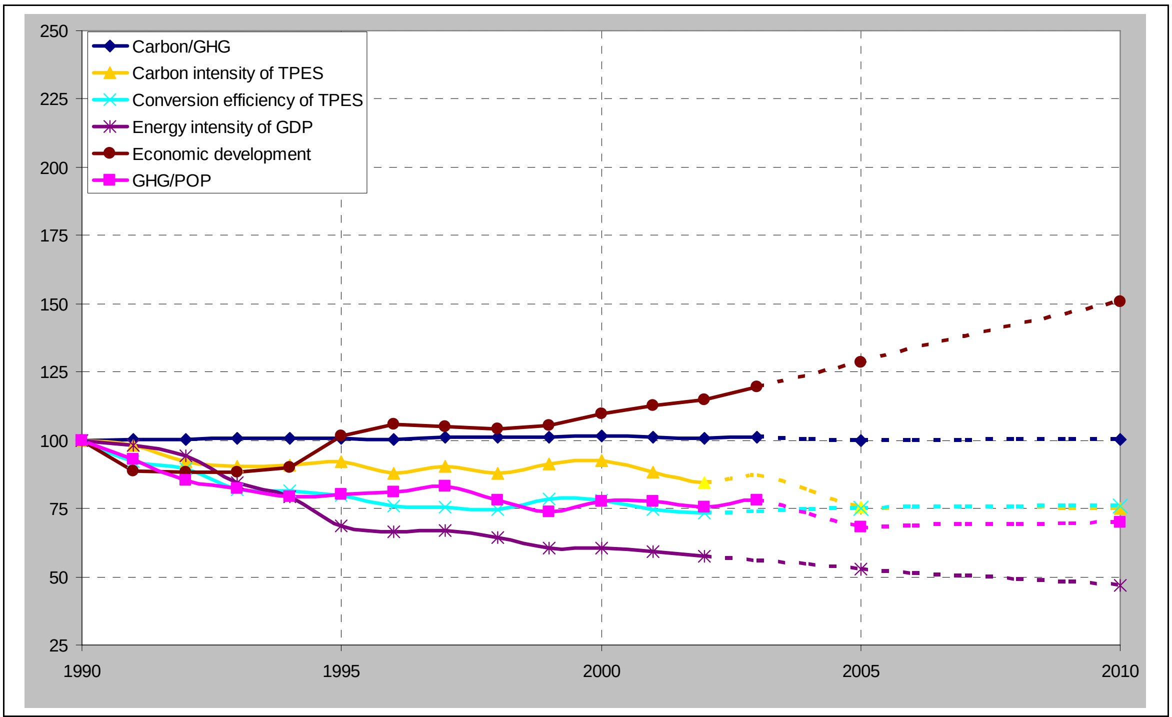
Source: *EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations*

3.4 Czech Republic

The share of CO_2 emissions in total greenhouse gas emissions remained rather constant between 1990 and 2002 at 85%. According to the projections, it will also remain at that level until 2010 (Figure 3.7).

The carbon intensity of the Czech energy sector decreased by about 10% in the first half of the nineties but remained at that level until 2002. However, the projections show that it will be reduced by 15 additional percentage points by 2005 and will stay at that level thereafter.

Figure 3.7 Driving forces of Czech Republic



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency varied somewhat but showed a downward trend up until 2002. By 2002 it had been improved by about 22%. However, it is expected to stay at that level in the future - clearly a sign that the conversion efficiency should gain more attention in the development of additional mitigation measures.

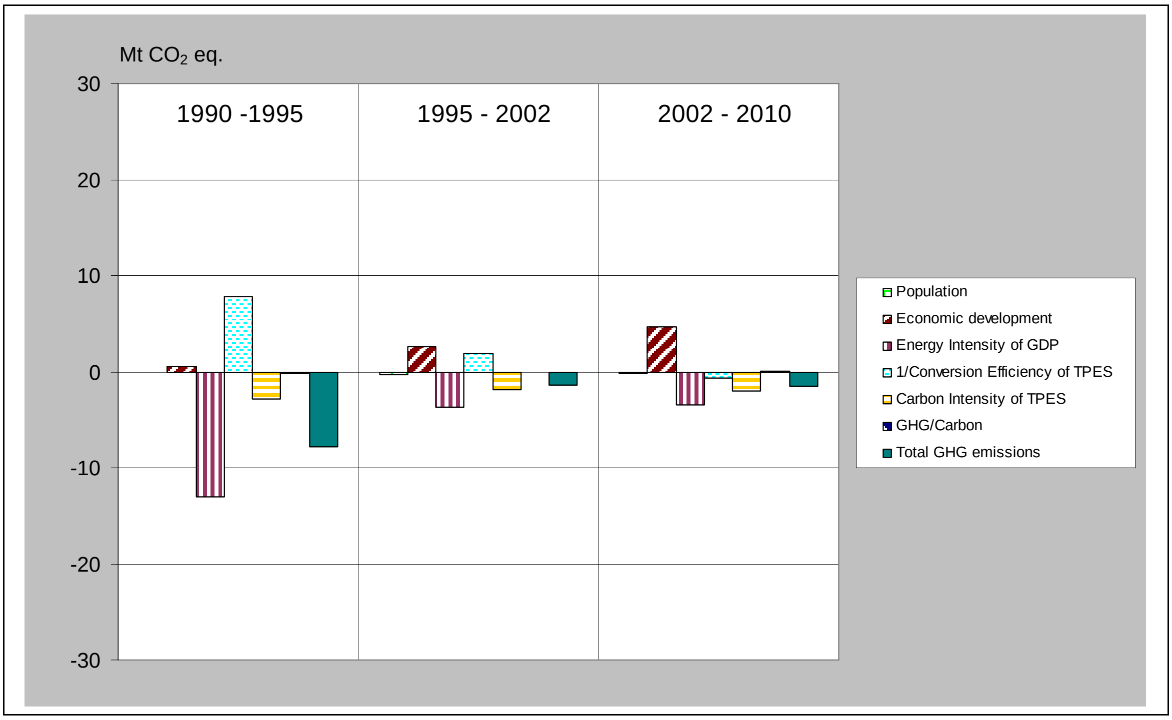
The energy intensity has decreased constantly in the past and is projected to decrease further. If the improvements can be realised in 2010 as projected, every product can be produced on average with less than half of the final energy that was consumed for the same product in 1990. However, one has to bear in mind that in 1990 the Czech Republic's energy intensity was more than six times higher than that of the EU-15 average. Despite the improvement, the energy intensity will still be three times higher than that of the EU--15 average in 2010. Further improvements seem to be possible if additional measures that address the energy intensity are adopted.

The economic development shows the same pattern that most other countries that acceded to the EU in 2004 do: A sharp downturn by more than 10% in the early nineties preceded a slow growth phase of several years without any growth until 2000, when it achieved the 1990 level again. According to the projections, the Czech economy will now grow at a constant rate to 150% of the 1990 level by 2010.

The per-capita greenhouse gas emissions in the Czech Republic clearly show a downward trend up to 2005, and then they will be stable or increase slightly but on a level which lies at about 30% under the base year value. The significant reductions of the per-capita greenhouse gas emissions up to 2005 can be attributed to significant reductions in energy and carbon intensity as well as to improvements in conversion efficiency. From 2005 onwards, the projected strong economic development negates further energy efficiency gains, so that no further reduction of the per-capita greenhouse gas emissions are expected.

Figure 3.8 shows that in absolute terms the decreasing energy intensity contributed by far the most to the emission reduction in the Czech Republic, which is a typical development in the new Member States. Although the annual contribution decreased after 1995, it is still the most influencing factor. While the conversion efficiency significantly delayed the emission reduction at the beginning of the nineties, this influence attenuates more and more, the conversion efficiency is projected to have a slightly decreasing effect on the emission trend up to 2010. The effect of the carbon intensity on the emission trend decreased slightly but is projected to remain more or less constant. In the future, the growth of the Czech economy will cause increasing GHG emissions, while all other driving forces have a compensating effect. The development in the Czech Republic over the whole period considered shows patterns similar to other new Member States.

Figure 3.8 Annual contribution of driving forces to the GHG emission trends and projections in the Czech Republic



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

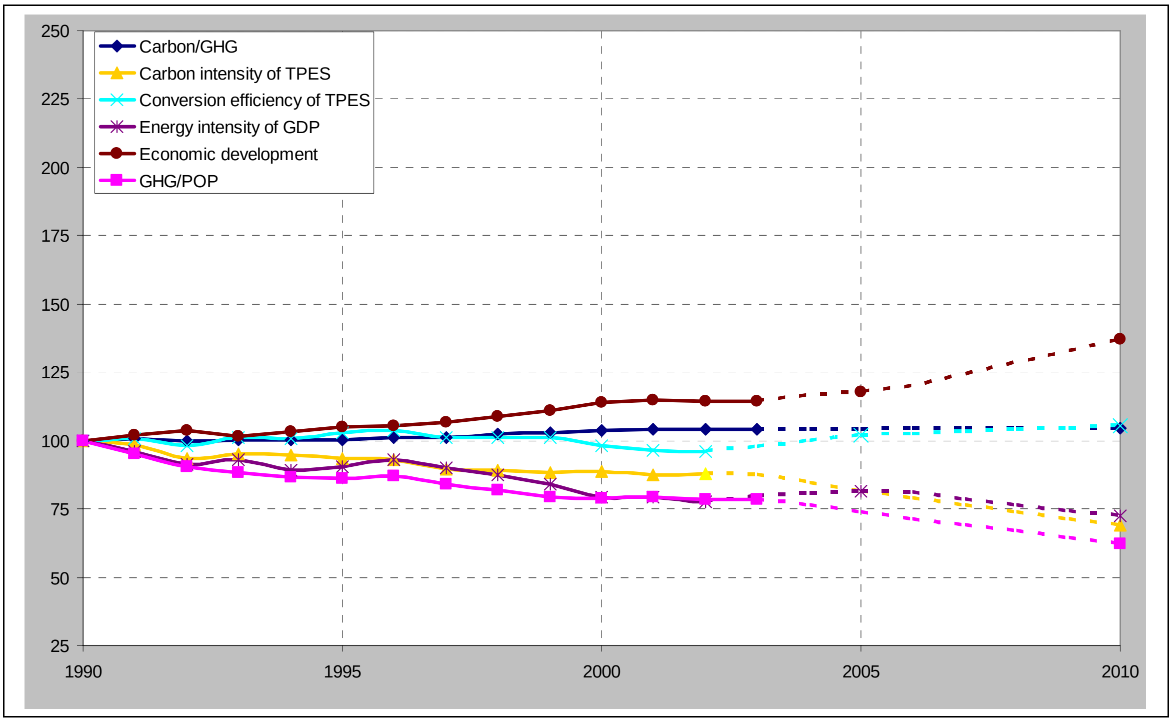
3.5 Germany

Germany's share of CO_2 emissions in total greenhouse gas emissions grew slightly between 1990 and 2002 but will decrease again almost to the level of 1990 (Figure 3.9). This indicates that efforts to reduce other greenhouse gases were more successful during the nineties. However, as these reduction potentials are being developed, mitigation measures have to focus on CO_2 once again in the phase between 2000 and 2010.

The carbon intensity of the energy sector decreased by about 12% up to 2002 and will decrease further. In 2010, the total primary energy demand will be supplied with 30% less CO_2 on average, mainly due to a shift from hard coal and lignite to natural gas and renewables. These indicators reflect the efforts of the German government to increase the share that renewable energies contribute to energy supply in Germany.

Up to 2000, the conversion efficiency varied more or less at the level of the year 1990 but decreased slightly thereafter. However, by 2010 it might be improved to 5% above the 1990 level.

Figure 3.9 Driving forces of Germany



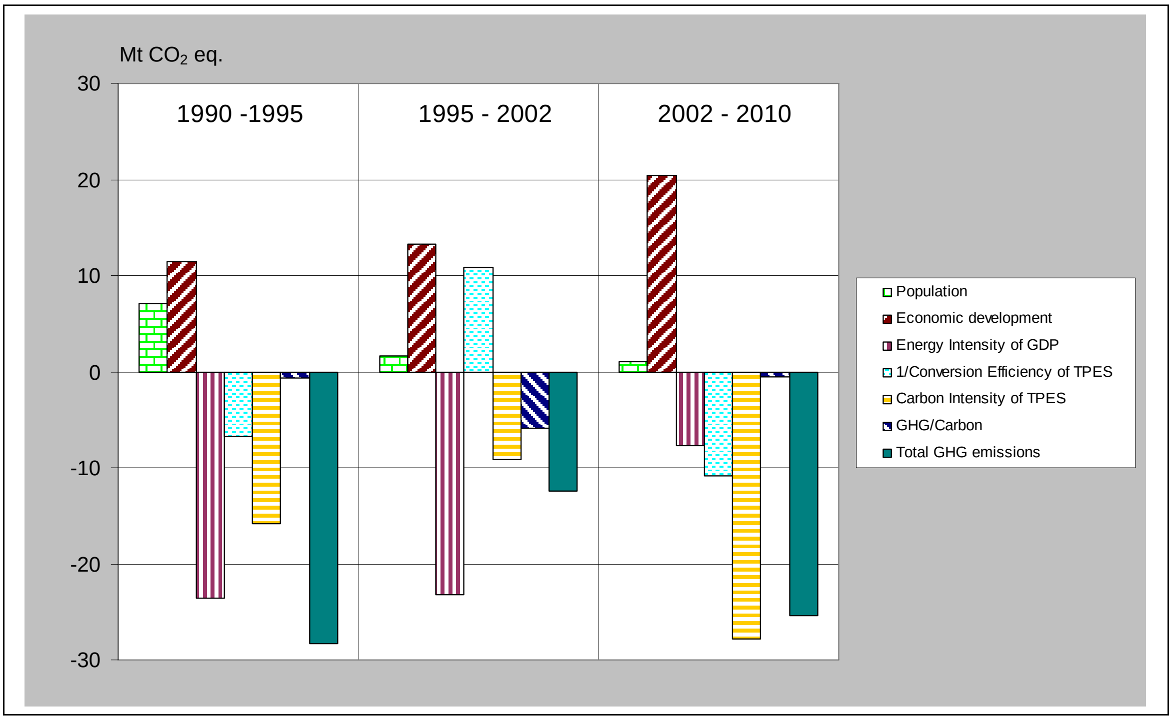
Source: EC (2003), EEA (2004), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), own calculations

The energy intensity of the German economy has developed in a similar fashion to the carbon intensity although it has experienced some ups and downs. Between 2002 it was improved by more than 20%, a rate which was exceeded only by Ireland and Luxembourg among the EU-15 Member States. However, a part of this success can be explained by the reunification and the much worse energy intensity in Germany's new *Länder* in the former east. According to the projections, the energy intensity can be further reduced below the 1990 level to 28% by 2010.

The real gross domestic product per capita grew in most years but decreased in 1993 and remained more or less unchanged between 2001 and 2003. For the second half of the first decade of the new century, GDP is projected to grow more strongly than in the years before and might increase to almost 38% above the level in 1990. Compared to other European countries, Germany's economic development is one of the lowest in the EU. However, due to low economic growth combined with decreasing greenhouse gas emissions, Germany can achieve a strong decoupling of its greenhouse gas emissions from economic development. In 2010 it will emit on average less than half the greenhouse gas emissions it emitted in 1990 to produce the same amount of products or services.

The per-capita greenhouse gases diminished significantly (20%) during the nineties. This strong downward trend is projected to continue further in the same magnitude just as Germany's carbon and energy intensity are also projected to decrease continuously up to 2010. The economic growth and the relative deterioration of the conversion efficiency cannot delay this trend. The German trend towards lower per-capita greenhouse gas emissions between 2002 and 2010 is by far the strongest among the EU-15 Member States. Within the context of all European Member States, it still accounts for the second strongest decrease in this period – after Lithuania.

Figure 3.10 Annual contribution of driving forces to the GHG emission trends and projections in Germany



Source: EC (2003), EEA (2004), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), own calculations

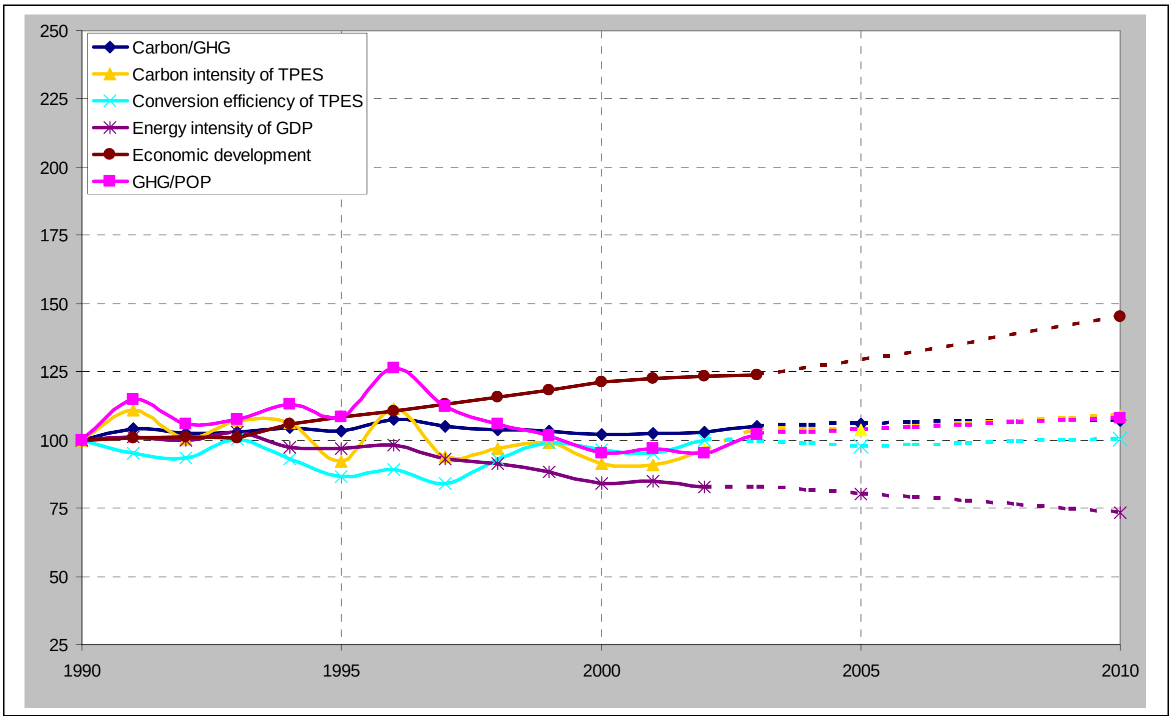
The results of the LMDI methods underline the trends described by quantifying the effects. Between 1990 and 2002 the decreasing energy intensity was influencing positively the greenhouse gas emission trend in Germany more than any other driving force. Figure 3.10 shows, however, that the improvement of the carbon intensity will play this role in the projections until 2010. Obviously a reversal of the trend regarding carbon intensity and conversion efficiency is projected. Deterioration of the conversion efficiency had an increasing emission effect between 1995 and 2002 and the contribution of the carbon intensity decreased in the second half of the nineties. However these two driving forces are projected to be responsible for the largest emission reductions until 2010 which should be reflected in the policies and measures.

3.6 Denmark

Some of Denmark's driving forces vary erratically (Figure 3.11 D). This is because Denmark's greenhouse gas emissions depend heavily on electricity trade with Finland, Norway and Sweden, whose electricity generation is to a larger extent based on hydro power plants. During dry years, Denmark exports electricity from fossil fuel plants to its Scandinavian neighbours, whereas it imports electricity from Finland, Norway and Sweden's hydro power plants during wet years.

The share of CO_2 in total greenhouse gas emissions rose initially but came down again to almost the same level as in 1990. However, it is expected to grow again up to 2010 and will then be more than 8% higher than in 1990. The possibility of reducing greenhouse gases other than CO_2 seems more likely in the future than the possibility of reducing of CO_2.

Figure 3.11 Driving forces of Denmark



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency of the Danish energy sector decreased substantially during the nineties but improved again towards the end of this period. According to the projections, it will rise again in the year 2010 to achieve almost the 1990 level. However, since the conversion efficiency is one of the highest in Europe and well above the average it does not seem very likely that it can be improved above the level already achieved in 1990.

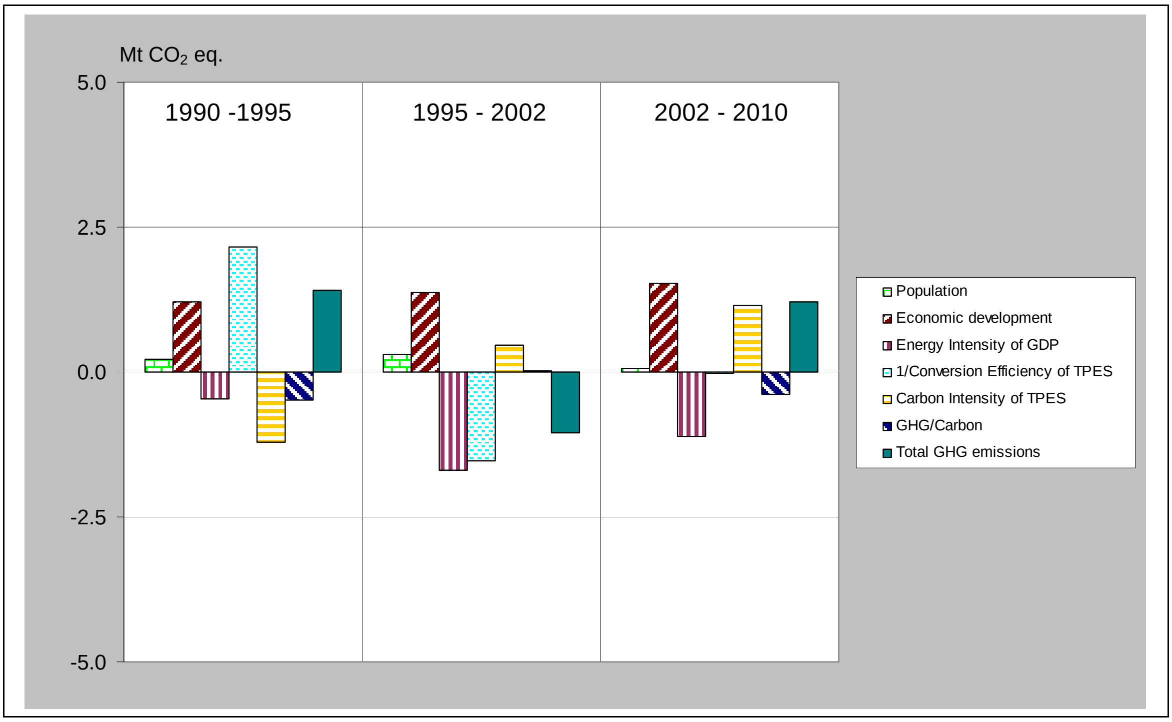
The energy intensity is not affected by variations in energy trade as it depends only on domestic supply and consumption. It had been improved by more than 15% between 1990 and 2002 and will be improved by 10 additional percentage points by 2010. Since the Danish energy intensity is one of the lowest in Europe, it will most likely be difficult to improve it through additional policies and measures beyond the projected levels.

Denmark's real gross domestic product per capita grew in a very continuous way except during the periods of 1991 to 1993 and 2002 to 2003, during which it remained almost constant. Since total greenhouse gas emissions grew at a slower pace, one can observe a decoupling of greenhouse gas emissions from economic development. However, the realised and expected decoupling in Denmark is lower than that in most of the EU-15 Member States, which can be explained by the already below-average value for greenhouse gas emission per GDP unit at the beginning of the nineties.

The course of the per-capita greenhouse gas emissions in Denmark is strongly influenced by the ups and downs of the other driving forces. There is a clear relationship between electricity generation and per-capita greenhouse gas emissions. In the year 1997, the per-capita greenhouse gas emissions reached a peak at a level which is about 30% above the 1990 level. Although it dropped again in 2000 below the 1990 level, it is projected to increase again by 10% above the 1990 level.

Figure 3.12 illustrates that the conversion efficiency deteriorated in the beginning of nineties, with the largest increasing effect on emission trend being – by far– in Denmark. At the end of nineties, however, a decreasing influence is evident, similar to that of the energy intensity in that period. The carbon intensity in Denmark which lies over the EU-15 average in 2002 and which is projected to deteriorate further up until 2010 seems to be the largest obstacle in achieving emission reductions.

Figure 3.12 Annual contribution of driving forces to the GHG emission trends and projections in Denmark



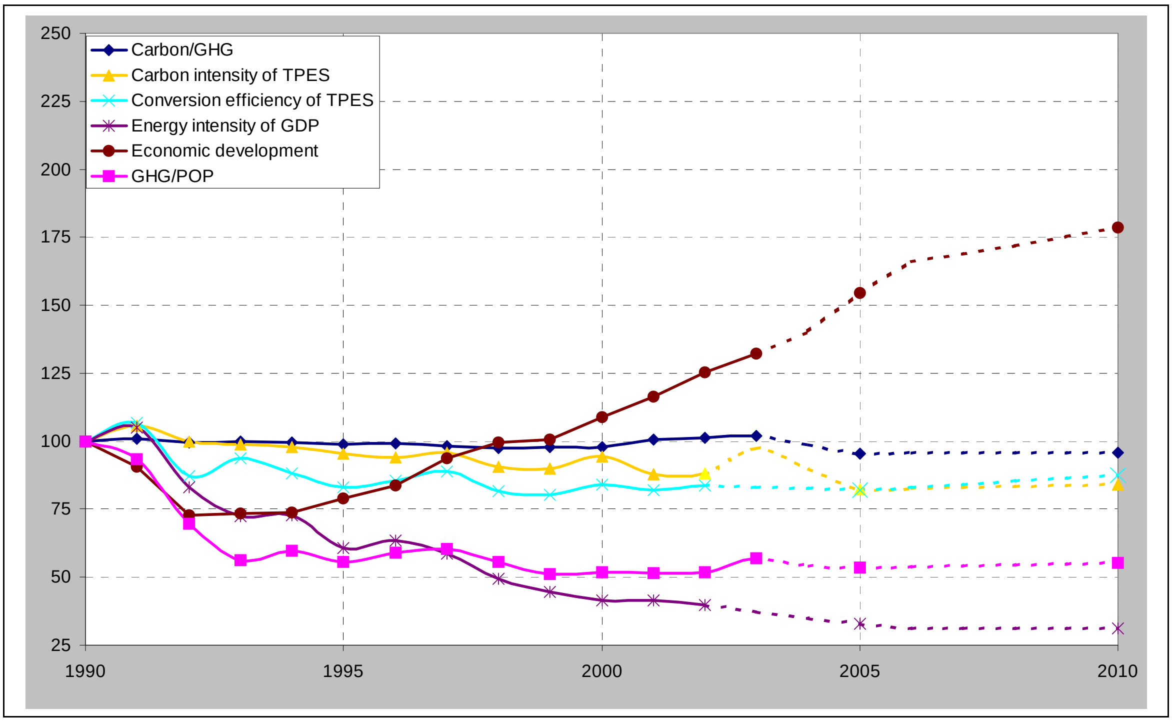
Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

3.7 Estonia

Estonia's share of CO_2 emissions in total greenhouse gas emissions has remained rather stable since 1990 (Figure 3.13), which indicates that the efforts to reduce CO_2 emissions were in line with the efforts to reduce other greenhouse gas emissions. In the future, the share will decrease slightly in such a way that the possibility of reducing CO_2 emissions is expected to be more realistic than the possibility of reducing other greenhouse gases.

The carbon intensity of the Estonian economy decreased by more than 10% between 1990 and 2002. Up to 2010 it will decrease further to 84% of the 1990 level. However, as it will still be remarkably higher than the EU average, there will be potential for additional reductions in the years after 2010.

Figure 3.13 Driving forces of Estonia



Source: EC (2003), EEA (2004), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency of the Estonian energy industry deteriorated substantially between 1990 and 2002. In the years to come, it will improve again slightly but remain more than 12% below the 1990 level, which is a clear indication that it can be improved further. However, since Estonia will achieve its Kyoto target without additional measures, it is not likely that this potential can be achieved before 2010, with the exception of developing it by means of additional demand from the European emissions trading scheme.

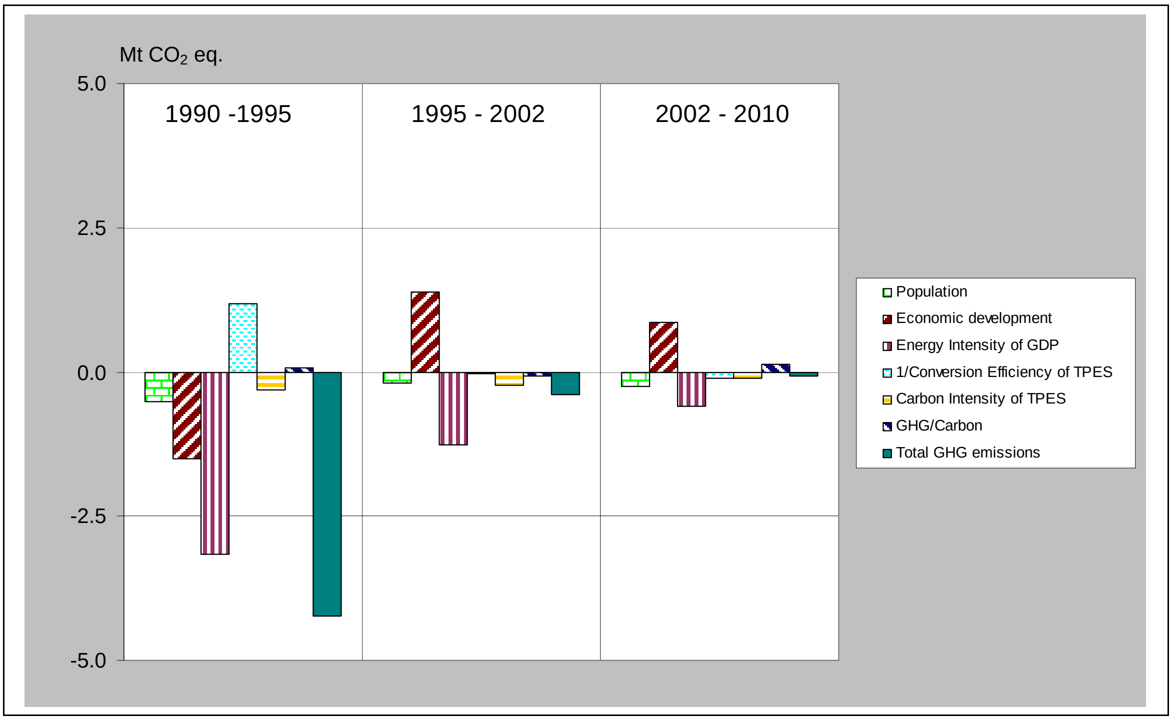
The energy intensity improved in an extreme fashion by more than 55% between 1990 and 2002 and will improve further to less than two thirds of its initial level. However, one has to bear in mind that it was the worst in the EU and will still be in 2010 four times higher than the EU average.

The development of the real per-capita gross domestic product typically applies to the new Member States. It decreased between 1990 and 1993 and started to grow thereafter, initially at a slower pace but then constantly at about 5% per year. Since it is projected that the growth rate will remain at that level, the per-capita gross domestic product will increase to 180% of its 1990 level. Along with decreasing greenhouse gas emissions, this development results in a remarkable decoupling of greenhouse gas emissions. However, in 2010 Estonia's greenhouse gas emission per unit of per-capital gross domestic product will still be more than seven times above the EU average.

Together with Luxembourg, Estonia showed the highest share of per-capita greenhouse gas emission in 1990. The very strong decline of the share by almost 50% up to 2002 compared to 1990 – one of the highest in the EU – and the subsequent stabilisation or, alternatively, the slight increase lead to a share in 2010 which will still be one of the highest in the EU.

The results of the LMDI method underline quantitatively the breakdown of the economy in the beginning of the nineties which is typical for several of the new EU Member States. Since 1995 the economic growth is compensated by all other driving forces. A similar development is projected up until 2010 but the contribution of all driving forces is not as distinct as it was at the end of the nineties. The population shrinking rate was highest in the EU at the beginning of the nineties and the one projected up until 2010 is also higher than the ones expected for the other Member States; in absolute terms, however, the influence on the emission level is minor.

Figure 3.14 Annual contribution of driving forces to the GHG emission trends and projections in Estonia



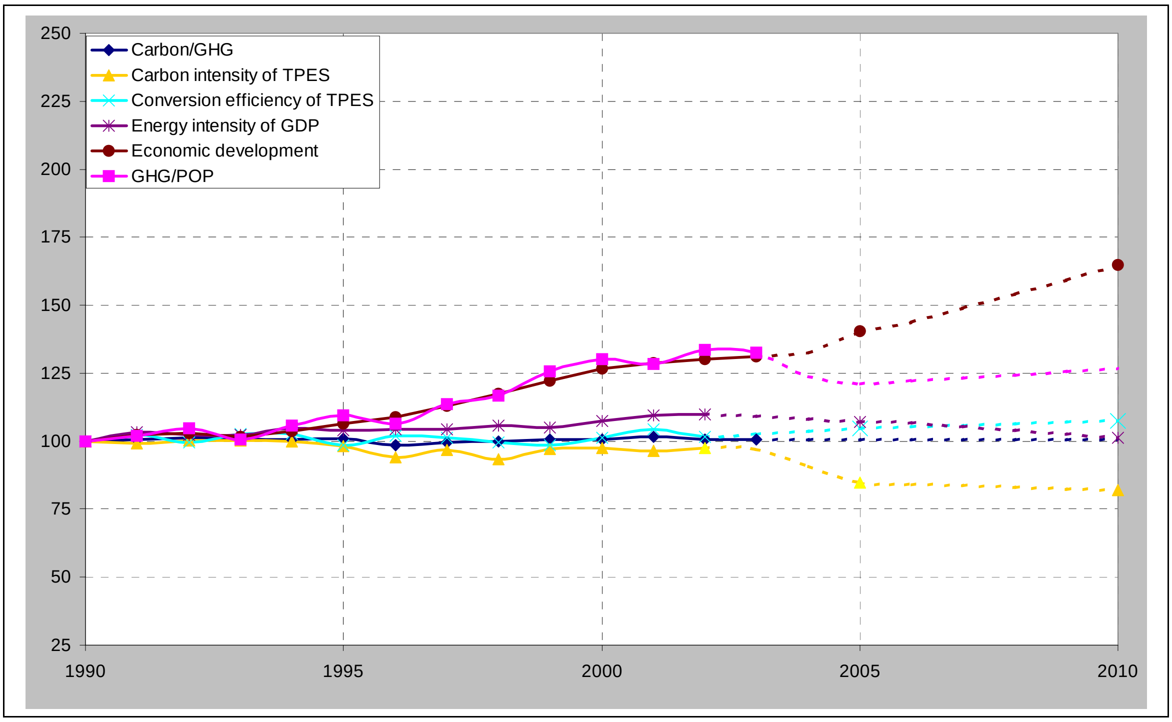
Source: EC (2003), EEA (2004), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), own calculations

3.8 Spain

Spain did not provide projections for total greenhouse gas emissions. Therefore, the future trend of the share of CO_2 in total greenhouse gas emissions cannot be assessed. But as it remained rather stable between 1990 and 2002 (Figure 3.15), it can be expected that it will also stay on that level in the years to come.

The carbon intensity of Spanish energy supply varied slightly between 1990 and 2002 but did not decrease significantly. In 2000 it was only 2% below the 1990 level. But since Spain has now adopted effective policies and measures to promote renewable energies, the energy intensity is projected to improve. In 2010 it will be almost 20% below the level in 1990.

Figure 3.15 Driving forces of Spain



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency of the Spanish energy sector varied between 1990 and 2000 around the 1990 level. According to the projections it will improve in a slightly better fashion than the conversion efficiency of the EU as a whole.

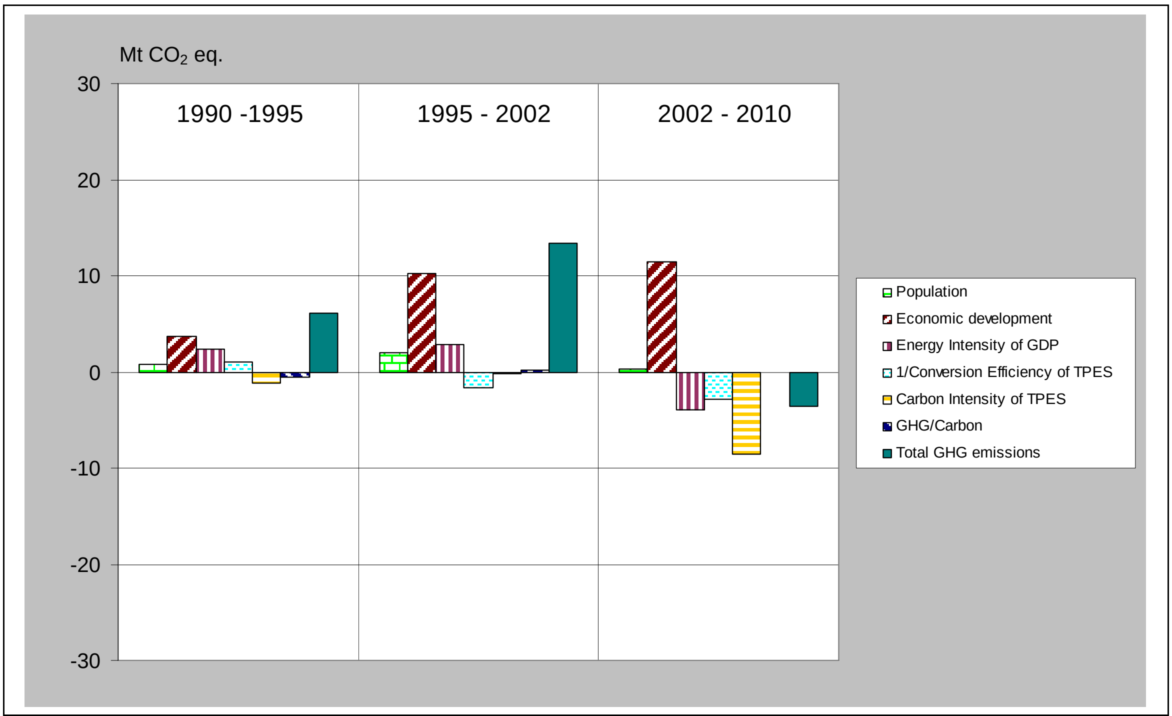
Besides Portugal, Spain is the only country of the EU-15 Member States that shows an increasing energy intensity in the period between 1990 and 2002. For the years to come it is projected to decrease again but will still be slightly above the 1990 level in 2010. Taking into account the improvements which other Member States have achieved with respect to these indicators, one can conclude that Spain might increase this potential through additional measures which address the energy intensity.

Between 1990 and 2002 the gross domestic product per capita grew on average by almost 2.5% in real terms. According to the projections, the growth rate will remain at that level so that the per-capita gross domestic product will increase to almost 165% of the 1990 level up to 2010. Although total greenhouse gas emissions grew and will continue to grow in Spain, they will not keep pace with economic development. However, at 23%, the decoupling in Spain is weaker than that of other European countries, again an indication that Spain might realize additional mitigation potentials if it adopts measures which improve the energy intensity in the Spanish economy.

The ratio of greenhouse gas emissions per inhabitant grew significantly in the last decade of the previous century, stronger than the other driving forces. The growth rate between 1990 and 2002 is similar to those of Portugal and Greece. However, while the ratio of the latter still continues to increase, in Spain the growth can be delayed. In absolute terms the ratio is – at least in 1990 – one of lowest in the European Union, similar to Portugal. In 2010 it will be still below the European average.

While in the past, the contribution of the strong economic development could not be compensated by the impact of other driving forces, it is projected that for the first decade of this century improvements of energy intensity, conversion efficiency and carbon intensity are significant enough to substantially reduce emission growth (Figure 3.16). Since the Spanish economy is expected to grow continuously, this seems rather ambitious and can be achievable through a multitude of effective policies and measures. At the beginning of nineties, improvements of the carbon intensity had a small positive impact on the emission trend which grew during the decade and is projected to continue to do so up until 2010. A strong trend reversal, however, is projected in regard to the energy intensity which ought to be adequately reflected in policies and measures by the Spanish government.

Figure 3.16 Annual contribution of driving forces to the GHG emission trends and projections in Spain



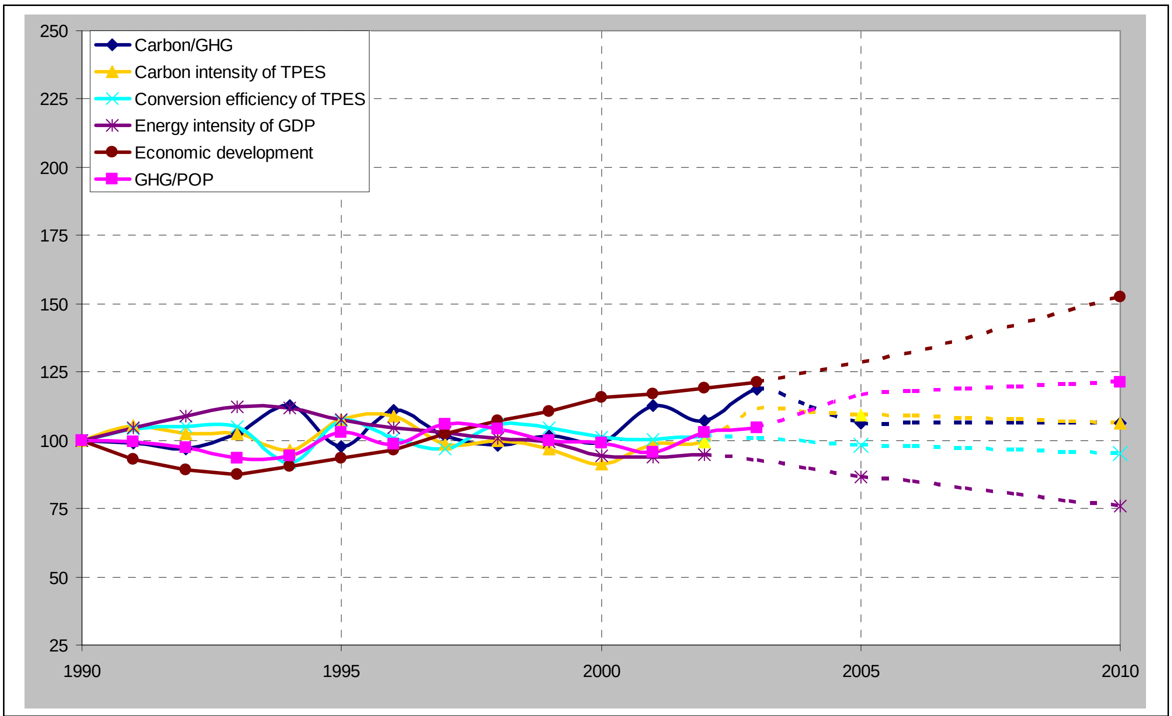
Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

3.9 Finland

Finland's share of CO_2 emissions in total greenhouse gas emissions increased only slightly between 1990 and 2002 (Figure 3.17) but is projected to grow a little bit more up to 2010, which underlines the fact that efforts to reduce other greenhouse gases are expected to be somewhat more successful than policies and measures to reduce CO_2.

The carbon intensity developed – similarly to the situation in Denmark – erratically, due to changes in the electricity trade balance of the Scandinavian countries. In 2002 it was some 5% below the level in 1990 and is projected to remain at that level until 2010. One has to bear in mind that the Finnish carbon intensity in 1990 was already below the European average. Taking into account the construction of a new nuclear power plant in Finland, which has been decided upon only recently, it can be expected that the carbon intensity will be reduced further. But since that plant will be put into operation only at the end of the recent decade, this decision will not influence Finland's carbon intensity performance in the period considered here.

Figure 3.17 Driving forces of Finland



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

Although the conversion efficiency developed erratically, it is more or less at the same level in 2002 as that in 1990. According to the projections, it will deteriorate up to 2010, but will nevertheless still be significantly above the EU average.

In 1990 the energy intensity was one of the highest of the EU-15 Member States. With the economic downturn in the early nineties it deteriorated further but has been improving constantly since 1994. In 2010 it will be almost 25% lower than the level in 1990. However, taking into account the improvements that are expected in other Member

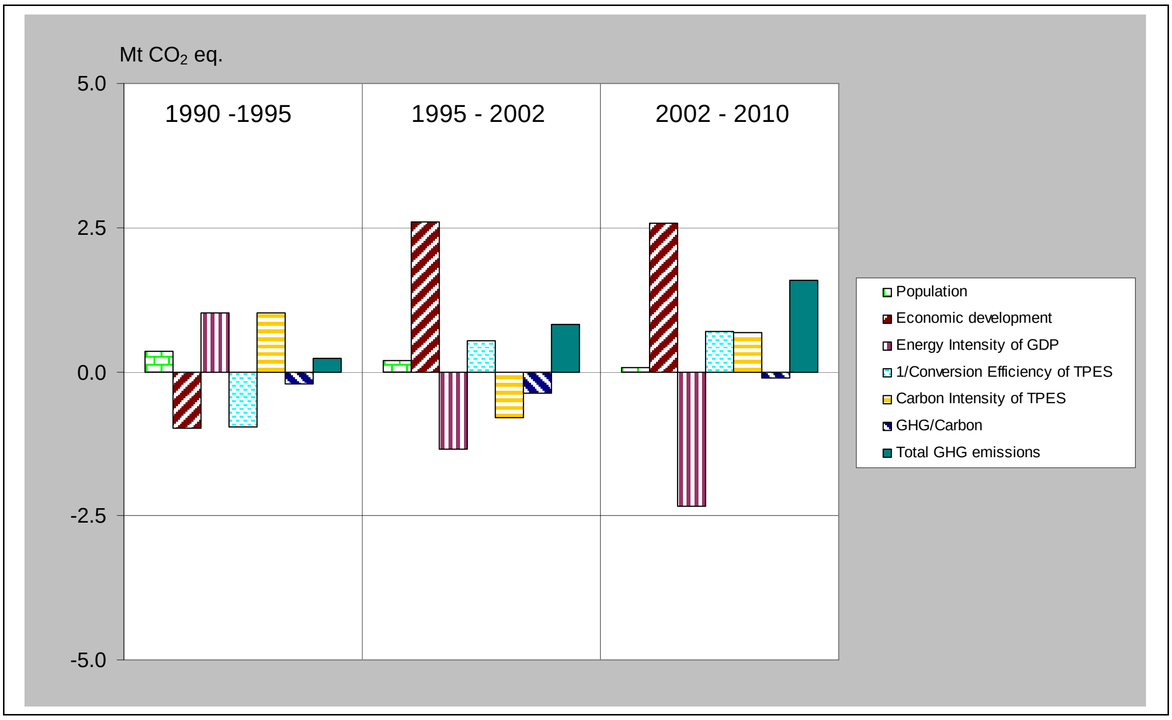
States, it seems likely that Finland can realise additional mitigation potential if it addresses this indicator with adequate policies and measures.

The economic development in Finland was different than the developments in the other EU-15 Member States and comes close to the developments in the new Member States in Central and Eastern Europe. It decreased between 1990 and 1993 but started to grow at a steady rate thereafter. In 2010 it might be more than 50% higher than in 1990. Since 1996, total greenhouse gas emissions are decoupled from the economic development, although less than the rate in other EU-15 Member States. However, a stronger decoupling can be expected when the new nuclear power plant is put into operation at the end of this decade.

Finland has the highest share of per-capita emissions in the EU-15 Member States both in 1990 and after a projected increase of about 10% will also have the highest share in 2010. This is probably due to the high energy intensity.

Figure 3.18 reveals the results of the LMDI decomposition method. In contrast to all other EU-15 Member States the shrinking economic development relatively improved the emission trend in the beginning of the nineties while the energy intensity had a deteriorating effect in the same order. Changes in conversion efficiency– Finland had one of the highest in the EU in 1990 – fluctuated in the nineties. In 1995 compared to 1990 it exerted a positive effect on the emission level, later on a negative one. In spite of the slight deterioration up until 2010, the conversion efficiency is turning out to be still one of the largest in the EU in 2010.

Figure 3.18 Annual contribution of driving forces to the GHG emission trends and projections in Finland



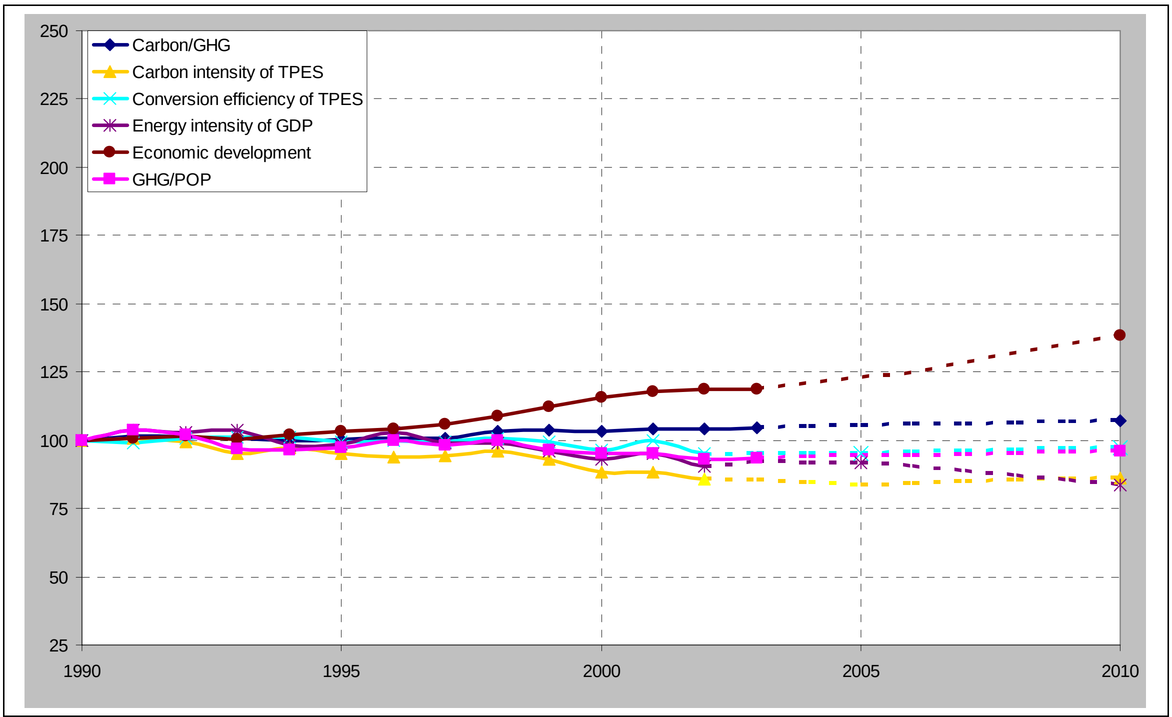
Source; EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

3.10 France

The share of CO_2 in total greenhouse gas emissions in France increased substantially in 1998 (Figure 3.19). Up to the end of the recent decade it will grow only slightly. Due to the fact that CO_2 emissions are expected to remain more or less stable whereas methane and nitrous dioxide are projected to decline, the share of CO_2 will also rise slightly in the future. In 2010 it will be some 6% above the level in 1990.

France's carbon intensity was already one of the lowest in 1990. Nevertheless, up to 2002 it decreased by about 10%. In the future it cannot be reduced much more but nevertheless by an additional 4 percentage points.

Figure 3.19 Driving forces of France



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency did not change very much but decreased to some extent between 1990 and 2002. Despite the trend to improve conversion efficiency in most of the European countries, this indicator will decline further in France, although only to a certain extent. In 2010 it will be more than 3% below the level in 1990. Taking into account the development in other European countries, one can conclude that it seems worthwhile to improve the conversion efficiency through additional policies and measures.

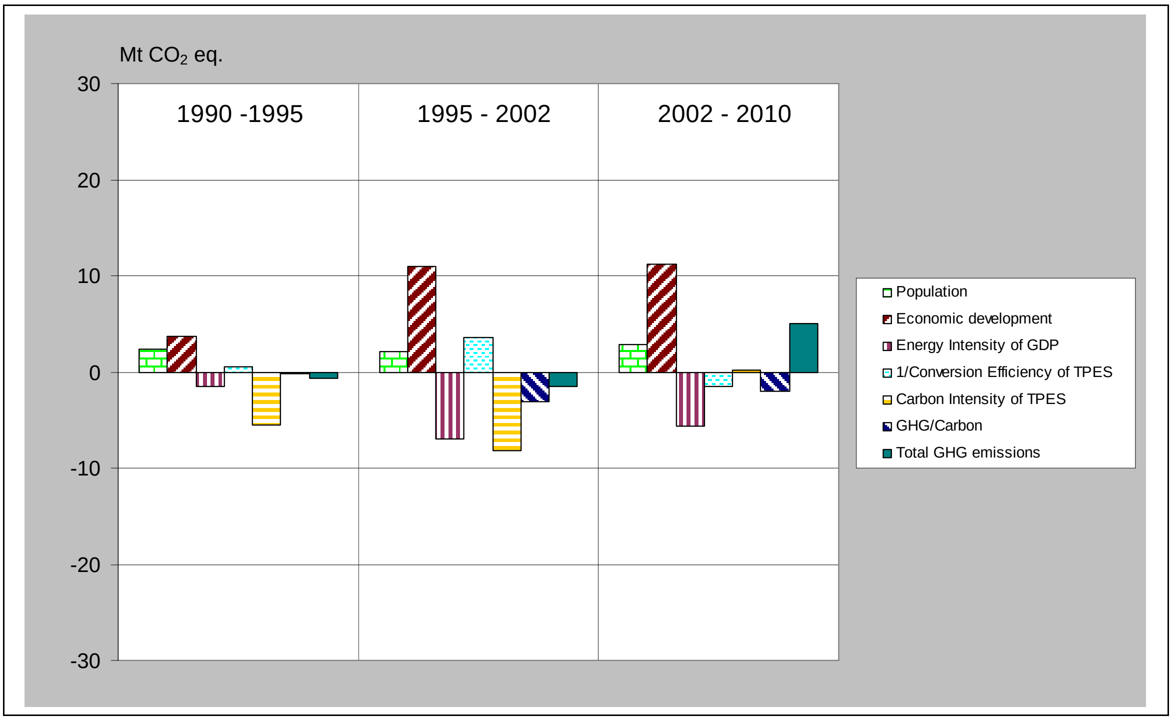
France's energy intensity was one of the lowest in Europe in 1990. Nevertheless, France managed to improve it by almost 7% by 2002. According to the projections, this trend will last until 2010, resulting in an energy intensity which is more than 16% below its 1990 level.

France's real gross domestic product per capita shrank in the years 1993 and 2003. In all other years it grew, substantially in part, at a somewhat slower pace (2001-2002). According to the projections, it will also continue to grow in the coming years. In 2010 it will be almost 40% above the level in 1990. Since total greenhouse gas emissions are expected to grow only slightly, a decoupling of total greenhouse gas emissions resulting from the economic development can be observed. In 2010, France will produce on average the same product with 30% fewer greenhouse gas emissions than in 1990.

The per-capita greenhouse gas emissions in France do not show significant changes, but show rather a slightly decreasing trend with some ups and downs of about -3% below the 1990 value.

Figure 3.20 shows that at the beginning of the nineties the diverse driving forces did not change much and had consequently a minor impact on the emission level. While at the end of the nineties the deterioration of the conversion efficiency and population and economic growth had to be compensated, it is projected that only the latter two have a significant increasing effect on the emission level up until 2010. The trend of deteriorating conversion efficiency is expected to stop having a positive effect on the emission level up to 2010. Regarding the energy and carbon intensity, a lower positive impact on the emission level up to 2010 is projected than these two driving forces exerted at the end of the last century.

Figure 3.20 Annual contribution of driving forces to the GHG emission trends and projections in France



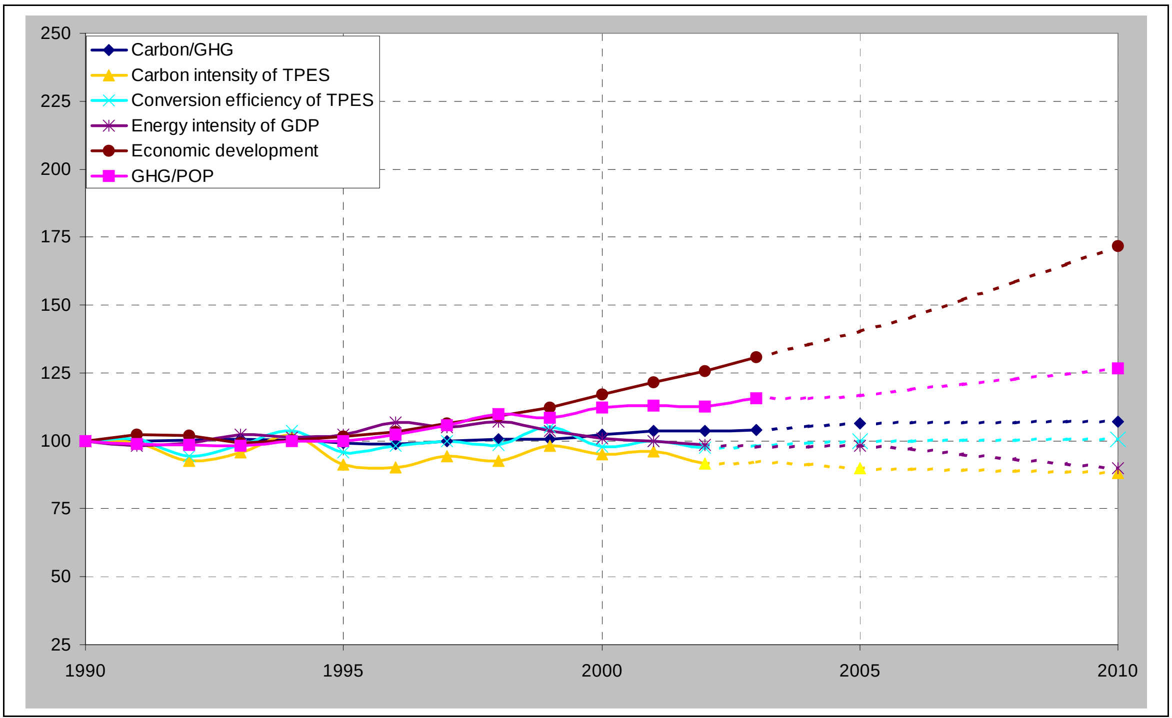
Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

3.11 Greece

Greece's climate indicators did not change very much and are projected to remain more or less stable until the end of this decade (Figure 3.21). This applies in particular to the share of CO_2 in total greenhouse gas emissions and to the conversion efficiency, which are expected to increase by less than 2% up until 2010.

The carbon intensity of the Greece energy supply fluctuated somewhat during the nineties but was almost 5% below the 1990 level in 2002. According to the projections, it can be reduced by almost 8 additional percentage points by 2010.

Figure 3.21 Driving forces of Greece



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

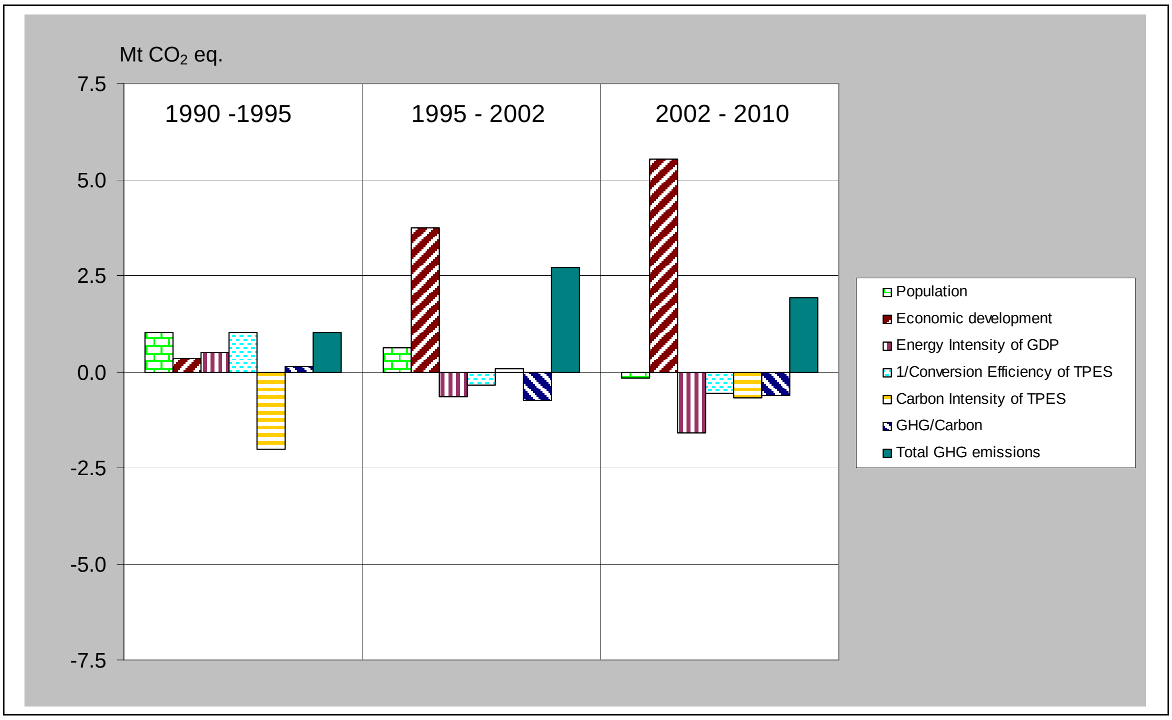
The energy intensity of Greece's economy did not improve, but rather deteriorated between 1990 and 1998. Only since then has it begun to decline. It is projected that this trend will persist until 2010, thus resulting in an energy efficiency 10% below the level of the year 1990. Since the energy intensity will still be then 35% above the average of that of the EU-15 Member States, there will still be potential for further improvements that can be addressed through additional policies and measures.

Greece's economy did not increase between 1992 and 1993 nor in 2002 but did in all other years. The per-capita gross domestic product in real terms grew by almost 2% per year during the nineties, and it projected growth of more than 3.5% per year until the end of the recent decade. In 2010 the Greece's per-capita gross domestic product will be some 70% above the level in 1990. Since total greenhouse gas emissions are growing at a lower pace than the economic indicators, one can observe a decoupling of the greenhouse gas emissions from the per-capita gross domestic product. However, the fact that greenhouse gas emissions per unit of per-capita gross domestic product in 2010 will still be twice as high as the average of those of the EU-15 Member States indicates that Greece can improve its performance through additional policies measures, in particular those which can improve the energy intensity of the Greek economy.

The per-capita greenhouse gas emissions are growing steadily. Although the energy and carbon intensity as well as the conversion efficiency remain stable or will decrease between 2002 and 2010, the per-capita greenhouse gas emissions are projected to increase due to the economic growth.

While in other Member States the changes in population did not have a significant influence on the greenhouse gas emission level (compared at least to the other driving forces), the high population growth in the nineties in Greece has a similar negative influence on the deterioration of the conversion efficiency. The improvements of the carbon intensity – Greece had the lowest in EU-15 in 1990 – could compensate all negative effects from the beginning of the nineties. Up until 2010, however, the very significant economic development is projected to be compensated by all other driving forces. The projected positive effects of energy intensity, carbon intensity and conversion efficiency for 2002 to 2010 on the emission level are significantly larger than those at the end of the last century. Thus, efforts have to be made to intensify the positive trend towards lower GHG emission levels.

Figure 3.22 Annual contribution of driving forces to the GHG emission trends and projections in Greece



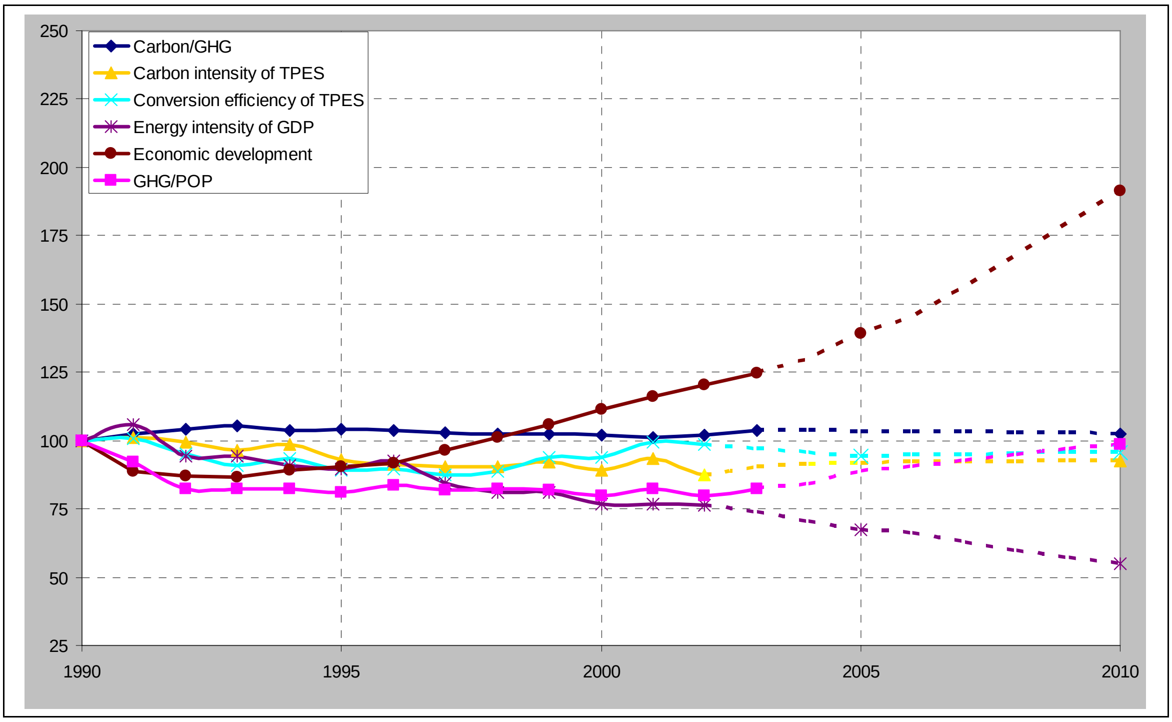
Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

3.12 Hungary

The share of CO_2 emissions in total greenhouse gas emissions basically did not change very much during the nineties (Figure 3.23). Until the end of the recent decade it will remain more or less stable. In 2010 it is expected to be some 4% below the level in 1990.

Both the carbon intensity of Hungarian energy supply and the conversion efficiency developed more or less in parallel during the nineties and will do so until 2010. However, the carbon intensity will then be 7% better than it was in 1990, whereas the conversion efficiency will be about 6% lower than it was in 1990.

Figure 3.23 Driving forces of Hungary



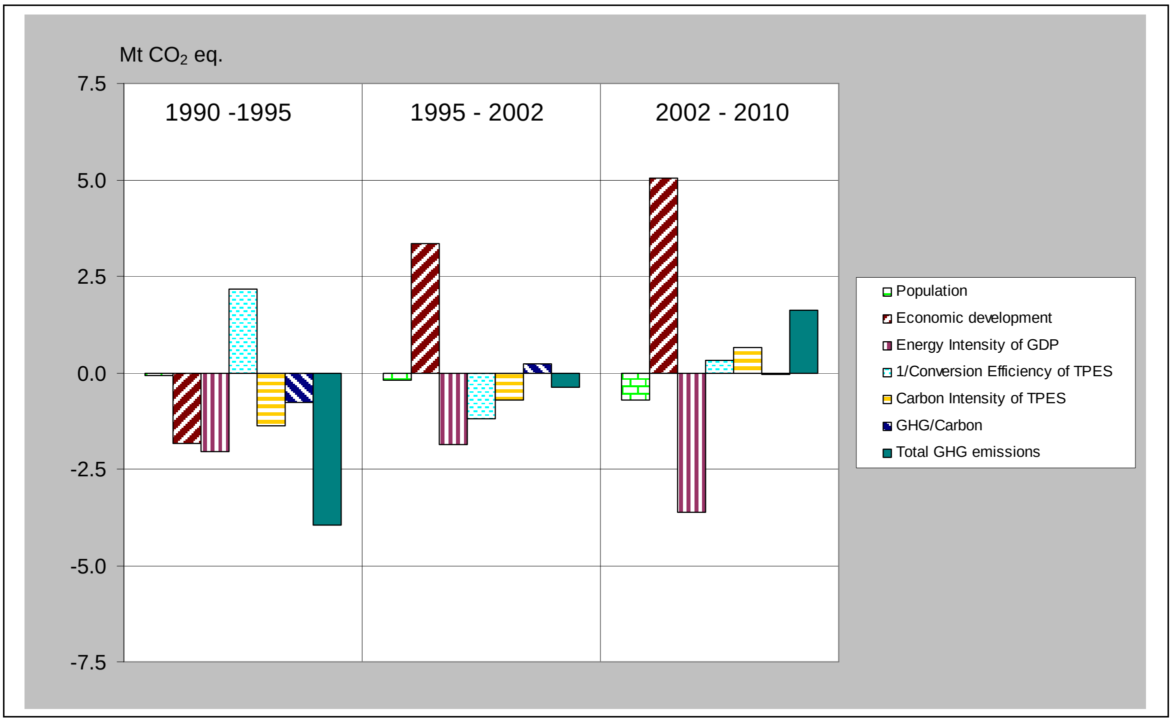
Source: EC (2003), EEA (2004), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), own calculations

Hungary has improved its energy intensity continuously. In 2002 it was almost 24% better than the level in 1990. According to the projections, the energy intensity can be reduced further and in 2010 will be about 55% below its level in 1990. Although Hungary's energy intensity is already better than the average of the new Member States, it is still substantially above the level of the EU-15 Member States. Correspondingly, there is still potential for improvements through additional policies and measures. But since Hungary can achieve its Kyoto target without additional policy measures, this potential might only be developed through the European emissions trading scheme.

The development of the gross domestic product per capita in real terms is quite similar to the development in Estonia. After a sharp downturn between 1990 and 1993, the economy rose again. In 1998 it had already exceeded the level of 1990 again and has continued to grow since then. According to the projections, the economy will grow on average by more than 5% per year during the period 2000 to 2010, resulting in a per-capita gross domestic product which is more than 90% above the level in 1990. Since total greenhouse gas emissions are expected in 2010 to almost achieve the level of 1990 assuming a substantial growth in the economy, a decoupling of greenhouse gas emissions from the per-capita gross domestic product can be observed. In 2010, Hungary will emit on average almost 45% fewer greenhouse gases than in 1990 to produce the same products. Hungary shows a course of the per-capita greenhouse gas emissions which is typical for the new Member States. In the first half of the period considered, the per-capita greenhouse gas emissions decreased. In the second half, they are projected to grow again beyond the 1990 level due to the high economic growth. Not even the projected decline in energy intensity of GDP can delay this development.

Figure 3.24 shows that the diverse driving forces of GHG emissions in Hungary are developing in a typical fashion for the new Member States. At the beginning of the nineties – like in the EU-9 average – only the conversion efficiency deteriorated, while due to the economic breakdown all other energy and emission driving forces showed a clear trend of improvement. While the conversion efficiency and the carbon intensity, along with the economic development, is projected to deteriorate the decreasing emission trend of the past, energy intensity improvements are expected to play a key role in keeping the emission level low.

Figure 3.24 Annual contribution of driving forces to the GHG emission trends and projections in Hungary



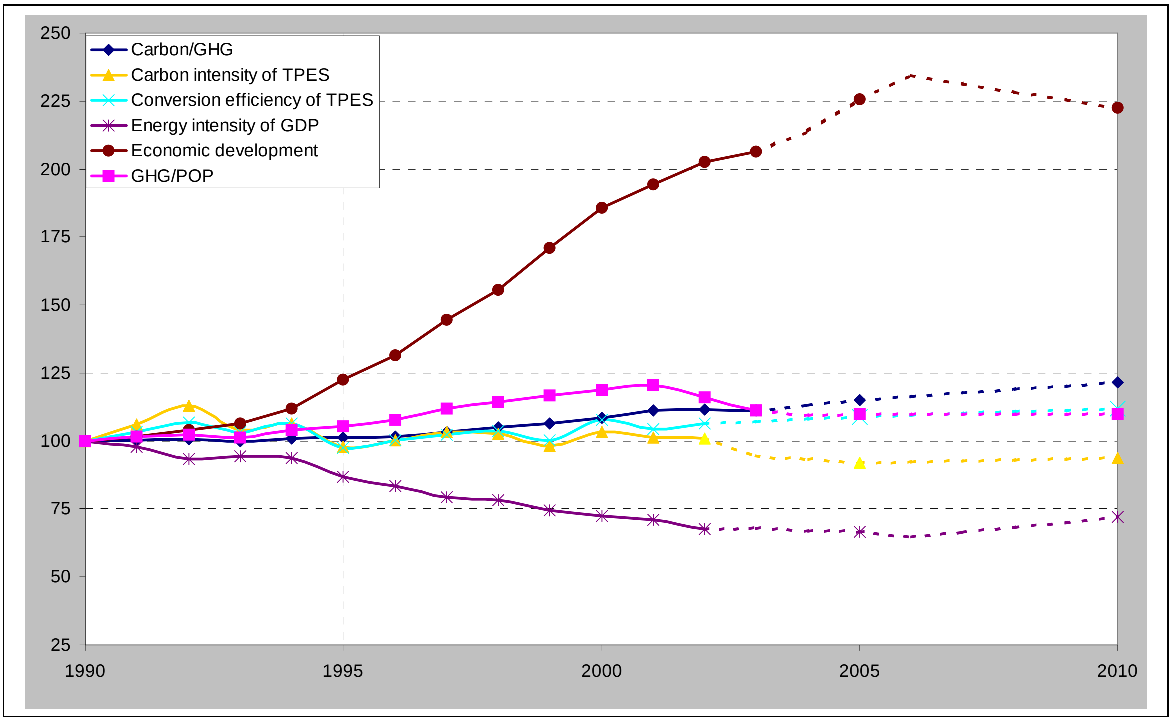
Source: EC (2003), EEA (2004), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), own calculations

3.13 Ireland

Ireland's share of CO_2 emissions in total greenhouse gas emissions grew continuously between 1990 and 2002 and will continue to do so up until 2010 (Figure 3.25). In 2010 it will be 20% above the level of 1990. Policies and measures to limit the increase of other greenhouse gases were obviously more effective than measures to limit the increase in CO_2 emissions.

The carbon intensity of the Irish energy supply varied somewhat during the nineties but remained more or less at the initial level. According to the projections, it can be improved slightly by 2010 by almost 7%.

Figure 3.25 Driving forces of Ireland



Source: EC (2003), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency varied likewise during the nineties. However, from 1995 onwards it improved continuously and will also do so in the future. In 2010 the conversion efficiency will be improved by some 14% compared to the level in 1990.

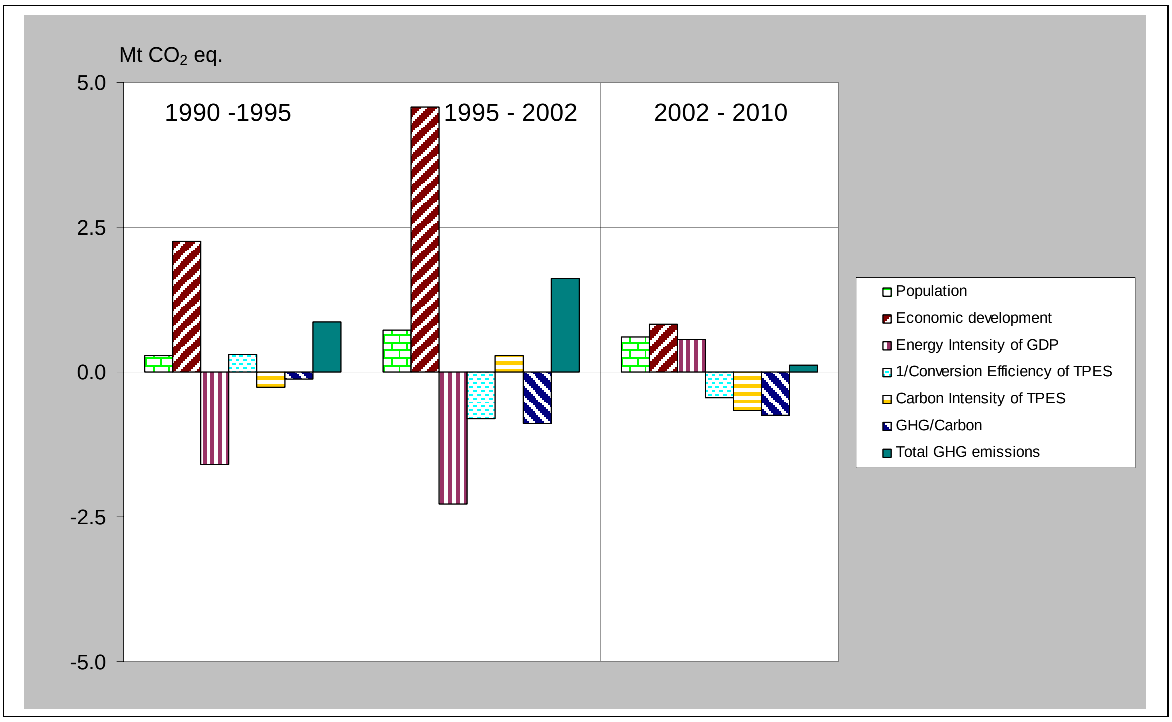
The energy intensity of the Irish economy was improved by almost 30% between 1990 and 2002. However, according to the projections it will remain at that level until 2010. However, since it would be somewhat above the average energy intensity of the EU-15 Member States by that time, further improvements might be achieved through additional policies and measures.

The economic development in Ireland is unique in Europe. The gross domestic product per capita grew continuously between 1990 and 2002, initially at a slow pace but then with real growth rates between 5 and 10%. According to the projections, this growth rate will not endure during the first decade of the new century. However, the economy will still grow on average by some 2% per year. In 2010 the real gross domestic product per capita will be more than 120% above the level in 1990. But since the total greenhouse gas emissions have grown and will continue to grow at a slower pace, greenhouse gas emissions have been decoupled from the economic development. By 2010 the greenhouse gas emissions per unit of gross domestic product per capita will have improved by more than 50%.

The per-capita greenhouse gas emissions show a remarkable decrease up to 2010 after a significant increase of per-capita emission at the end of the last century due to economic growth. This trend gives the impression that a reversal of the per-capita emission growth took place in 2002.

Figure 3.26 shows that while the effect of the high economic development and population growth was compensated by energy intensity in the past and from 1995 onwards by the conversion efficiency, the contribution of all driving forces to the GHG emission output is levelling. In Ireland, measures of GHG other than CO_2 had a significant positive influence on the emission level.

Figure 3.26 Annual contribution of driving forces to the GHG emission trends and projections in Ireland



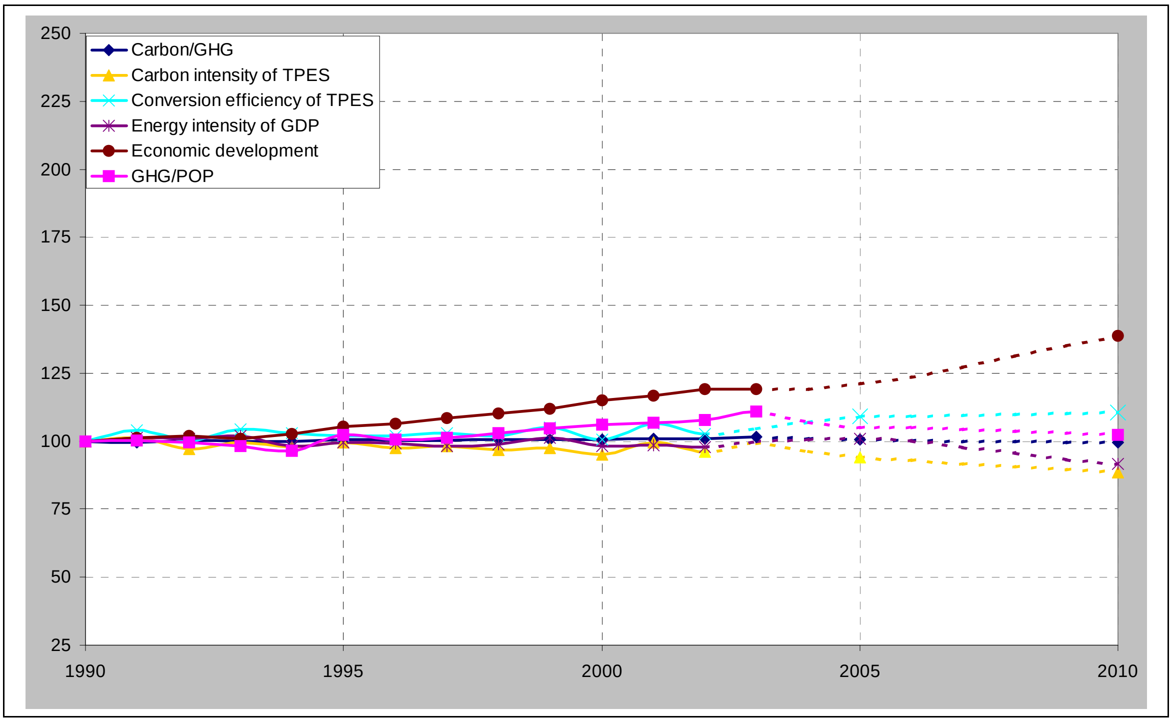
Source: EC (2003), Eurostat (2004b), UNFCCC (2005), own calculations

3.14 Italy

Italy's share of CO_2 in total greenhouse gas emissions remained absolutely stable during the nineties and will do so in the first decade of the new century (Figure 3.27).

The carbon intensity of Italy's energy supply has improved slightly but will deteriorate again up until 2010 so that it is only 2% below the level it was in the year 1990. Since Italy's carbon intensity is also above the average of the EU-15, there is still the possibility that it can be addressed by additional policies and measures.

Figure 3.27 Driving forces Italy



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency varied to some extent but developed basically on an increasing trend. Up until 2002 it has improved by more than 6% compared to 1990. According to the projections, it can be further improved by some 3 percentage points up until 2010.

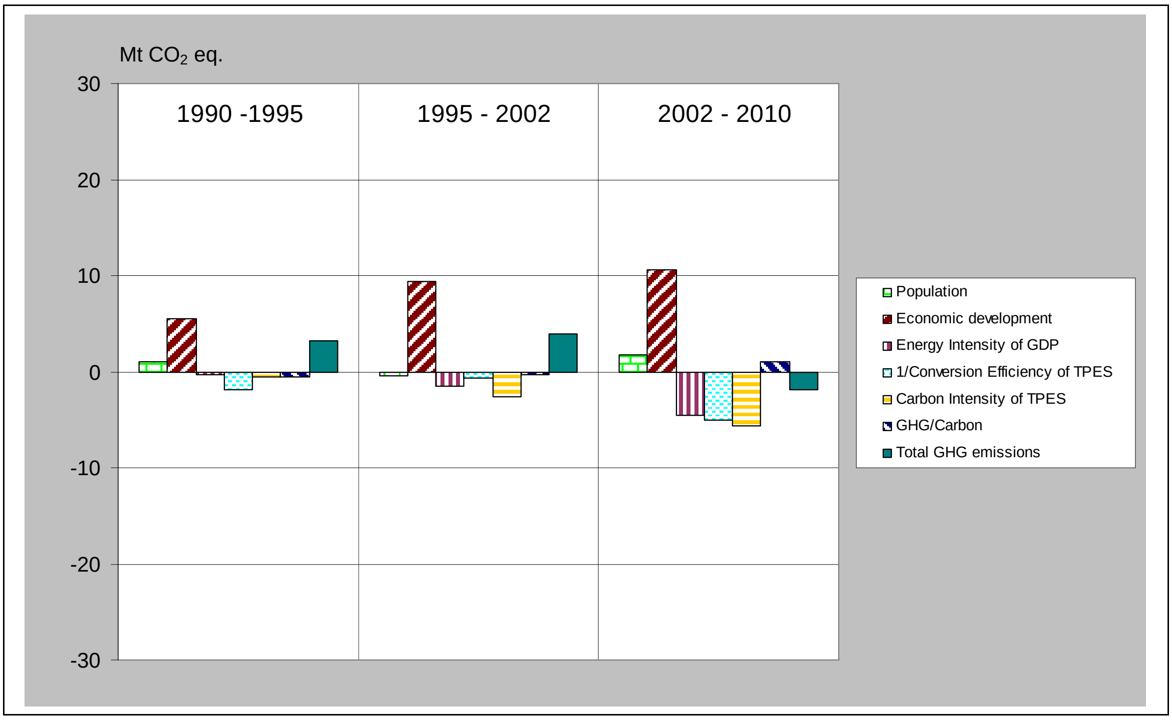
Since Italy's energy intensity in 1990 was already at the level of the average of the EU-15 Member States, it was not very much improved during the nineties and remained more or less at that level despite some variations. For the future it is projected to decline again but it will not catch up on the progress of the EU-15 Member States on the whole. In 2010, Italy's energy intensity will be almost 10% above the average of the EU-15.

Italy's development in the gross domestic product per capita in real terms is quite similar to that of most of the other EU-15 Member States: no or negative growth in 1993 and 2003 but continuous growth in all other years. According to the projections, the gross domestic product per capita will also grow in the future. In 2010 it is expected to be almost 40% above 1990 levels. Since total greenhouse gas emissions grew at a slower pace than the economy, a decoupling can also be observed in Italy. However, the projected improvements are some of the lowest in Europe among both EU-15 Member States and new Member States. In 2010, Italy will only emit 20% fewer greenhouse gases to produce the same products as in 1990.

Regarding the per-capita greenhouse gases, Italy shows a continuous upward trend between 1900 and 2002 and between 2002 and 2010. While the EU-15 Member States show on average a decline in the per-capita emissions during these periods, Italy, on the other hand, goes against the European trend.

Figure 3.28 gives a quantitative overview of the annual contribution of the driving forces to the GHG emission trends and projection in Italy. While at the beginning of the nineties the emission level rose due to the economic and population growth, the energy related driving forces improved slightly at the end of the nineties and are projected to reverse the emission trend up until 2010 – compensating even higher economic and population growth. The strong increase in contribution to a positive emission trend of the energy related driving forces indicates that potentials are identified and must have been addressed by policies and measures in order to achieve this positive development.

Figure 3.28 Annual contribution of driving forces to the GHG emission trends and projections in Italy

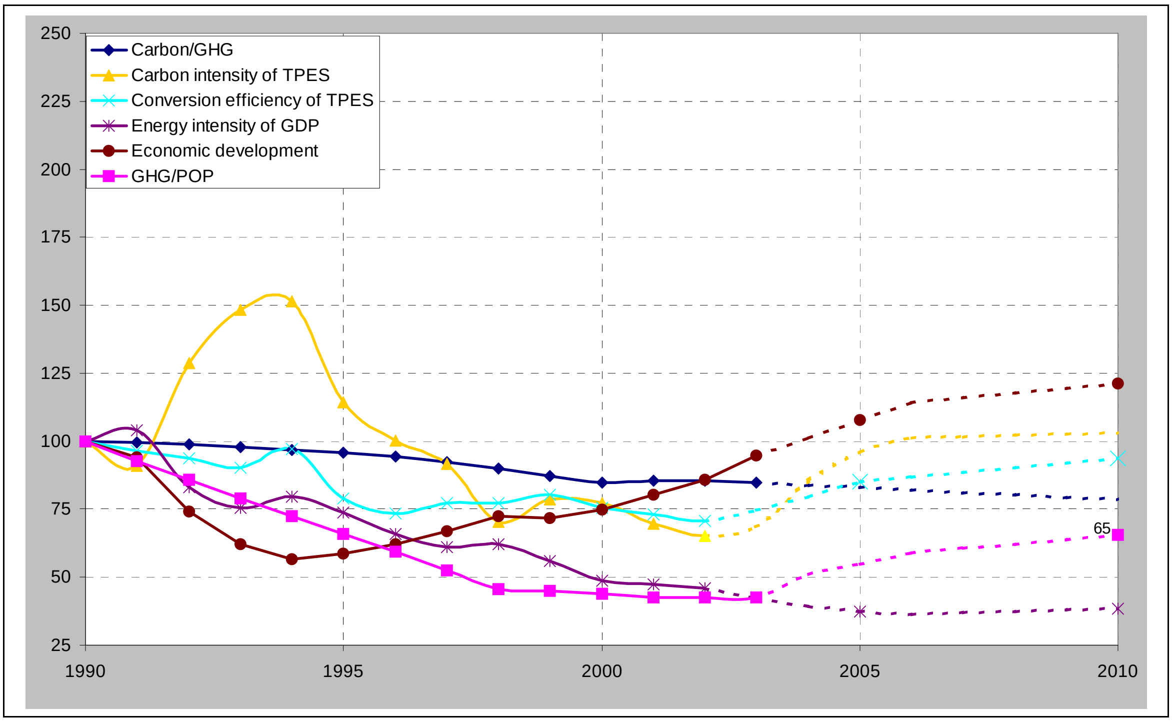


Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

3.15 Lithuania

Lithuania did not provide projections for greenhouse gas emissions. Thus, several indicators can only be projected based on own calculations. The historic trend shows that the share of CO_2 in total greenhouse gas emissions fell by more than 20% between 1990 and 2002 (Figure 3.29). This indicates that Lithuania was more successful in the reduction of CO_2 than in the reduction of other greenhouse gases.

Figure 3.29 Driving forces of Lithuania



Source: EC (2003), Eurostat (2004b), UNFCCC (2005), own calculations

All other indicators beside the per-capita greenhouse gases developed erratically as in most of the other new Member States but with stronger deviations. Until 1994, the carbon intensity of the Lithuanian energy supply rose dramatically to more than 150% of the 1990 level, but declined thereafter to less than 70% of the 1990 level in 2002.

The conversion efficiency of the Lithuanian energy sector also varied substantially but it basically declined by almost 30% between 1990 and 2002. According to the projections, it will improve again in the future, but not above the level in 1990.

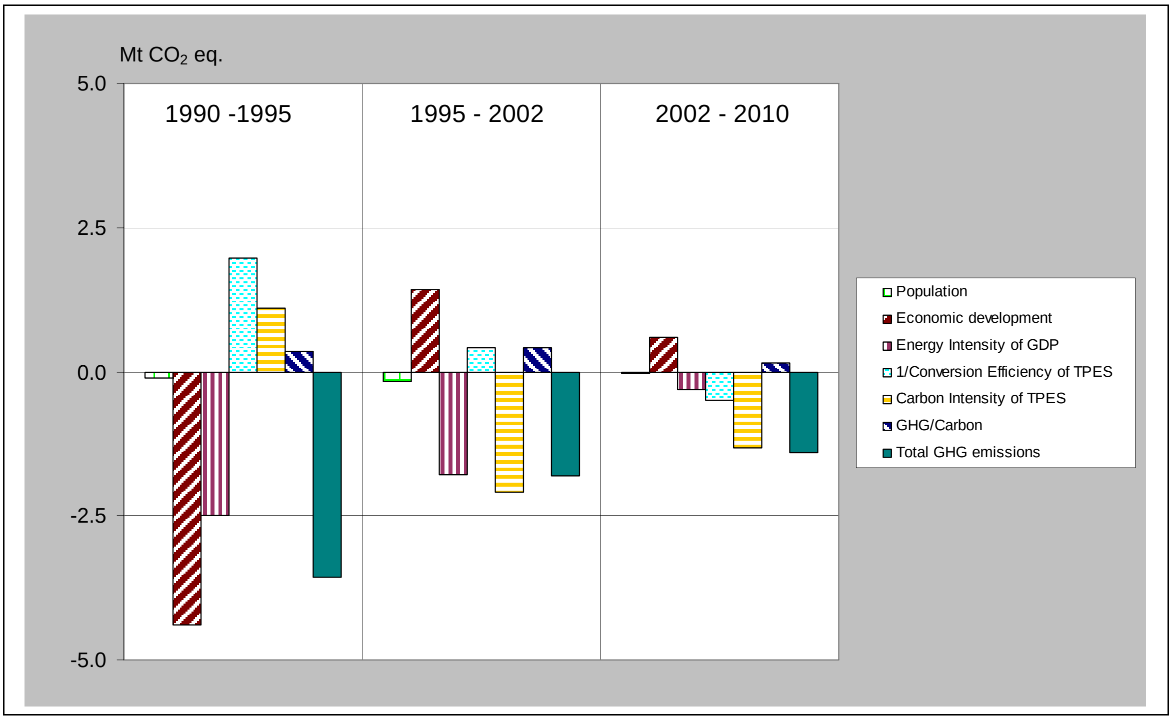
The energy intensity had been improved by more than 50% between 1990 and 2002 and will decline further to almost 40% of the initial value in 1990. Since Lithuania's energy intensity was one of the highest in Europe in 1990 – exceeded only by Estonia –, the potential for improvement was great. In 2010 there will still be a large potential as Lithuania's energy intensity will still be then four times higher than the EU average.

The economic development showed the same pattern as in the other new Member States in Central and Eastern Europe. However, the decline in the early nineties was much stronger in Lithuania. Between 1990 and 1994, the gross domestic product per capita dropped by 44%. Since then the economy has grown again. According to the projections, Lithuania will only achieve its 1990 level in 2005 but will continue to grow thereafter. In 2010 the gross domestic product per capita will be in real terms some 30% above the level in 1990. Correspondingly, the greenhouse gas emissions will be decoupled systematically from the economic development. In 2010 one unit of gross domestic product per capita will be produced with almost 85% fewer greenhouse gas emissions on average than in 1990.

Lithuania had the highest per-capita emissions in 1990 in Europe. Between 1990 and 1998 they fell constantly by over 50%. Since then they have remained more or less at the same level. As Lithuania does not provide any projections on greenhouse gases for 2010, further conclusions cannot be drawn.

Figure 3.30 indicates that in Lithuania the economic breakdown at the beginning of the nineties had the strongest positive influence of all driving forces, followed by the energy intensity. The deterioration of the carbon intensity in this period was not typical for a new Member State. However, from 1995 onwards, a similar trend as in the other new Member States is obvious in Lithuania with the exception of the carbon intensity which has – after the strong increase at the beginning of the nineties – a positive influence on the emission level which is in relative terms above average in the new Member States.

Figure 3.30 Annual contribution of driving forces to the GHG emission trends and projections in Lithuania



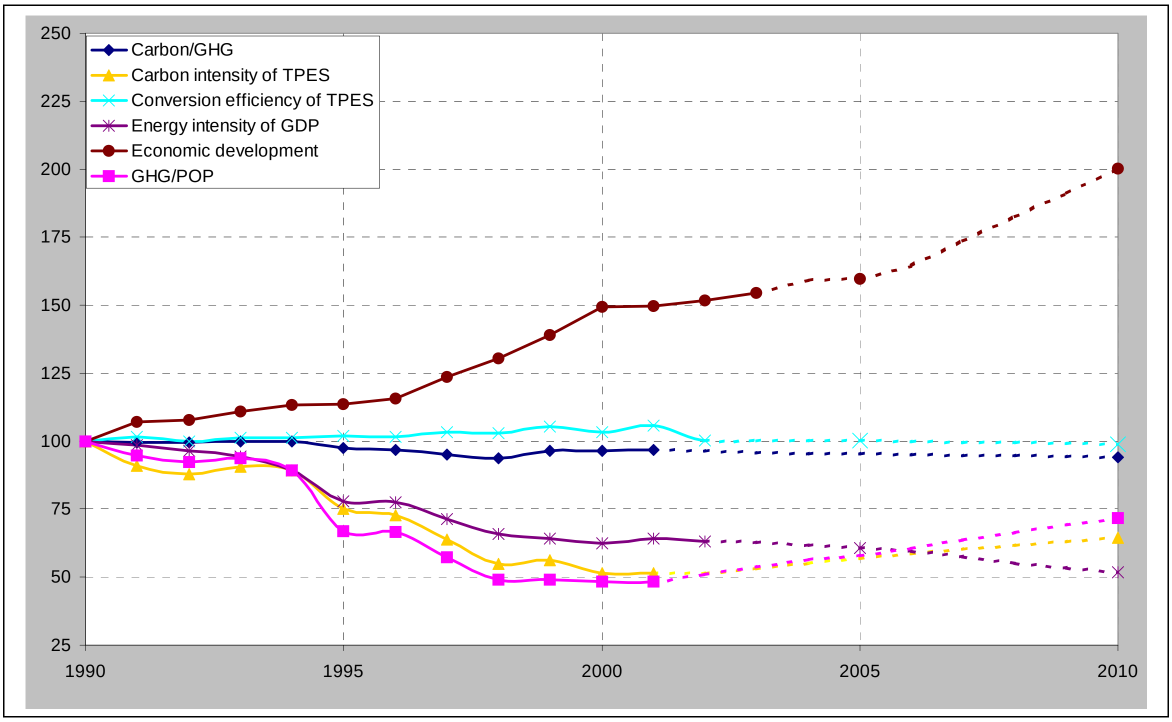
Source: EC (2003), Eurostat (2004b), UNFCCC (2005), own calculations

3.16 Luxembourg

The share of CO_2 in total greenhouse gas emissions was almost constant during the nineties but is projected to decline to some extent up until 2010 (Figure 3.31). It will then be 5% lower than in 1990, indicating that the efforts to curb CO_2 emissions are expected to be slightly more successful than the mitigation of other greenhouse gases.

The carbon intensity of Luxembourg's energy supply dropped substantially between 1990 and 2000 to almost 50% of the initial value. This had been achieved above all through the closure of a steel plant in 1994. According to the projections, by 2010 the carbon intensity will rise again slightly to about 65% of its initial value but will still be then below the EU average.

Figure 3.31 Driving forces of Luxembourg



Source: EC (2003), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency of Luxembourg's energy industry has remained and will remain more or less at the same level as in 1990. Since it is already one of the highest in Europe, it will be difficult to improve upon it further.

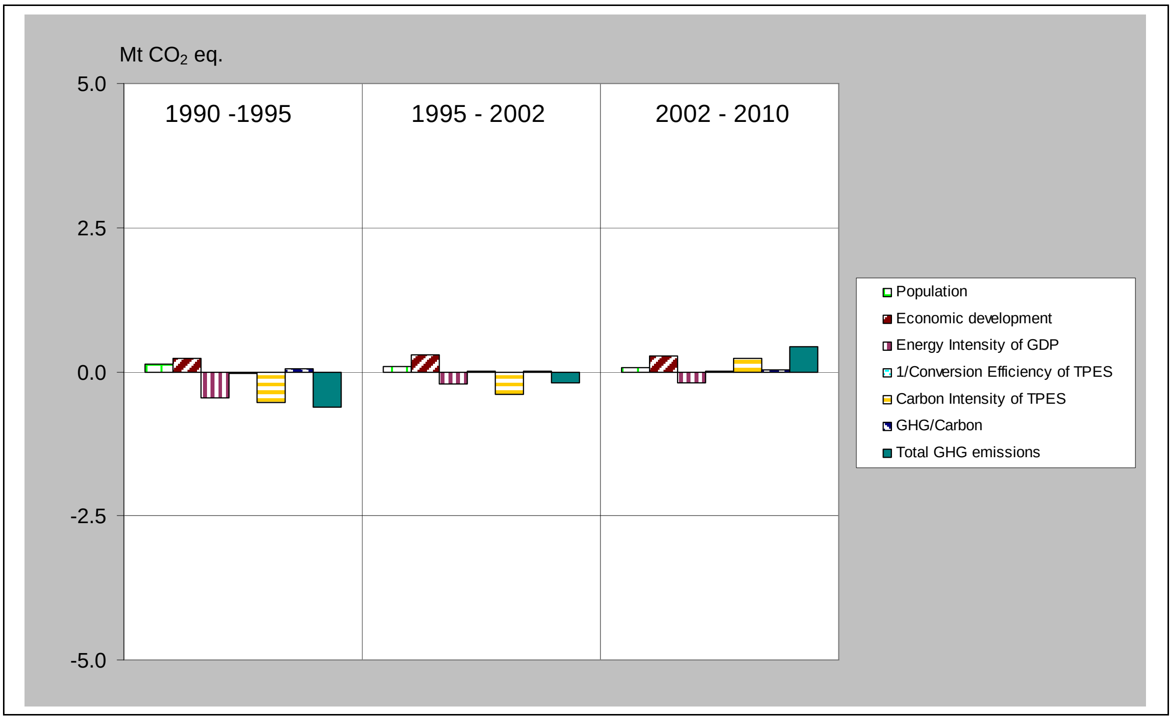
The energy intensity of Luxembourg's economy developed similarly to the carbon intensity and was also influenced by the closure of the steel plant in 1994. It declined by almost 40% between 1990 and 2000. As opposed to the carbon intensity, the energy intensity will decline further in the future. In 2010, it will be almost 50% below its initial value in 1990. However, since it will still be one third higher than the average of the EU-15, it might be improved more through additional policies and measures that address the energy intensity.

The economic development was somewhat different to the development in the larger Member States. The per-capita gross domestic product grew more slowly in the first half but then grew surprisingly strongly during the second half of the nineties. Only in the years 1992, 1995 and between 2002 and 2003 did the per-capita gross domestic product show virtually no growth. In 2000 the gross domestic product per capita was almost 50% above its initial value. By 2010 it will be twice as high as in 1990. Since total greenhouse gas emissions are not expected to grow again above the level in 1990, one can consider them as decoupled from economic development. By 2010 the greenhouse gas emissions per unit of per-capita gross domestic production will be about 65% lower than in 1990.

Luxembourg shows – parallel to the carbon and energy intensity improvements – a very strong decline in per-capita greenhouse gases in the period between 1990 and 2002, the strongest decline among EU-15. In absolute terms, Luxembourg showed the highest per-capita greenhouse gas emissions in the EU in 1990. Between 2002 und 2010 it is projected to have by far the strongest relative increase of per-capita greenhouse gases in the EU which again amounts to the highest per-capita greenhouse gas emissions in the EU by far.

Figure 3.32 indicates that – due to the Luxembourg's low emission level in absolute terms – the changes of the driving forces do not have significant influence in absolute terms. Nevertheless, it is obvious that at the beginning of the nineties, the changes of energy related driving forces led to a positive emission trend. This trend could not, however, be maintained at that degree at the end of the nineties and it is even projected to end up in a relatively high emission increase up until 2010.

Figure 3.32 Annual contribution of driving forces to the GHG emission trends and projections in Luxembourg



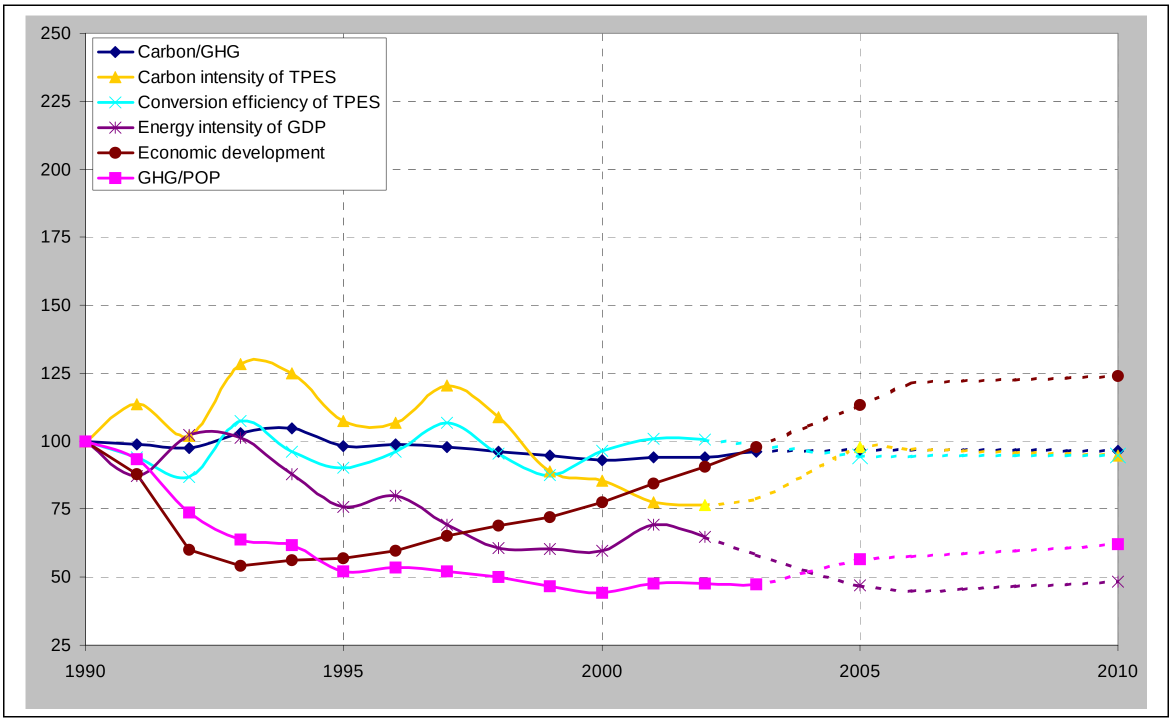
Source: EC (2003), Eurostat (2004b), UNFCCC (2005), own calculations

3.17 Latvia

Latvia's share of CO_2 emissions in total greenhouse gas emissions decreased by 6% between 1990 and 2002 (Figure 3.33). According to Latvia's projection, it will increase again. In 2010 it will be only 3.5% below its initial value in 1990.

In 1990 Latvia had the lowest carbon intensity of all new Member States, also significantly below the EU-15 average. In spite of this favourable initial level the carbon intensity could be reduced by 23% between 1990 and 2002, however there had been large increases above the 1990 level in the nineties. According to the projection provided by Latvia, the carbon intensity will increase again up until 2010, it will be only 5% below its initial value and end up in an carbon intensity higher than the European average.

Figure 3.33 Driving forces of Latvia



Source: EC (2003), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency varied substantially during the nineties but resulted in 2002 with the 1990 level. Up to 2010 it will slightly deteriorate (by 6%).

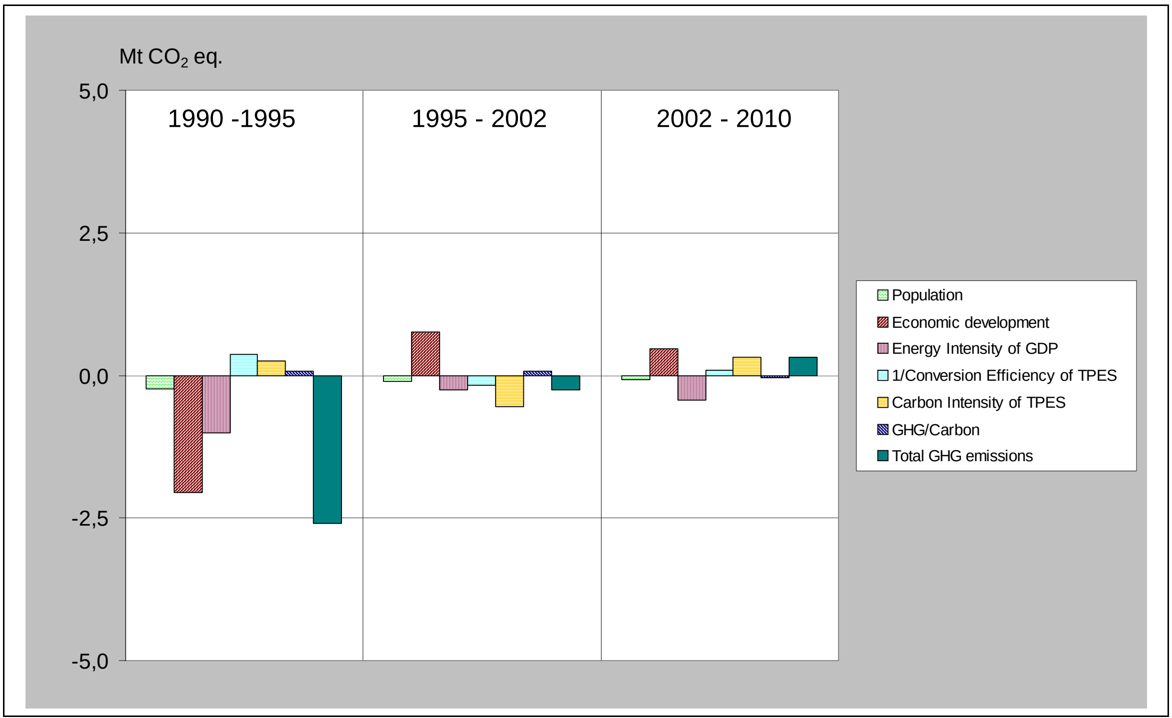
In the past, the energy intensity showed a typical development for a new Member State. Between 1990 and 2002 it declined by 35%. According to the projection provided by Latvia, it will further decline to 49% of the 1990 level by 2010. Since the energy intensity will still be four times higher than the EU average, one can expect that it can be further improved through additional policies and measures which address the energy intensity.

Latvia's economic development is quite similar to the development of its neighbour Lithuania, which witnessed a sharp decline in the early nineties and then continuous growth thereafter. Like Lithuania, Latvia will once again only reach the level of gross domestic product per capita in 2003 that it had achieved in 1990. Up to 2010 it will increase to 24% above its initial level. Despite the comparatively slow economic development, greenhouse gas emissions can still be decoupled substantially from the economic development given the decline.

In the nineties, greenhouse gas emissions per capita developed in Latvia in a similar manner to those of Lithuania and Estonia: they underwent a strong, continuous decline. The projections, however, indicate a reverse trend typical of the new Member States. Although the energy intensity of GDP is projected to improve greatly, the economic growth and a slight increase of the conversion efficiency counteract this trend.

Figure 3.34 reveals the annual contribution of driving forces to the GHG emission trends and projections in Latvia. In Latvia, changes in energy intensity had the strongest decreasing effect on the emission level between 1990 and 1995 which is typical for a new Member State. Furthermore, it is striking that the population was shrinking in the nineties, theirs was one of the highest shrinking rates in the EU. After 1995 the contribution of the diverse driving forces is typical for the new Member States.

Figure 3.34 Annual contribution of driving forces to the GHG emission trends and projections in Latvia



Source: EC (2003), Eurostat (2004b), UNFCCC (2005), own calculations

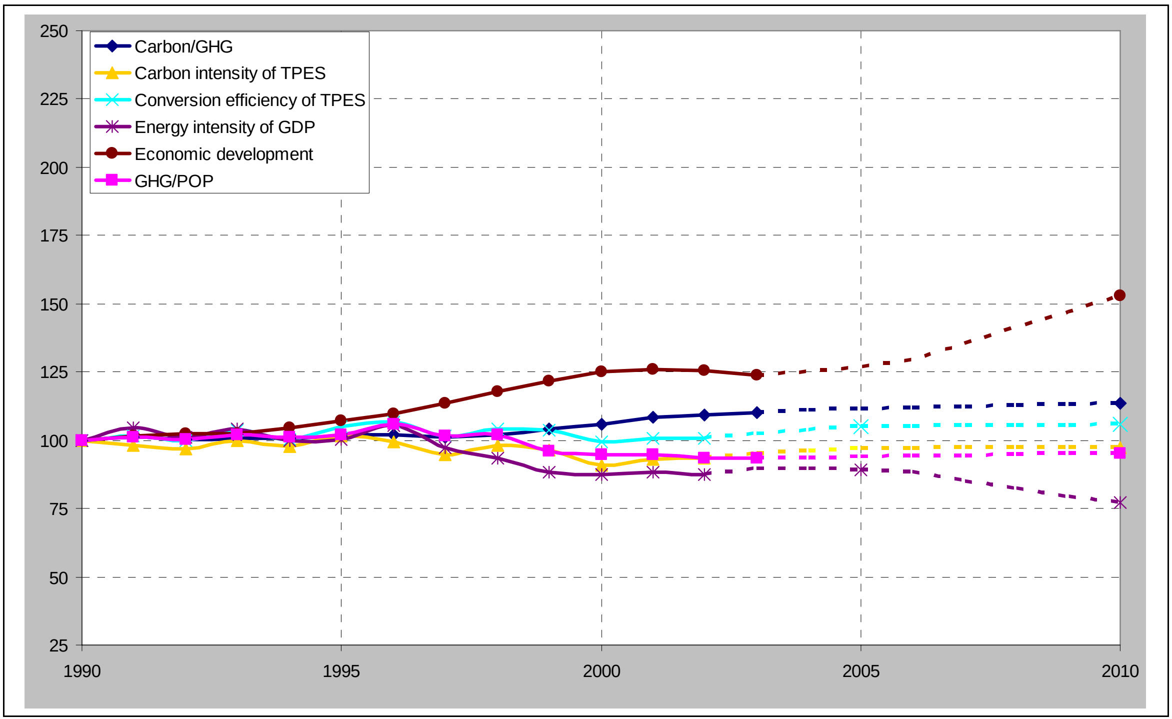
3.18 The Netherlands

The Netherlands' share of CO_2 emissions in total greenhouse gas emissions remained almost constant during the nineties but started to rise at the end of this period (Figure 3.35). It will rise further, although at a slower pace up until 2010. It will then be 12%

higher than it was in 1990, which indicates that efforts to curb other greenhouse gases were and will be more successful than the efforts to mitigate CO_2.

The carbon intensity of the Dutch energy supply varied somewhat in the second half of the nineties but remained more or less at its initial level and will continue to do so up until 2010. But since it is already one of the lowest in Europe, it will be difficult to improve it further.

Figure 3.35 Driving forces of the Netherlands



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

Likewise, the conversion efficiency remained more or less stable during the nineties, although it varied somewhat in the second half. According to the projections, the conversion efficiency will improve up until 2010 and will then be almost 6% above its 1990 value. However, a comparison with the conversion efficiency of other Member States reveals that it might be improved further if additional policies and measures are adopted to develop these potentials.

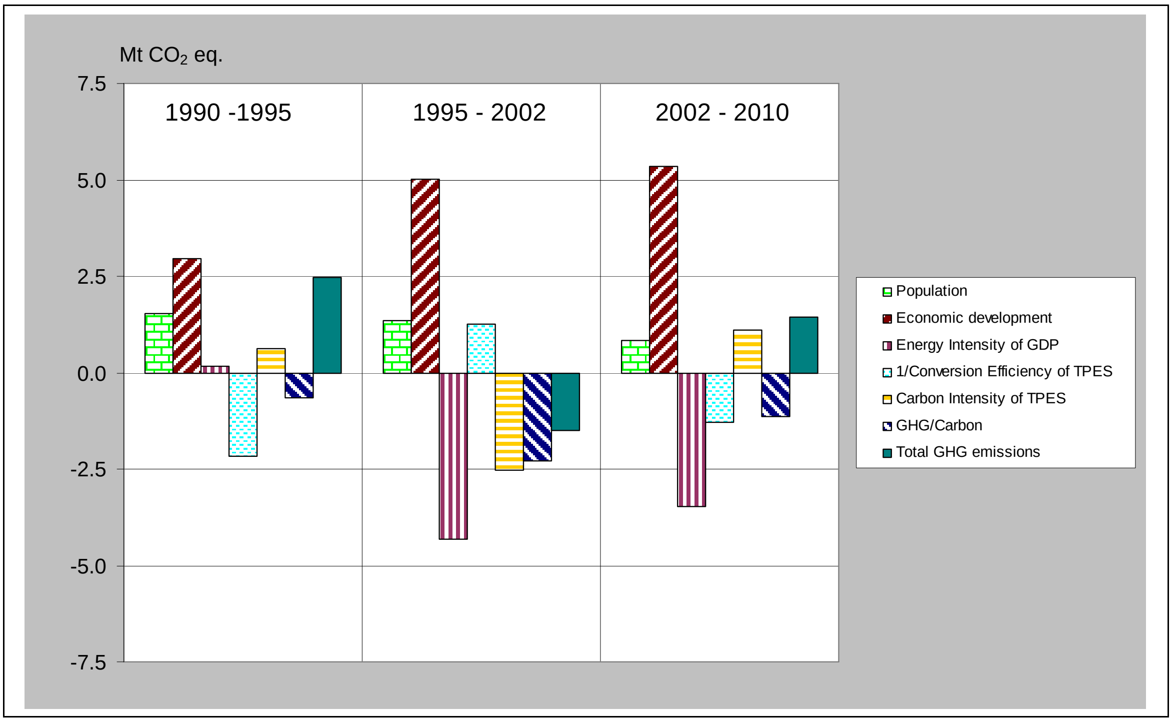
The energy intensity of the Dutch economy also remained stable during the first half of the nineties. However, in the second half of the nineties it improved considerably and will continue to improve up until 2010. It will then be 23% below the level in 1990 and exactly at the level of the EU-15 on average.

The gross domestic product per person increased more or less continuously during the nineties but decreased again in the period 2000 - 2003. According to Dutch projections, it will start to grow again. In 2010 the indicator will be almost 53% above the initial value in 1990. In the Netherlands, greenhouse gas emissions have also been decoupled from economic development as they grew only slightly and considerably less than the economy. In 2010 every unit of per-capita gross domestic product will be produced with 37% fewer greenhouse gas emissions.

At the beginning of the nineties the per-capita greenhouse gas emissions went hand in hand with the conversion efficiency, energy and carbon intensity and remain rather stable. After growing and falling again, they level out in 2000 just below the basic per-capita emission of 1990. In future they are projected to remain stable at the 2000 level.

Figure 3.36 illustrates the annual contribution of the driving forces to the GHG emission trends and projections in the Netherlands. It can be seen that the conversion efficiency had – in contrast to the average trend in the EU-15 – the strongest positive effect on the emission level between 1990 and 1995. From 1995 onwards however, other energy related driving forces gained importance for the positive emission trend: energy intensity and carbon intensity improved and at least the energy intensity is projected to improve further but with a lower contribution compared to the end of the nineties. In the Netherlands, the reduction of GHG other than CO_2 played an important positive role in the past in decreasing the emission level. The contribution in the projection is smaller but still significantly positive for the emission trend.

Figure 3.36 Annual contribution of driving forces to the GHG emission trends and projections in the Netherlands



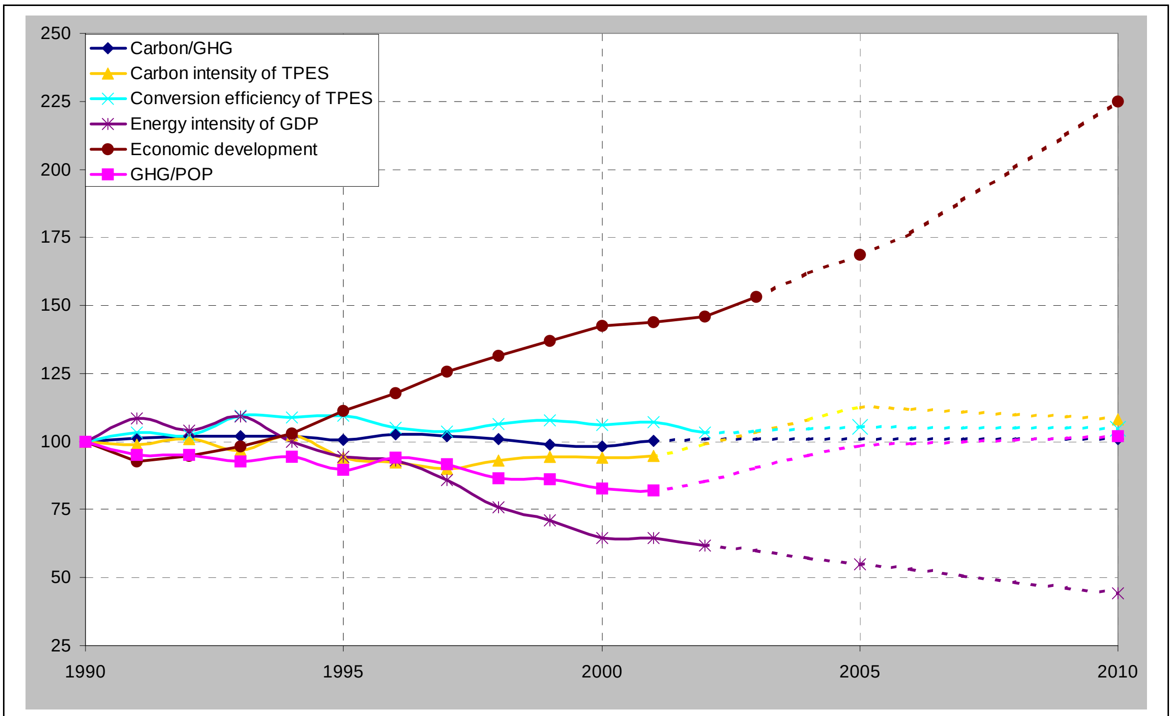
Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005) own calculations

3.19 Poland

The share of CO_2 emissions in total greenhouse gas emissions remained rather stable during the nineties in Poland (Figure 3.37). Although Poland has yet to provide projections for greenhouse gases, it can be assumed that it will not change considerably in the years to come.

The carbon intensity of the Polish energy supply also changed significantly during the nineties, at least in comparison to most of the other new Member States in Central and Eastern Europe. But according to the projections, it will increase slightly up until 2010 to 8% above its value in 1990. The fact that the Polish carbon intensity was and will be the highest in Europe clearly indicates that it can be addressed by additional policies and measures. However, as Poland will achieve its Kyoto targets without additional measures, this potential can probably be realised in the short term only by means of the European emissions trading scheme.

Figure 3.37 Driving forces of Poland



Source: EC (2003), EEA (2004), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), World Bank (2004), own calculations

The conversion efficiency of the Polish energy industry remains almost constant during the nineties and will not change much until 2010. It will then be 4% above the level in 1990 and the equivalent of the average of the new Member States.

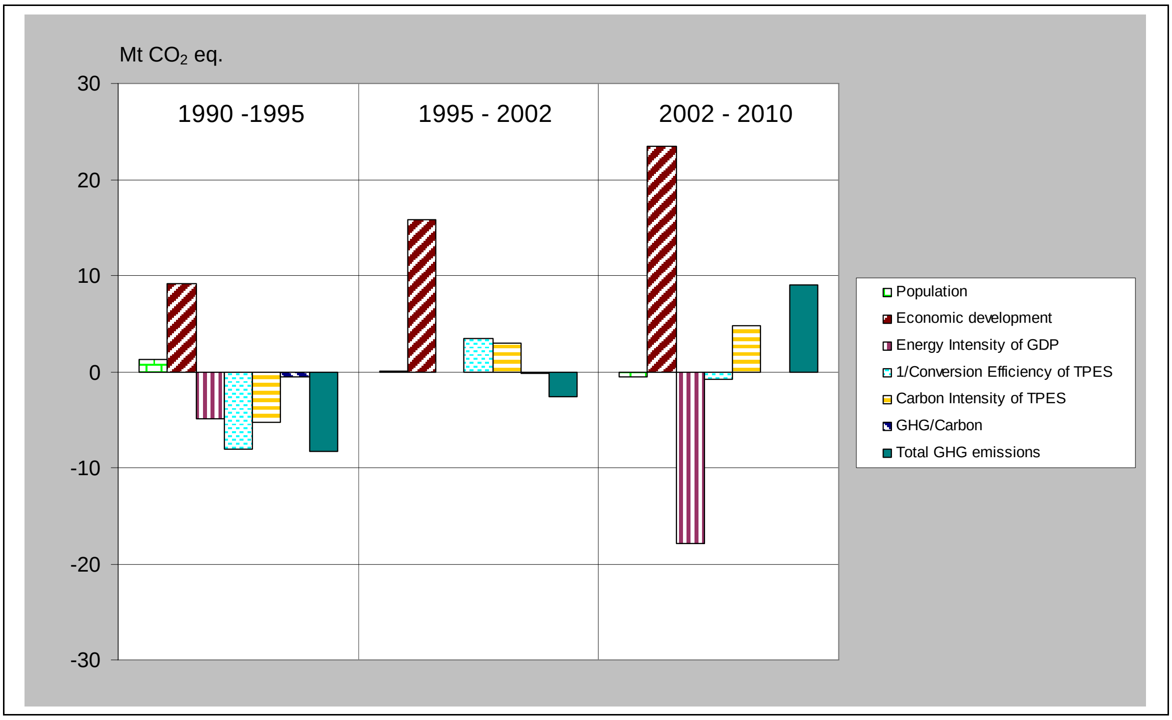
The energy intensity of the Polish economy improved substantially, although only since 1993. Up to 2002 it was already more than 55% below the level in 1990. In the future it will improve even more. In 2010 only 44% of the energy will be needed to produce the same products as were produced in 1990. However, since the Polish energy intensity will still be 2.5 times higher than in the EU-15 Member States, there will still be potential on average to improve it further by means of new policies and measures.

The economic downturn has started earlier in Poland than in the other new Member States in Central and Eastern Europe. Only one year of that downturn fell into the nineties. Therefore, Poland started to grow again in 1992. By 2003 the per-capita gross domestic product was again more than 50% above the initial value in 1990. In 2010 it will be almost 125% above 1990 levels. Greenhouse gas emissions will exceed the 1990 levels in 2006 but still fall short of economic development. As a result, greenhouse gas emissions in Poland will also be decoupled from economic development. Correspondingly, in 2010 the greenhouse gas emissions per unit of per-capita gross domestic product will be 55% lower than in 1990.

In the nineties, the share of the per-capita greenhouse gas emissions decreased but is projected to increase again in 2010 to the 1990 value due to high economic growth. While the share in 1990 is in absolute terms slightly below the European average, in 2010 the share will instead be above it.

At the beginning of the nineties, improvements of the energy intensity often have a strong positive influence on the greenhouse gas emission trend in the new Member States. In Poland, however, this effect occurs later, at the end of the nineties and is projected to continue up until 2010. A strong trend reversal regarding the energy intensity is expected between 2002 and 2010. If this trend reversal will not be successful, a very high emission growth can be expected as other driving forces are not expected to compensate the high economic growth.

Figure 3.38 Annual contribution of driving forces to the GHG emission trends and projections in Poland



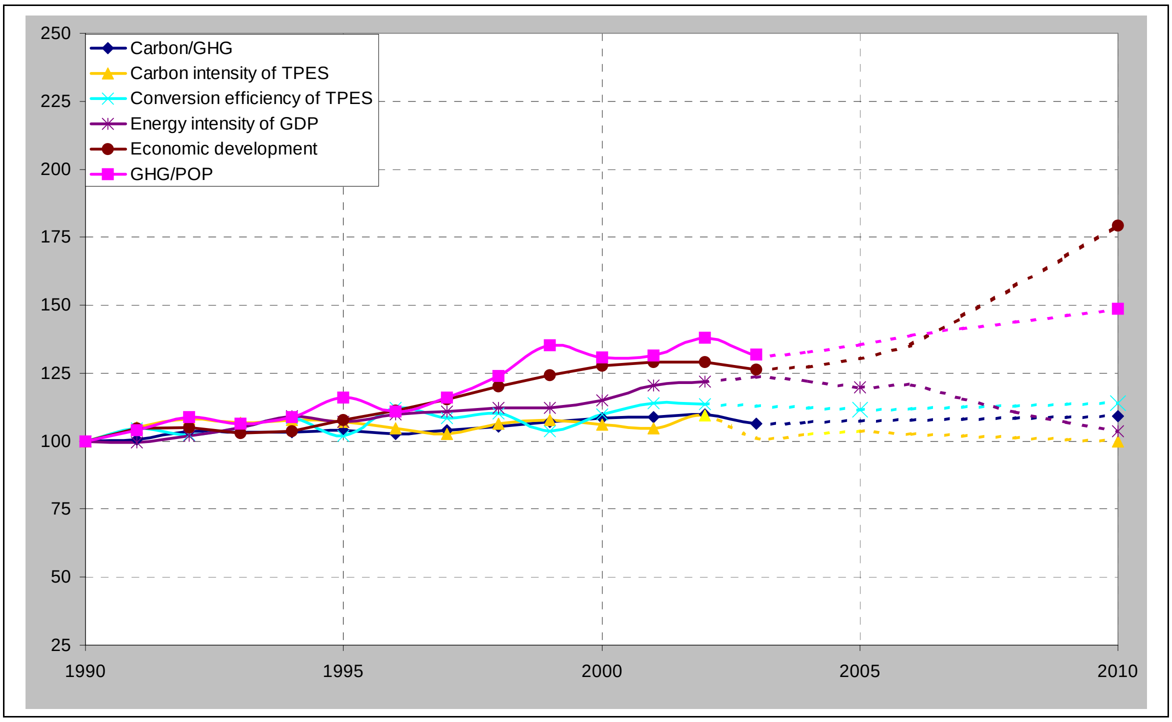
Source: EC (2003), EEA (2004), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), World Bank (2004), own calculations

3.20 Portugal

Portugal's share of CO_2 in total greenhouse gas emissions increased continuously between 1990 and 2002 and will continue to grow, although at a slower pace up until the end of the recent decade (Figure 3.39). Obviously it was more successful in mitigating other greenhouse gases than CO_2.

The carbon intensity demonstrated inconsistent change: it grew and declined again but was almost 7% above the initial value in 2002. In the years to come it will go down again to the initial level in 2010. However, additional measures to improve it further will be rather difficult to develop, as it will only be slightly above the EU average.

Figure 3.39 Driving forces of Portugal



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

Portugal's conversion efficiency varied somewhat during the nineties but showed an upward trend. According to the projections, it can be improved only slightly in the future. In 2010 it will be almost 14% above the initial level in 1990 and also slightly above the average of the EU-15.

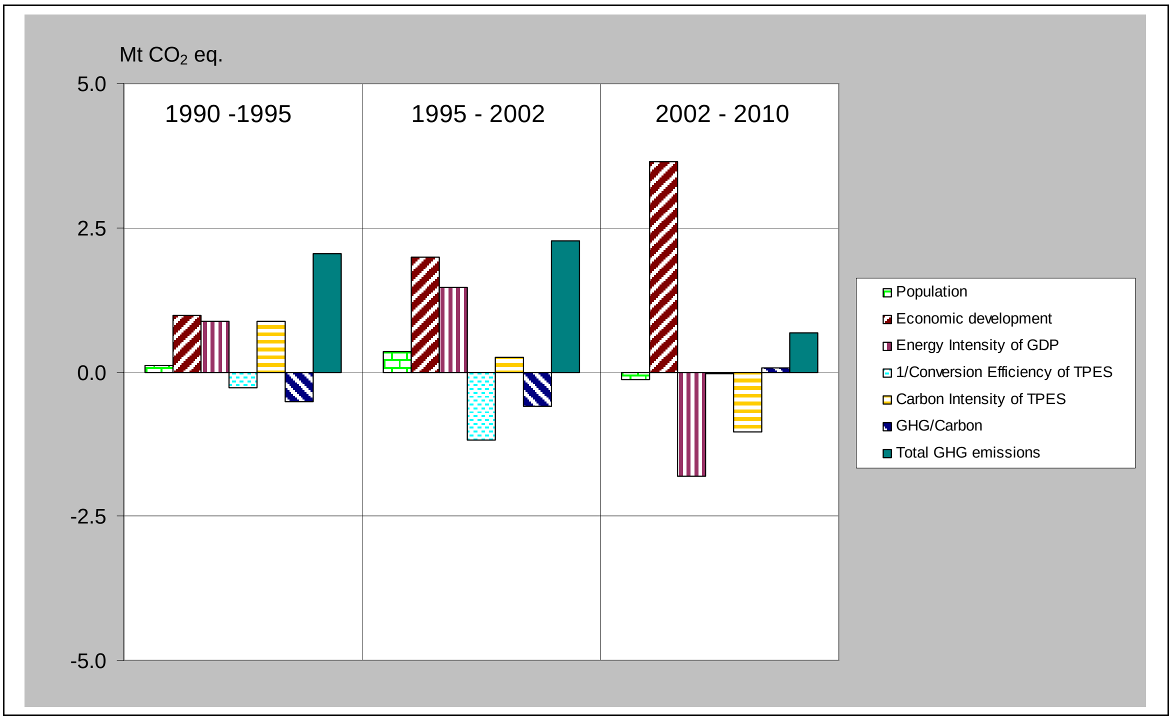
Similar to Spain and in contrast to most of the other EU-15 Member States, Portugal's energy intensity did not decline during the nineties. In 2002 it was 15% above the level in 1990. According to the projections, it can be improved in the future but will still not go beyond the initial value. In 2010 it will be 3.5% above the level in 1990 and substantially above the average energy intensity of the EU-15 Member States. This indicates that there is still potential for improvement that might be developed through additional measures.

The gross domestic product per capita grew in most years except between 1992 and 1993 and between 2002 and 2003. According to the projections, it will continue to grow until the end of the recent decade. In 2010 it will be almost 80% above the initial value in 1990. Total greenhouse gas emissions grew and are expected to grow at a slower pace so that they will be decoupled from the economic development. In 2010 Portugal will emit on average one third fewer greenhouse gases to produce the same amount of products and services as in 1990.

In 1990, Portugal's share of per-capita greenhouse gas emissions is by far the lowest in the European Union. It increases strongly in the nineties and is projected to grow further to more than 40% over the 1990 value in 2010. In absolute terms however, the share will still be below the European average.

Figure 3.40 reveals that in the past the GHG emission level rose strongly due to population and economic growth as well as due to the deterioration of carbon and energy intensity. The sole slightly positive influence came from the conversion efficiency and the other GHG emission reductions compared to carbon dioxide. While the economic development is expected to grow even more strongly in future than in the past, a trend reversal regarding the carbon intensity and one a more significant one of energy intensity is expected. Although the latter two driving forces do not completely compensate the negative impact of the economic development they are at least expected to slow down the emission growth.

Figure 3.40 Annual contribution of driving forces to the GHG emission trends and projections in Portugal



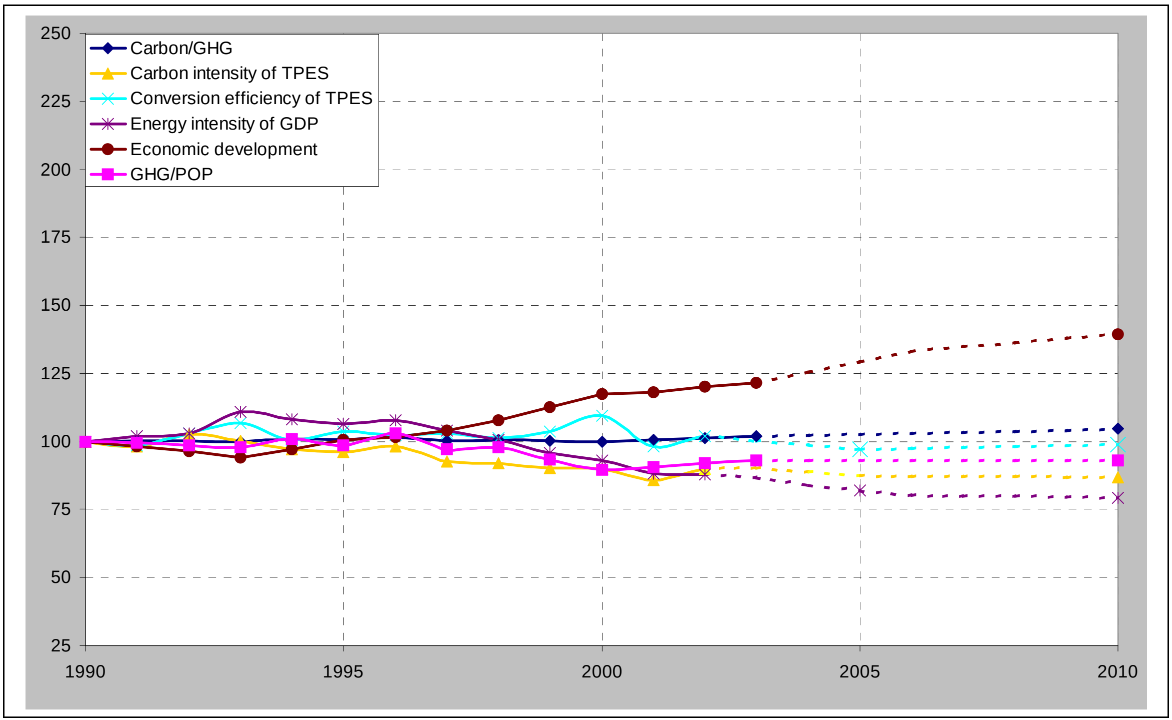
Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

3.21 Sweden

Sweden's share of CO_2 in total greenhouse gas emissions remained rather stable during the period between 1990 and 2002 (Figure 3.41). It will, however, increase slightly up until 2010, which indicates that measures to mitigate other greenhouse gases are expected to be more effective than measures to curb CO_2.

Due to a high share of nuclear and renewable energies in electricity generation, Sweden's carbon intensity was already the lowest of the EU-15 Member States in 1990. Nevertheless, it had been improved during the second half of the nineties. In 2002 it was 12% below its 1990 level. According to the projections it will remain at that level up until 2010.

Figure 3.41 Driving forces of Sweden



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

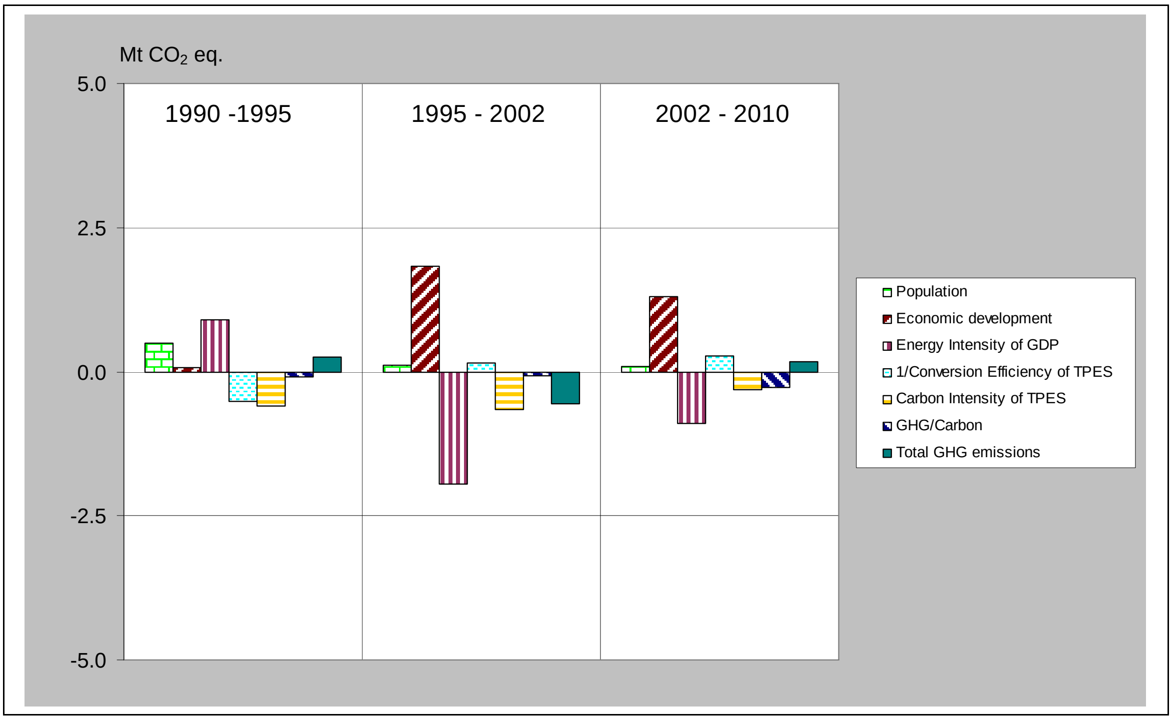
The conversion efficiency was equivalent to the average of the EU-15 Member States at the beginning of the nineties. Basically it remained at that level during the nineties although it fluctuated somewhat. In 2010 it will still be at that level, slightly below the average of the EU-15 Member States at that point.

The energy intensity of the Swedish economy was slightly above the average of the EU-15 Member States in 1990 but deteriorated between 1990 and 2003. It then improved again and is expected to be 20% below the 1990 level in 2010. However, since it will still be above the average of the EU-15 Member States it might be improved further through new policies and measures which address energy intensity.

Sweden's economy declined from 1990 to 2003 by more than 6% but started to grow constantly thereafter, although at a slower growth rate after 2000. According to the projections, the per-capita gross domestic product will increase in real terms to almost 40% above the initial value in 1990. As a result of that growth and more or less stable greenhouse gas emissions, the latter will be decoupled from economic development. In 2010 the greenhouse gas emissions per unit of per-capita gross domestic product will be 30% lower than in 1990.

During the nineties, the per-capita greenhouse gas emissions oscillated around the 1990 value. A decline of around 9% is expected up until the year 2000 and is projected to be stable until 2010. In absolute terms the share of greenhouse gas emissions per capita in Sweden is one of the lowest in the EU, both in 1990 and in 2010. This can be attributed to the high share of nuclear and renewable energies in the Total Primary Energy Supply.

Figure 3.42 Annual contribution of driving forces to the GHG emission trends and projections in Sweden



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

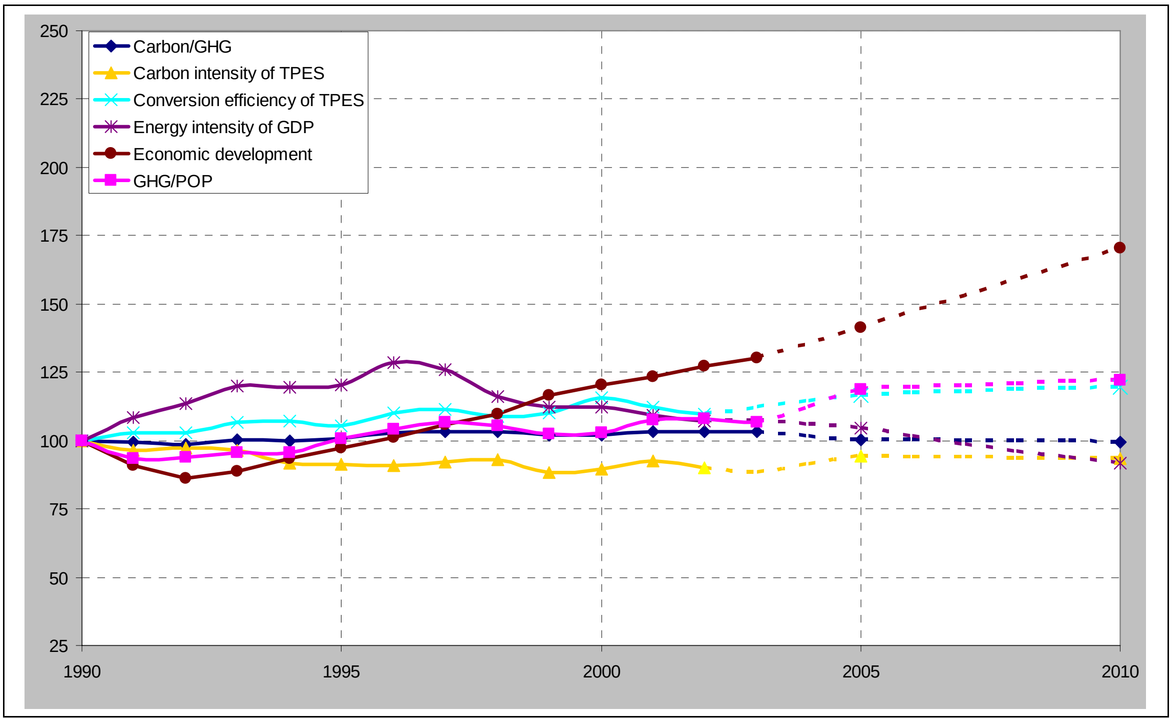
Figure 3.42 reveals that the driving forces did not change much at the beginning of the nineties. In contrast to the EU-15 trend in that period, energy intensity and not economic growth was the key driving force to increase the emission level. A trend reversal followed at the end of the nineties: a highly increasing effect by economic development but significant improvements in energy intensity as compensation. The trend of the individual driving forces between 1995 and 2010 is projected to continue, but significantly more moderate in the annual contribution – i.e. positive contribution of carbon and energy intensity improvements only half as large as in the precedent period, the conversion efficiency deteriorates even more – in total contributing to an increasing emission trend up until 2010.

3.22 Slovenia

Slovenia's share of CO_2 in total greenhouse gas emissions remained almost constant during the nineties and is expected to do so until 2010 (Figure 3.43). In 2010 it will be only 2% above 1990 levels.

The carbon intensity of the energy supply was already lower than those of some of the EU-15 Member States in 1990. It then varied somewhat but continued more or less at the same level. In 2010 it will be about 4% below the initial value in 1990, but then somewhat above the average of the EU-15 Member States, which indicates that it could be improved further through additional policies and measures.

Figure 3.43 Driving forces of Slovenia



Source: EC (2003), EEA (2004), Eurostat (2004b), Republic of Slovenia (2002), UNFCCC (2005), own calculations

The conversion efficiency was continuously improved during the nineties. In 2002 the conversion efficiency of the Slovenian energy industry was already 15% more efficient than in 1990. According to the projections it will be improved further up until 2010 and then be almost 20% above the level in 1990.

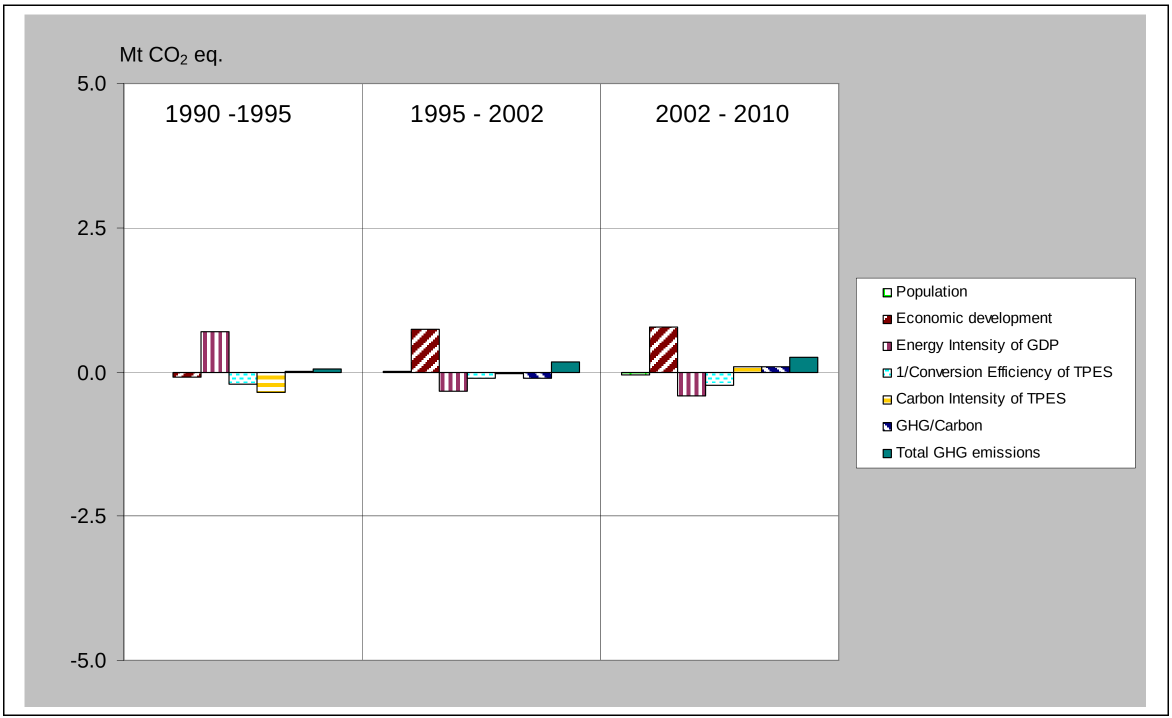
The energy intensity of the Slovenian economy increased remarkably at the beginning of the nineties and was almost 30% above the initial value in 1990 in 1996. In 2002 it was still 8% above 1990 levels although it was improved continuously thereafter. In the future it will decline further. Nevertheless, in 2010 it will only be 10% below its initial value in 1990, some 70% above the average of the EU-15 Member States. Correspondingly, it might be further reduced through additional policies and measures.

Slovenia's gross domestic product per capita dropped by 14% between 1990 and 1992 but started to grow again thereafter. In 1996 it was again above the 1990 levels. When the projected growth up until 2010 is taken into account, the economy will rise more than 72% above the initial value by 2010. Since greenhouse gas emissions are projected to grow at a slower pace, they can be considered decoupled from the economic development although the decoupling is much lower than in most of the other new Member States. In 2010, Slovenia will emit 30% fewer greenhouse gases per unit of gross domestic product per capita than in 1990.

Slovenia is the only new Member State which shows increasing per-capita greenhouse gas emissions in the period between 1990 and 2002. In Slovenia, the typical decline of the per-capita greenhouse gas emissions in the new Member States lasted only 2 years. The reverse trend of raising per-capita emissions started much earlier compared to the other new Member States in which the reverse point occurs at the end of the nineties. While the absolute value of per-capita greenhouse gas emissions in Slovenia is far below the average one in the new Member States in 1990, it will be higher than the average in 2010.

In contrast to many other new Member States the emission intensity deteriorated at the beginning of the nineties, having a relatively strong increasing effect on the emission level similar to Estonia. Slovenia had one of the lowest energy intensities in the new MS in 1990.

Figure 3.44 Annual contribution of driving forces to the GHG emission trends and projections in Slovenia



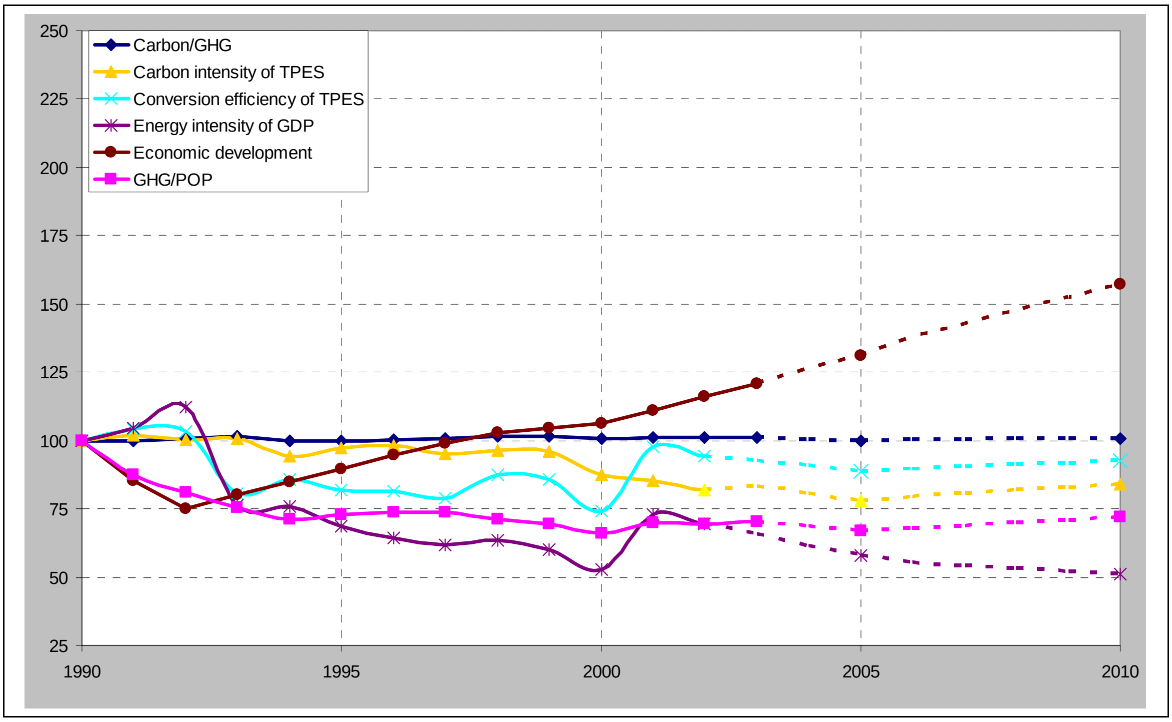
Source: EC (2003), EEA (2004), Eurostat (2004b), Republic of Slovenia (2002), UNFCCC (2005), own calculations

3.23 Slovak Republic

The share of CO_2 in total greenhouse gas emissions remained rather stable in the Slovak Republic and will do so up until 2010 (Figure 3.45). In 2010 it is expected to be only 1% above the level in 1990.

The carbon intensity of Slovakia's energy supply improved substantially during the period between 1990 and 2002. In 2002 it was almost 17% below the initial value in 1990. According to the projections provided by the Slovak Republic, it will more or less remain at that level until 2010.

Figure 3.45 Driving forces of Slovak Republic



Source: EC (2003), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency of the Slovakian energy industry developed rather erratically but with a declining trend. In 2000 it was 15% below its initial value in 1990 but improved again substantially in the next year. For the year 2010 it is projected to be 7% below the 1990 levels, substantially below the average of the EU-15 Member States.

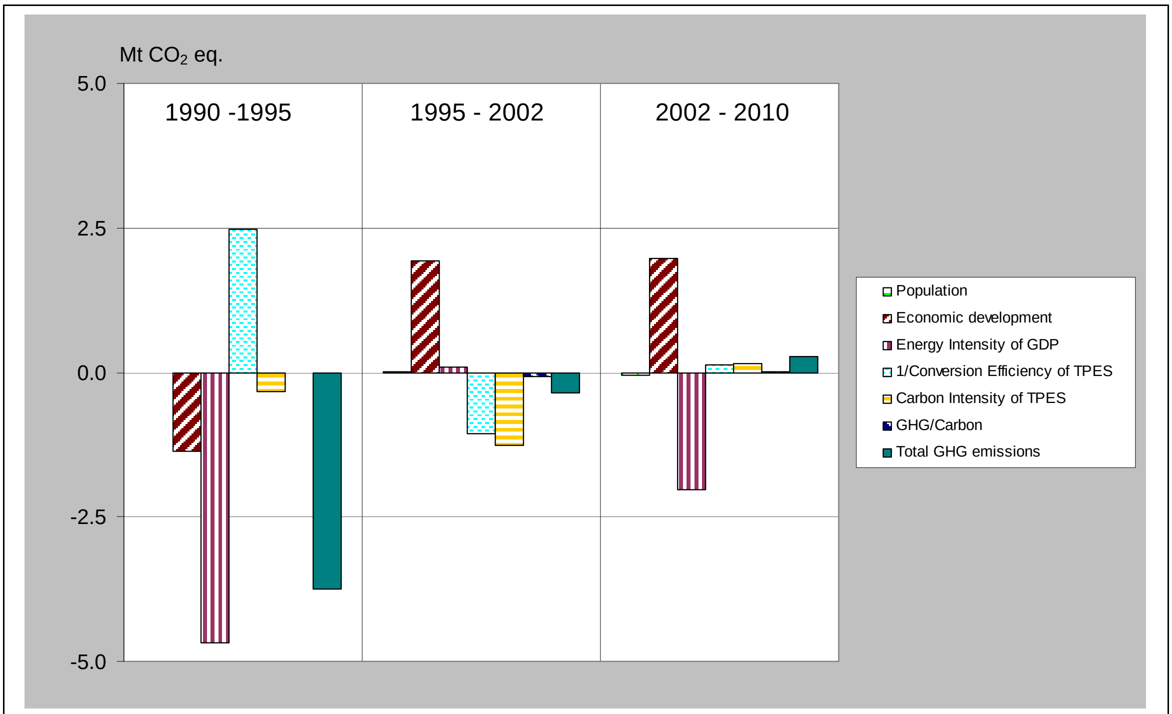
Similar to values of other new Member States, the energy intensity increased initially and decreased strongly thereafter. In total, in the year 2000 the energy intensity of the Slovakian economy had improved by 46%. According to the projections it will remain at that level until 2010 despite some variations that might occur. However, the fact that it will be then still more than three times above the average of the EU-15 Member States indicates that there is still potential for further improvements that might be addressed through additional policies and measures.

The economic development was also similar to the one observed in some of the other new Member States. The real gross domestic product per capita declined between 1990 and 1992 by almost 25% but grew again thereafter. In 1997 the economy had already achieved the 1990 level again. Up to 2010 it will grow to 57% above the level in 1990. Since greenhouse gas emissions will still be below the level in 1990, one can consider them decoupled from economic development. In 2010 the Slovak Republic will emit 55% fewer greenhouse gas emissions to produce the same amount of products and services as in 1990.

The development of the per-capita greenhouse gases is also similar to that observed in most of the new Member States. After a strong decline of over 30% due to the described energy and carbon intensity as well as conversion efficiency gains, there is a rebound in 2000 followed by an increasing trend. Nevertheless, the projected level of per-capita emissions in 2010 still remains almost 30% below the 1990 level.

Figure 3.46 shows the annual contribution of driving forces to the GHG emission trends and projection in the Slovakian Republic which is similar to average EU-10. Striking is the strong negative effect of deterioration of conversion efficiency at the beginning of the nineties which was by far compensated by energy intensity improvements and the economic breakdown. While especially the conversion efficiency had a positive impact on the emission level between 1995 and 2002, this role is projected to be taken by energy intensity improvements up until 2010. In total, for the Slovak Republic the contribution of the driving forces to the GHG emission trends up until 2010 are typical for the new Member States.

Figure 3.46 Annual contribution of driving forces to the GHG emission trends and projections in Slovak Republic



Source: EC (2003), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), own calculations

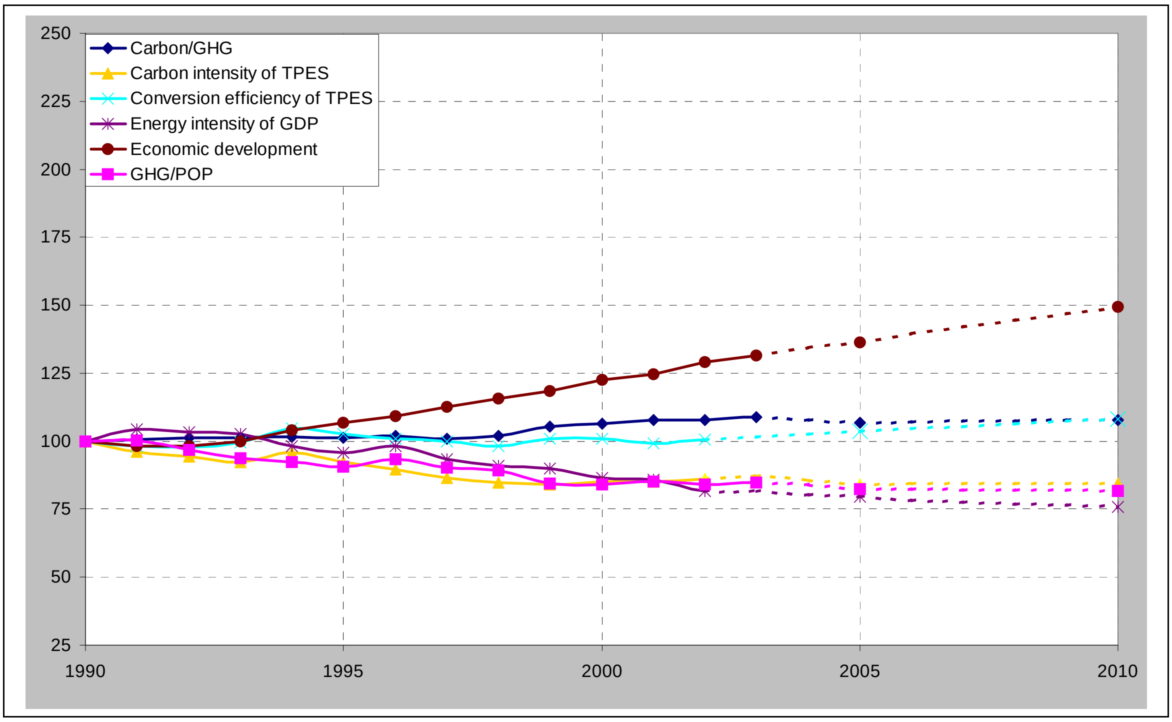
3.24 United Kingdom

The United Kingdom's share of CO_2 in total greenhouse gas emissions did not change very much between 1990 and 1998 but then increased by 5 percentage points up until

2002 (Figure 3.47). According to the projections, it will remain at that level up until 2010 when it will be some 8% above the initial level in 1990.

The carbon intensity of United Kingdom's energy supply was improved considerably between 1990 and 2002 when it was already 16% below 1990 levels. Up to 2010 it will remain at that level.

Figure 3.47 Driving forces of United Kingdom



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

The conversion efficiency of the energy sector in 1990 was almost at the same level as the average of the EU-15 Member States. During the nineties it varied somewhat but remained more or less at that level. Up to 2010 it can be improved and will then be almost 8% above the initial level in 1990.

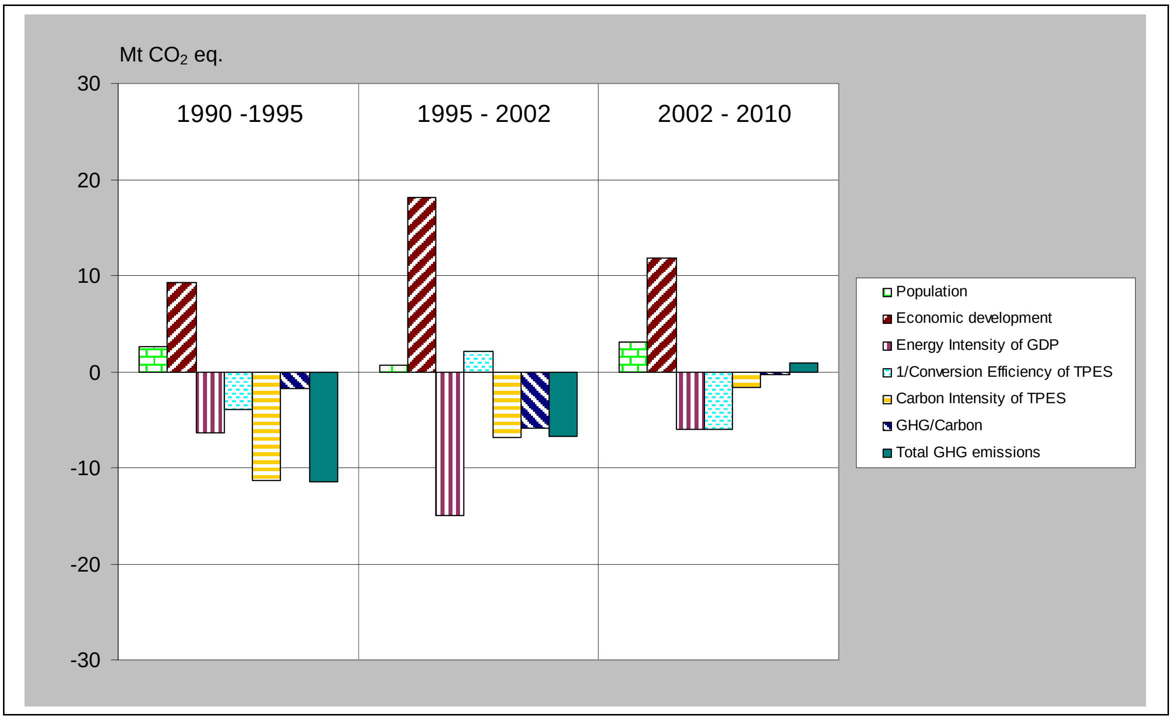
Basically the energy intensity of the United Kingdom's economy showed a downward trend although it grew slightly in 1991 and 1996. Until 2002 the energy intensity had improved by more than 14% compared to the level in 1990. According to the projections submitted by the United Kingdom, this trend will continue up until 2010. The energy intensity will then be almost 24% below the initial value in 1990. However, it might be improved further since it will still be above the average of the EU-15 Member States.

The per-capita gross domestic product declined in real terms between 1990 and 1992 but started to grow constantly thereafter. In 2003 it was already more than 30% above the level in 1990. In 2010 it will be almost 50% above the initial value in 1990. As greenhouse gas emissions declined and will decline further in that period, one can consider them decoupled from economic development. In 2010 the United Kingdom will emit only 55% of the greenhouse gas emissions it had emitted in 1990 to produce the same amount of products or services.

Considerable improvements concerning the per-capita greenhouse gas emission could be attained in the United Kingdom. This can be attributed to the energy and carbon intensity gains. The projected development of capita greenhouse gas emissions lies within the average of the EU-15 Member States: a slight decrease of one percent between 2002 and 2010.

Figure 3.48 reveals the remarkable emission reductions in the United Kingdom by showing the contribution of the individual driving forces to this trend in the past. As can be seen the energy and carbon related driving forces compensated by far the population and economic growth in the beginning of the nineties. Between 1995 the contribution of the economic growth even increased but could be still compensated by energy and carbon intensity improvements. Up until 2010 the economic development is expected to slow down compared to the end of the nineties, but the compensating effect of the other driving forces is also shrinking. In spite of a trend reversal regarding the conversion efficiency towards a decreasing effect – the conversion efficiency in the United Kingdom is expected to experience the second highest relative improvement in EU-15 – the emission level is projected to rise compared to 2002.

Figure 3.48 Annual contribution of driving forces to the GHG emission trends and projections in the United Kingdom



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

3.25 Overview

Additional insights are revealed by a comparison of the changes of the driving forces carbon intensity, conversion efficiency and energy intensity and – as a result – of the per-capita greenhouse gas emissions in the individual Member States. Furthermore an overview of the results of the index decomposition analysis supplement the analysis results in a quantitative manner. For the EU comparisons we separated the changes already realised in the period between 1990 and 2002 from the expected changes in the future.

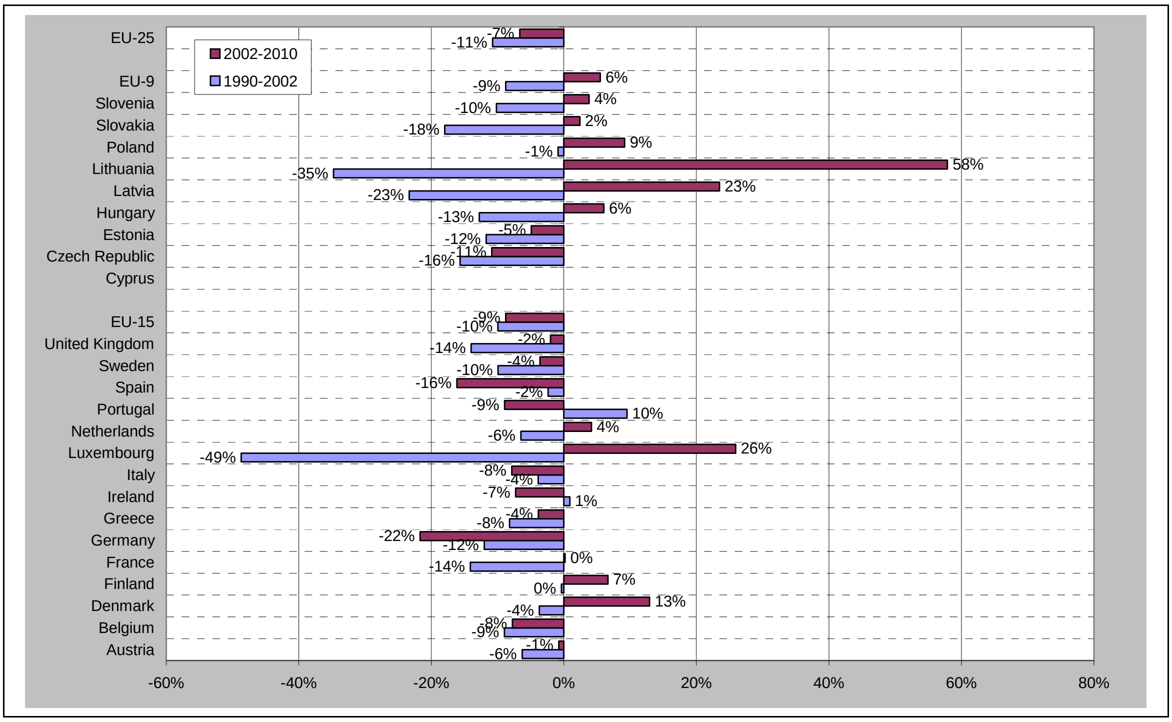
On average the carbon intensity of all 24 Member States considered was improved by 11% during the period between 1990 and 2002 (Figure 3.49). In the years to come it will further improve although at a slower pace (-7%) which can be explained by the deterioration of carbon intensity in the new Member States (+6%).

In the Member States in which the carbon intensity of the energy supply improved the most, it will deteriorate again in the future (Lithuania, Latvia, Luxembourg). In contrast, the carbon intensity will improve in the future in Member States in which this indicator rose in the past (Portugal, Ireland).

The United Kingdom, the Slovak Republic, Slovenia and Sweden improved their carbon intensity during the period between 1990 and 2002 but will remain more or less at that level up until 2010. Germany, the Czech Republic, Greece and Spain had improved the carbon intensity of the energy supply during the nineties but will continue to do so even more up until 2010.

Only in Denmark, Finland, Latvia and Poland will the carbon intensity be higher at the end of the recent decade than in 1990. In particular whether additional policies and measures can be introduced in these countries to change this trend before the end of the period should be assessed. Moreover, countries with smaller improvements might consider additional policies and measures since the good performance of some of the other Member States shows that the carbon intensity can be reduced substantially.

Figure 3.49 Changes in carbon intensity



Source: EC (2003), EEA (2004), Eurostat (2004b), UNFCCC (2005), own calculations

For the European Union as a whole the conversion efficiency virtually did not change during the nineties and will not do so up until 2010, (Figure 3.50). The same applies to Cyprus, Greece, France, Sweden and Latvia.

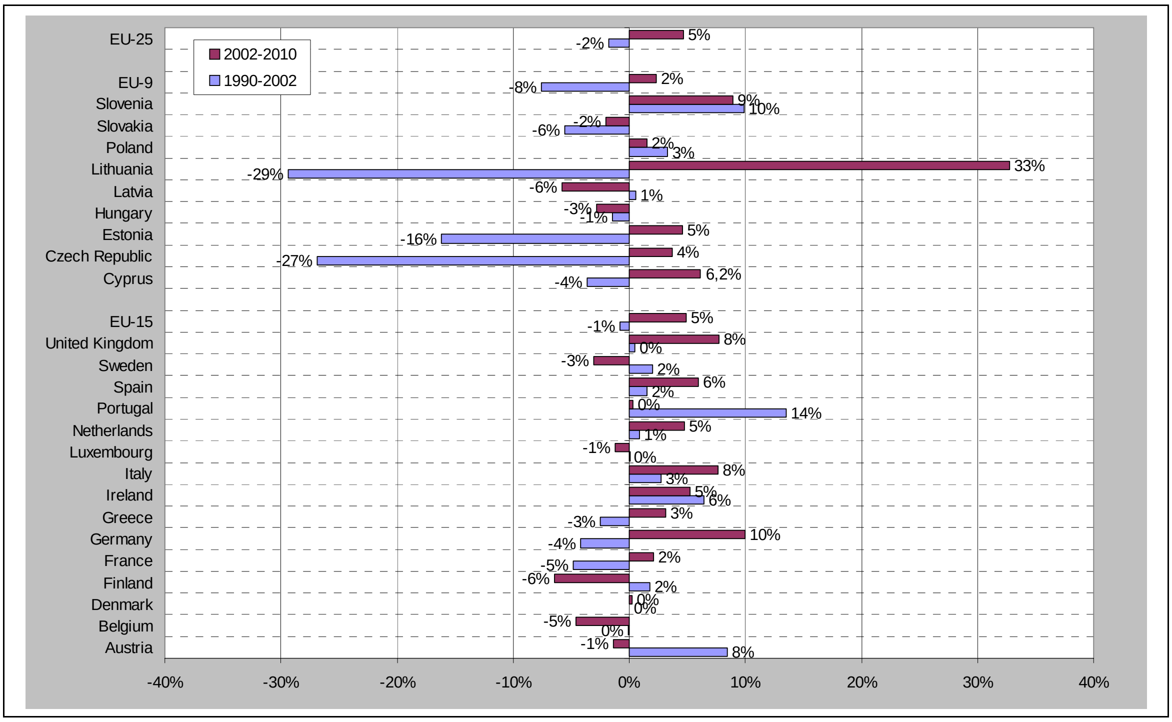
In Sweden, Germany and the United Kingdom the conversion efficiency of the energy sector deteriorated during the nineties, but it will improve again and over-compensate the deteriorations up until 2010.

Slovenia and Portugal achieved substantial improvements in the conversion efficiency during the period between 1990 and 2002. However, in the future the improvements will be substantially smaller. The conversion efficiency in 2010 will be much better than in 1990.

Ireland and Spain have achieved some improvements in the conversion efficiency in the past and will continue to do so, more or less at the same pace, in the future.

In the Czech Republic, Estonia and Lithuania the conversion efficiency deteriorated substantially during the nineties but only in the latter country will this trend be reverted and over-compensated in the future. Correspondingly, in particular the Czech Republic and Estonia should check whether there is potential for future improvements.

Figure 3.50 Changes in conversion efficiency



Source: EC (2003), Eurostat (2004b), own calculations

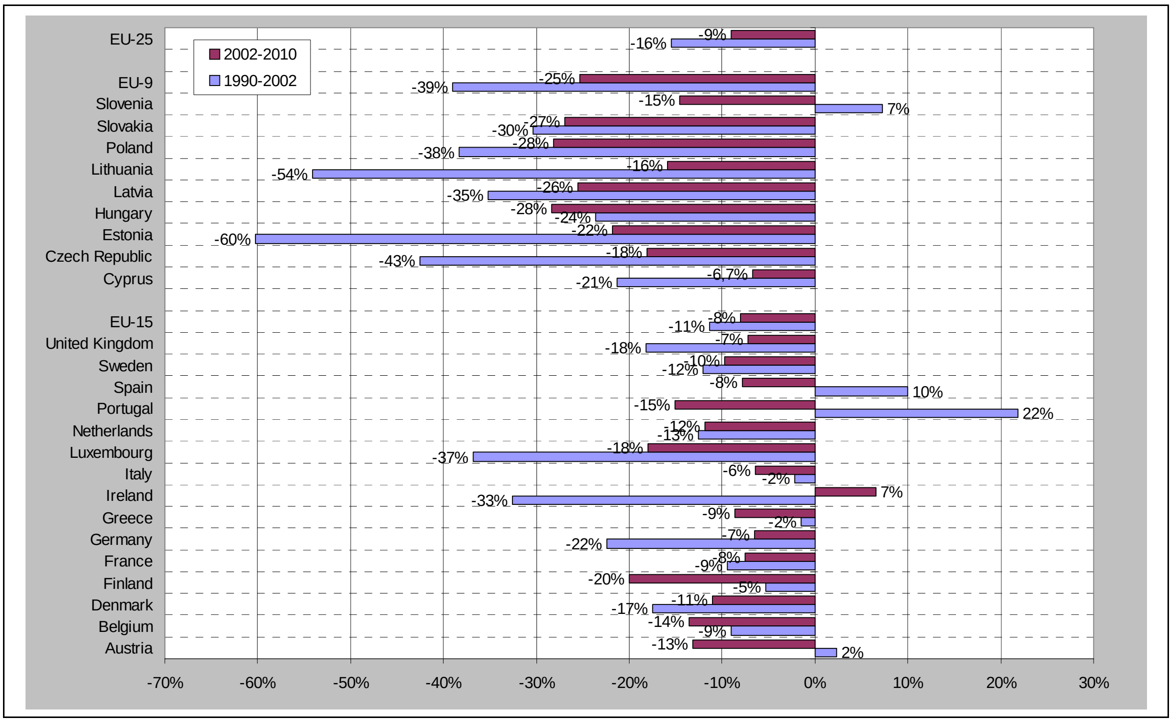
On average in the EU, the energy intensity was improved by 16% during the nineties and will be further improved by an additional 7% up until 2010 (Figure 3.51). While there is an obvious overall trend to lower energy intensities, the performance of the individual Member States varied substantially; the energy intensity in the new Member States was improved and is projected to improve much more than in the EU-15 Member States.

Since the energy intensity of the new Member States was several times worse than the EU average in 1990, these countries achieved the largest improvements in the past and will improve the energy intensity of their economies even further up until 2010.

The energy intensity increased only in Spain, Portugal and Slovenia during the nineties. In the future it will improve again but only in Slovenia will it be below the 1990 level by 2010.

Among the EU-15 Member States, Germany and Denmark achieved substantial improvements during the nineties but will achieve only smaller improvements up until 2010. Belgium, Finland and France achieved only smaller improvements in the past but are expected to improve the energy intensity of their economies even more so in the future.

Figure 3.51 Changes in energy intensity



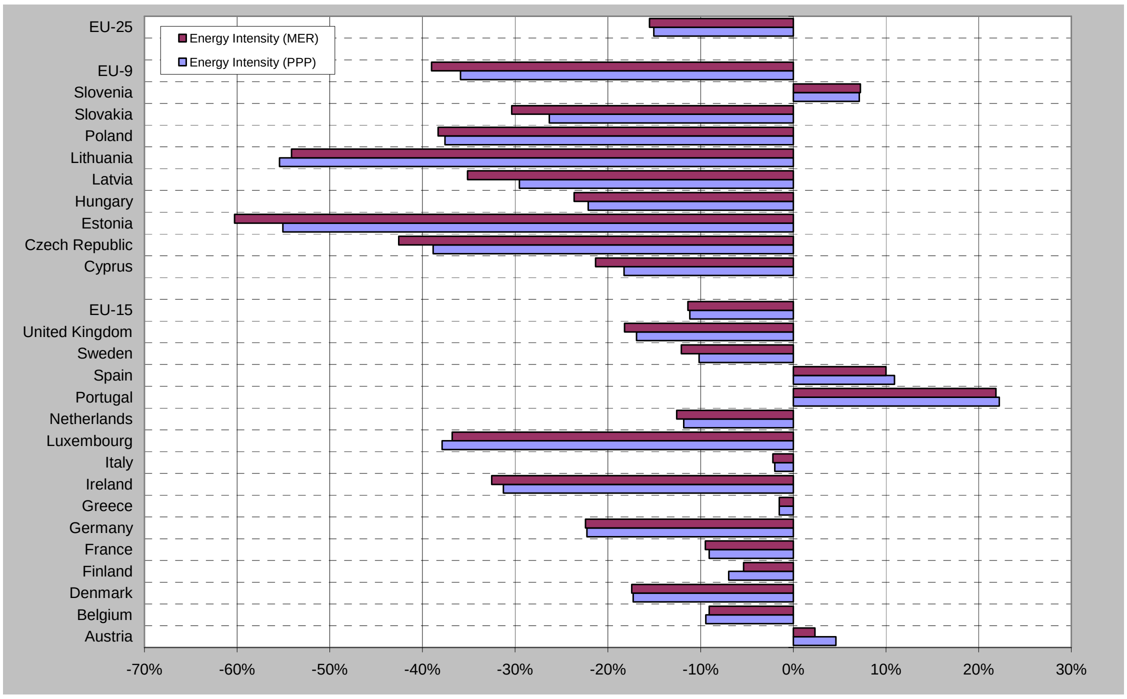
Source: EC (2003), EEA (2004), Eurostat (2004a), Eurostat (2004b), UNFCCC (2005), own calculations

Effect of the GDP approach on changes in energy intensity

Figure 3.52 provides an overview of the effect on changes in energy intensity depending on which approach is selected regarding GDP values. As no GDP projections based on PPP are available, only the trends are analysed. It can be easily seen that the choice of GDP approach does not have a structural influence on changes in energy intensity. In absolute terms, the energy intensity changes in the MER-based approach are both in EU-15 and EU-9 on average higher than in the PPP-based approach. However there are individual Member States in which it is vice versa (Latvia, Lithuania, Spain, Portugal, Luxembourg, Finland, Belgium and Austria).

Although the level of energy intensity for individual years varies significantly depending on the GDP approach selected (Figure 2.2), the GDP approach has only small impacts on the development of the energy intensity over time. It does not structurally affect the development of the driving forces. Therefore, we find that focussing our analysis just on the MER approach is very justified.

Figure 3.52 Changes in energy intensity based on PPP and MER GDP (1990 - 2002)

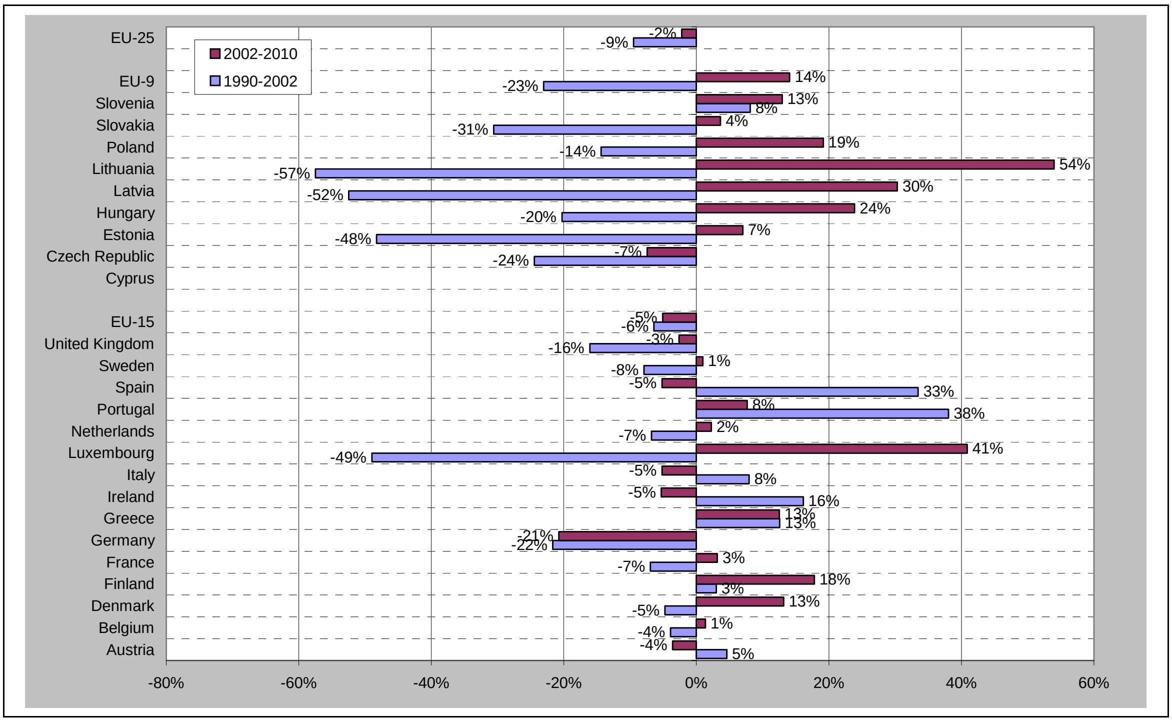


Source: Eurostat (2004b), World Bank (2004), calculation by Öko-Institut

Figure 3.53 illustrates an overall trend to lower per-capita emission in the last decade of the previous century for both the new and EU-15 Member States. However, some EU-15 Member States (Portugal, Spain, Austria, Italy and Greece) with high economic growth and an absolute share of per-capita greenhouse gas emissions which is significantly under both the European average and the average of the EU-15 Member States, show an increase in the per-capita greenhouse gas emissions in this period. Furthermore, Slovenia is the only new Member State which has an increasing share between 1990 and 2002.

Regarding the projected greenhouse gas emissions per inhabitant, a homogenous structure is not apparent. There are both new and EU-15 Member States with raising per-capita emissions. The overall trend in the EU-15 Member States still remains negative (-5%), the one in the New Member States reversed: a growth of 14% is projected between 2002 and 2010. However, the performances of the individual Member States vary substantially, some will have high growth (Lithuania, Latvia, Poland, Hungary and Luxembourg), others are projected to show a negative trend regarding the per-capita emissions (Austria, Germany, Ireland, Italy, Spain, the United Kingdom and the Czech Republic).

Figure 3.53 Changes in per-capita greenhouse gas emissions



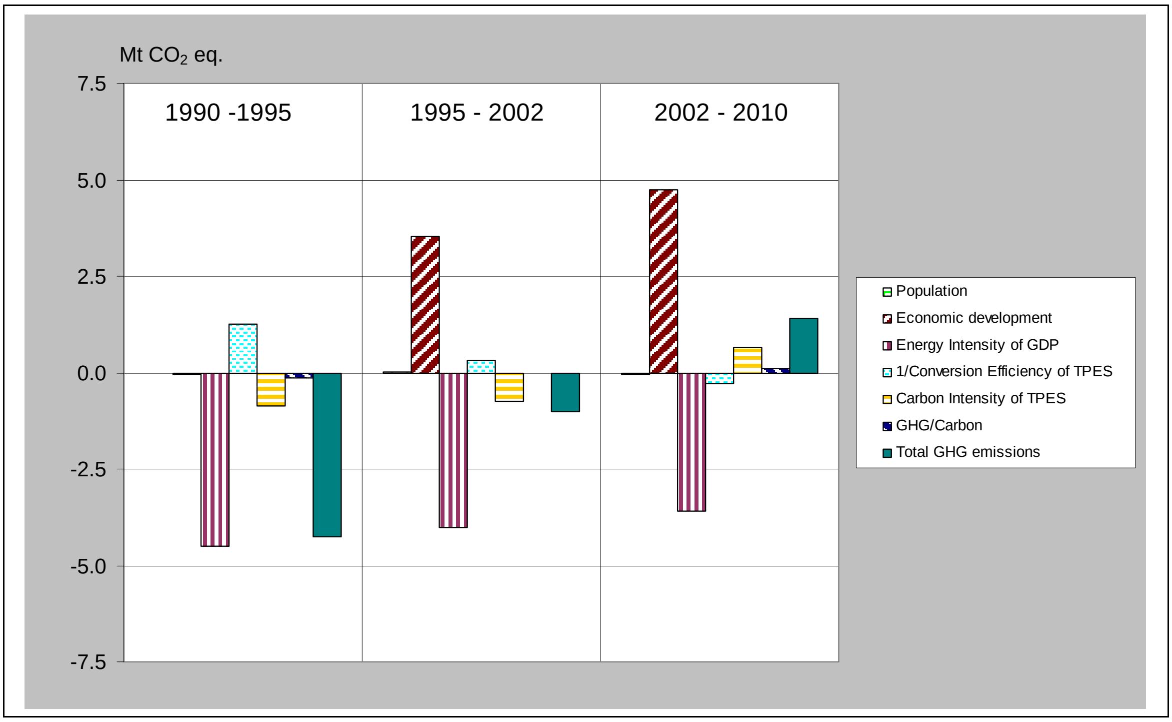
Source: EC (2003), EEA (2004), Eurostat (2004a), Eurostat (2004b), IEA (2002), own calculations

Finally an overview is given of the annual contribution of the driving forces on the overall emission trend for the new Member States (EU-9, except Malta) and the EU-15 respectively. Figure 3.54 shows how the individual driving forces influenced the emission level between 1990 and 1995 as well as between 1995 and 2002 and which contribution is projected until 2010.

On average, the improvement of energy intensity has the largest positive influence on emission reduction (between 1990 and 1995 (1995-2002) emission reduction of -4.5 Mt CO_2 (-4 Mt CO_2) annually) in the new Member States and is projected to be the only driving force which has a significant decreasing effect on the emissions in the next years (-3.03 Mt CO_2 annually). The effective average annual reduction in total greenhouse gas, however, was slightly lower (-4.24 Mt CO_2) at the beginning of the nineties and significantly lower at the end of the nineties (-1.02 Mt CO_2). At the beginning of the period considered, the emission reduction was delayed by the deteriorating conversion efficiency (+1.25 Mt CO_2), then mainly by the increasing emission effect of the economic development (+3.5 Mt CO_2). Some more positive effects on the emission level derived from improvements of the carbon intensity (1990-1995 -2 Mt CO_2), 1995-2002 -0.73 Mt CO_2 annually) but in future this driving force is projected to delay the emission reduction. In the future the GHG are projected to grow (+3.5 Mt CO_2 annually), mainly due to the annual increasing effect of economic development (+4.7 Mt CO_2) which cannot be compensated any longer by improvements of the energy intensity (-4 Mt CO_2 annually).

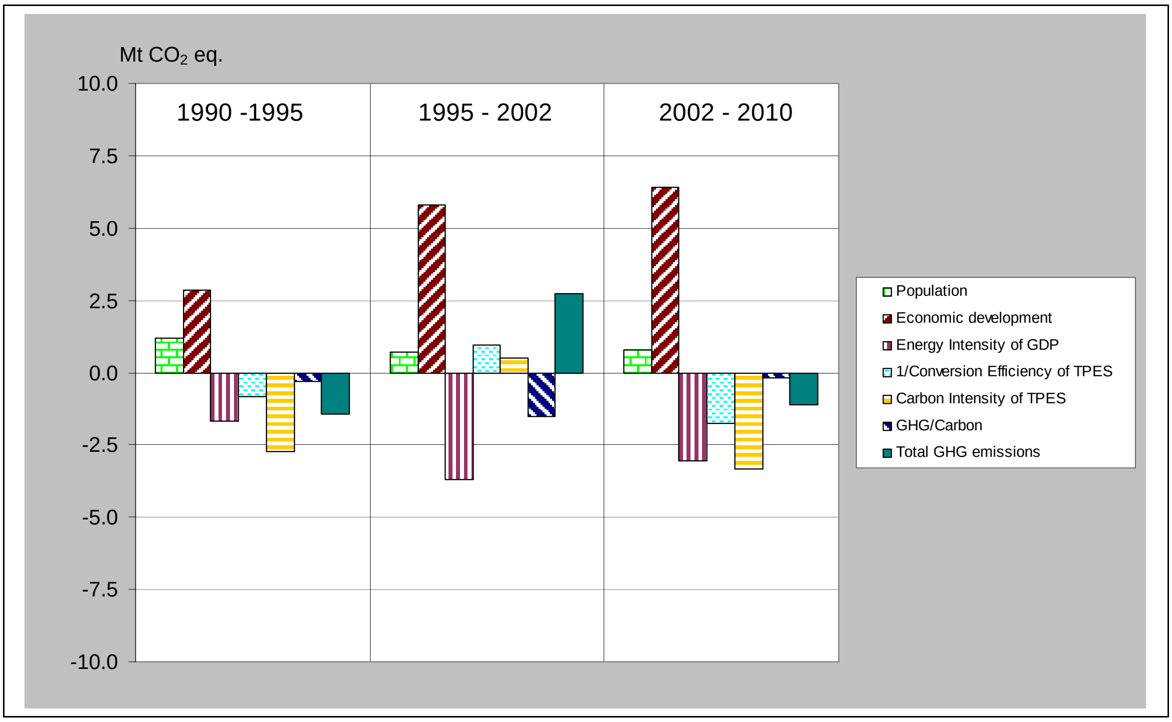
The overview of EU-15 shows a slightly different picture. The energy intensity in EU-15 also had a great positive influence on the emission trend (between 1990 and 1995 (1995-2002) -7 Mt CO_2 (-3.7 Mt CO_2) annually, however at the beginning of the nineties and up until 2010, the improvements of the carbon intensity have, in contrast to the new Member States, a significant influence on the reduction of greenhouse gas emissions which is even larger than that of the energy intensity. The conversion efficiency, which shows a favourable trend in the new Member States, turned out to be a limiting factor for the emission reductions in the EU-15 at the end of the nineties; however, improvements in the future support the compensation of the increasing emission by economic development. It total, the total GHG emissions are projected to show a favourable trend again after an increase between 1995 and 2002.

Figure 3.54 Annual contribution of driving forces to the GHG emission trends and projections in the new Member States (EU-9, except Malta)



Source: EC (2003), EEA (2004), Eurostat (2004b), IEA (2002), UNFCCC (2005), own calculations

Figure 3.55 Annual contribution of driving forces to the GHG emission trends and projections in EU-15



Source: EC (2003), EEA (2004), Eurostat (2004b), IEA (2002), UNFCCC (2005), own calculations

4 In-depth analysis of selected driving forces

4.1 Aim, methodology and data sources

In general, the effects of certain policies and measures can be assessed more easily on a sectoral than on a macroeconomic level. Based on this fact, an in-depth analysis on a sectoral level seems to be indispensable. However, data availability and comparability is often not as good on the sectoral as on the macroeconomic level. Given this trade-off, one has to find a balance between detail, comparability and significance.

This chapter covers the results of an in-depth analysis of selected driving forces on the sectoral level. It was intended that the following results provide, on the one hand, a more detailed picture of selected driving forces described in Chapter 2.7 and, on the other hand, they should serve as a sound basis for the assessment of policies and measures presented in chapter 5. Based on these two aims the driving forces for the in-depth analysis were selected.

Furthermore, the aim was to focus on the most significant sectoral emission sources and on those emission sources in which the emission reduction potential are the greatest. For example the transport section is one of the most significant sectoral emission sources but past experience shows that emission reductions in absolute terms are very difficult to achieve. However, solid waste disposal – a small emission source compared to transport – is projected to contribute significantly to the emission reduction in the EU until 2010 by virtue of the existing policies and measures. Figure 5.1 in section 5.1 gives an overview of the projected effect of the most important policies and measures. The Member States indicated that their largest reduction potential occurs in the field of power generation (renewable energy, CHP), energy consumption (energy efficient appliances, building standards), transport (ACEA Agreement) and waste.

Based on these considerations, it was decided that the following driving forces be analysed in more detail:

- Conversion efficiency of heat and power generation
(including combined heat and power generation)
- Carbon intensity of fossil and total primary energy supply
(including renewable and nuclear energy)
- Energy intensity of transport

The need to differentiate structural and efficiency effects was already identified in the discussions of the methodological approach (section 2.1). As a second important aspect, the carbon intensity of power generation will be analysed in more detail; the power generation by renewable and nuclear energies will be regarded separately. As a consequence, the carbon intensity of the power generation by fossil fuels can be described more easily: shifts from a carbon-intensive to a less carbon-intensive fuel are no longer overlapped by other influencing factors on the overall carbon intensity. As the transport section represents an important, and in most of the Member States a growing, sector which has significant influence on the final energy consumption and thus on the energy intensity, it will be assessed more comprehensively. Several indicators were identified for the in-depth analysis of each of these driving forces. They reflect the past trends, the current status and key future developments in each EU Member State.

The focus of the indicator-based sectoral assessment in this section is laid on an overall comparison of the trends and projections in the 25 EU Member States rather than an in-depth analysis of the individual countries. However, the aim is to identify remarkable trends and projections in individual Member States by analysing the overall EU trends. In the case of striking trends on the Member State level, these developments are assessed on the basis of the more detailed sectoral data.

Sectoral energy data and indicators are available from different data sources which are already described in section 2.1 (EC 2003; EU Member States; Eurostat 2004). Additionally the Odyssee database (ECN 2005a) could be of relevance to the compilation of the transport database.

However, complete projections for all 25 EU Member States are only provided by the European Energy and Transport Trend Report (European Commission 2003). Therefore this report is taken as basis for all projections. The trends up until 2002 are taken from Eurostat (2004) provided that time series were available for all Member States. As the trends in the European Commission's (2003) report are often based on Eurostat data as the primary data source, the combination of these two data sources is appropriate.

4.2 Conversion efficiency of heat and power generation

In section 2.7, the conversion efficiency (TFC/TPES) of the respective economies in the EU Member States was discussed in detail. An increasing trend of the conversion efficiency signifies that more final energy was or will be produced from less primary energy sources. However, the conversion efficiency is a result of several overlapping and partly conflicting effects:

- The efficiency effect due to the commissioning of more efficient thermal power plants and boilers.
- The shift from heat to power consumption strongly influences the conversion efficiency. The overall conversion efficiency might, for example, decrease due to a shift from heat to power consumption although the conversion efficiency of heat and power plants has improved.
- The average efficiency of coal fired power plants is lower than the efficiency of gas power plants. A fuel shift from gas to coal would, therefore, reduce the overall conversion efficiency even though the average efficiency of coal and gas plants was increased.

- An increase in combined heat and power generation would improve the conversion efficiency but only if the efficiency of heat and power generation is considered together.
- Since the conversion efficiency is defined as total primary energy supply per total final energy consumption, it will also be distorted by changes in the electricity trade balance.

In order to properly address potentials for efficiency improvements which can be achieved through policies and measures – for example the promotion of CHP – or to assess the impacts of already implemented policies and measures, additional indicators which reflect the above mentioned effects are necessary. Against this background, an in-depth analysis of the following indicators was undertaken.

$$\frac{TPES}{TFC} \rightarrow \quad \frac{TEC}{TFC};\frac{NIE}{TEC};\frac{TEG}{PESEG};\frac{TSG}{PESSG};\frac{TEG_{cogen}}{TEG};\frac{TSG_{cogen}}{TSG}$$

Table 4.1 provides an overview of the input energy unit for the indicators and the data sources applied; subsequently the significance of the indicators is briefly described.

Table 4.1 Input units and data sources used for detailed assessment of conversion efficiency

Abbreviation	Name	Data sources	
		Trends (1990 - 2002)	Projections (2002 - 2010)
TPES	Total Primary Energy Supply	Eurostat (2004)	EC (2003)
TFC	Total Final Energy Consumption	Eurostat (2004)	EC (2003)
TEC	Total Electricity Consumption	EC (2003)	EC (2003)
NIE	Net Import of Electricity	Eurostat (2004)	EC (2003)
PESEG	Primary Energy Supply of Electricity Generation	EC (2003), own calculation	EC (2003)
PESSG	Primary Energy Supply of Steam Generation	EC (2003), own calculation	EC (2003)
TEG_{cogen}	Total Electricity Generation in Cogeneration plants	EC (2003)	EC (2003)
TSG	Total Steam Generation	EC (2003)	EC (2003)
TSG_{cogen}	Total Steam Generation in Cogeneration plants	EC (2003)	EC (2003)

Source: Öko-Institut

Calculation of Primary Energy Supply of Electricity and Steam Generation

In EC (2003), data on fuel input in thermal power plants are basically available. However, the total fuel input into combined heat and power plants is included there. In order to allocate the amount of fuel consumed for electricity generation from the amount used for heat generation in combined heat and power plants, the following assumptions and calculations were made:

As an allocation rule, we determined the fuel consumption for co-generated heat by estimating the marginal loss of electricity generation per unit of marginal steam extraction, assuming that the loss of electricity generation would be generated in the same plant through additional fuel combustion. On average, about 1.75 kWh additional steam can be extracted using 1 kWh fuel. Based on this allocation rule and the amount of steam generated in CHP plants, the fuel input for steam generation in CHP plants is determined. Finally, the Primary Energy Supply for Electricity Generation is identified by subtracting the fuel input for steam generation in CHP plants from the total fuel consumption in thermal power plants. The Primary Energy Supply for Steam Generation amounts to the sum of the fuel input for steam generation in CHP plants and the fuel input in district heating and industrial boilers available.

- *Total Electricity Consumption as a share of Total Final Energy Consumption/Net Import of Electricity as a Share of Total Electricity Consumption*

  Changes in Electricity Consumption as a share of Total Final Energy Consumption indicate a shift from heat to electricity consumption or vice versa. However, since this indicator overlaps with change in the electricity trade balance the total final consumption has to be adjusted by alterations in the trade balance.

- *Total Electricity Generation divided by Primary Energy Supply of Electricity Generation and Total Steam Generation divided by Primary Energy Supply of Steam Generation*

  These indicators reflect the efficiency of electricity and the efficiency of steam generation separately. Drawback of this approach is that an increase in combined heat and power production reduces the efficiency of electricity and steam generation.

- *Electricity and Heat Generation in Cogeneration Plants as a Share of Total Electricity and Heat Production*

  These indicators are analysed in order to separate the impacts of changes in the share of cogeneration on the efficiency of electricity or heat generation (see above). Since increasing the share of CHP is also an important policy for GHG reduction, these indicators can also indicate potentials to intensify this policy.

The indicators described above are analysed in two different ways:

- The level of the indicator in absolute terms in the reference years 1990 (if data available, else 1995), 2002 and 2010
- The relative change of the indicator in the past (1990-2002) and in the projected change in future (2002-2010)

By considering both aspects, the absolute level and relative trends, appropriate conclusion can be drawn. For example, if one Member State shows an efficiency of electricity generation which is far below the EU- average, it is usually easier to achieve large improvements than in a Member State in which the efficiency of electricity generation is already high. Great relative changes of the energy efficiency must be assessed under this aspect in order to evaluate the efforts made and the success of the policies and measures respectively. The relevant indicators in absolute terms are presented at the beginning of the individual section as an overview.

4.2.1 In-depth analysis of conversion efficiency

The in-depth analysis is based on the data given in Table 4.2.

Table 4.2 Selected indicators in 1990, 1995, 2002 and 2010

		Conversion efficiency	TEC/ TFC	NIE/ TEC	EG/ PESEG *)	SG/ PESSG *)	% of electricity from CHP *)	% of steam from CHP *)
Austria	1990	0.75	0.20	-0.01	0.39	0.97	0.21	0.59
	2002	0.81	0.19	0.01	0.42	1.21	0.23	0.58
	2010	0.80	0.21	-0.01	0.46	1.23	0.27	0.60
Belgium	1990	0.62	0.16	-0.06	0.38	1.06	0.04	0.37
	2002	0.62	0.19	0.10	0.42	1.12	0.06	0.46
	2010	0.59	0.19	0.05	0.49	1.17	0.08	0.49
Denmark	1990	0.74	0.18	0.24	0.42	1.25	0.69	0.57
	2002	0.74	0.19	-0.06	0.43	1.34	0.58	0.68
	2010	0.74	0.20	0.04	0.46	1.39	0.53	0.72
Finland	1990	0.73	0.23	0.18	0.41	1.23	0.34	0.63
	2002	0.74	0.27	0.15	0.44	1.17	0.35	0.56
	2010	0.69	0.28	0.08	0.46	1.14	0.34	0.52
France	1990	0.59	0.19	-0.15	0.34	1.00	0.02	0.29
	2002	0.57	0.22	-0.20	0.32	0.99	0.03	0.26
	2010	0.58	0.24	-0.12	0.38	1.04	0.05	0.33
Germany	1990	0.64	0.17	0.00	0.37	1.01	0.09	0.58
	2002	0.62	0.20	0.02	0.40	1.22	0.10	0.66
	2010	0.68	0.19	0.01	0.42	1.34	0.12	0.71
Greece	1990	0.59	0.17	0.02	0.33	0.96	0.02	0.21
	2002	0.58	0.21	0.06	0.37	0.99	0.03	0.27
	2010	0.60	0.23	0.00	0.40	1.04	0.03	0.36
Ireland	1990	0.69	0.14	0.00	0.37	0.91	0.01	0.12
	2002	0.73	0.17	0.02	0.42	0.98	0.01	0.23
	2010	0.77	0.18	0.00	0.49	1.05	0.03	0.33
Italy	1990	0.68	0.17	0.16	0.37	1.33	0.13	0.69
	2002	0.70	0.19	0.18	0.40	1.34	0.15	0.70
	2010	0.75	0.19	0.10	0.48	1.37	0.15	0.73
Luxembourg	1990	0.93	0.11	0.95	0.27	0.88	0.10	0.67
	2002	0.93	0.13	0.61	0.48	1.26	0.35	0.63
	2010	0.92	0.14	0.68	0.54	1.27	0.10	0.67
Netherlands	1990	0.55	0.15	0.13	0.39	1.35	0.36	0.70
	2002	0.55	0.17	0.16	0.44	1.42	0.44	0.77
	2010	0.58	0.18	0.17	0.50	1.45	0.32	0.79
Portugal	1990	0.62	0.18	0.00	0.36	1.23	0.09	0.64
	2002	0.71	0.19	0.05	0.42	1.27	0.09	0.65
	2010	0.71	0.20	0.02	0.46	1.26	0.14	0.62
Spain	1990	0.61	0.19	0.00	0.37	1.09	0.06	0.43
	2002	0.62	0.21	0.03	0.42	1.15	0.09	0.50
	2010	0.65	0.22	0.00	0.48	1.25	0.13	0.62
Sweden	1990	0.64	0.34	-0.01	0.45	0.97	0.05	0.21
	2002	0.65	0.34	0.04	0.39	0.95	0.08	0.22
	2010	0.63	0.33	0.03	0.40	0.95	0.13	0.22
United Kingdom	1990	0.65	0.17	0.04	0.40	1.09	0.04	0.43
	2002	0.65	0.19	0.03	0.44	1.28	0.08	0.64
	2010	0.70	0.20	0.04	0.51	1.30	0.10	0.66
EU-15	**1990**	**0.64**	**0.18**	**0.01**	**0.38**	**1.09**	**0.15**	**0.48**
	2002	**0.63**	**0.21**	**0.02**	**0.41**	**1.17**	**0.18**	**0.52**
	2010	**0.66**	**0.21**	**0.01**	**0.46**	**1.22**	**0.17**	**0.56**

		Conversion efficiency	TEC/ TFC	NIE/ TEC	EG/ PESEG *)	SG/ PESSG *)	% of electricity from CHP *)	% of steam from CHP *)
Cyprus	1990	0.65	0.12	0.00	0.33	0.87	0.00	0.00
	2002	0.63	0.18	0.00	0.35	0.87	0.00	0.06
	2010	0.67	0.17	0.00	0.38	0.92	0.01	0.19
Czech Republic	1990	0.80	0.11	-0.01	0.31	1.30	0.35	0.63
	2002	0.58	0.18	-0.22	0.34	1.29	0.35	0.64
	2010	0.60	0.20	-0.18	0.36	1.31	0.30	0.66
Estonia	1990	0.60	0.10	-1.03	0.32	1.10	0.53	0.34
	2002	0.51	0.18	-0.13	0.33	1.05	0.88	0.39
	2010	0.53	0.19	-0.15	0.38	1.15	0.53	0.53
Hungary	1990	0.67	0.14	0.35	0.32	1.13	0.10	0.55
	2002	0.66	0.16	0.14	0.34	1.44	0.17	0.75
	2010	0.64	0.20	0.10	0.42	1.52	0.24	0.85
Latvia	1990	0.71	0.25	0.41	0.22	1.03	0.26	0.29
	2002	0.85	0.11	0.48	0.33	0.93	0.29	0.23
	2010	0.81	0.17	0.35	0.37	0.95	0.33	0.21
Lithuania	1990	0.64	0.10	-1.00	0.19	1.12	0.04	0.35
	2002	0.45	0.15	-0.97	0.35	1.07	0.25	0.41
	2010	0.60	0.15	0.02	0.45	1.15	0.59	0.49
Poland	1990	0.59	0.14	-0.01	0.34	1.09	0.37	0.48
	2002	0.61	0.15	-0.07	0.36	1.15	0.35	0.54
	2010	0.62	0.18	-0.05	0.37	1.33	0.31	0.67
Slovak Republic	1990	0.62	0.15	0.22	0.56	0.43	0.10	0.86
	2002	0.58	0.18	-0.18	0.41	0.78	0.10	0.12
	2010	0.57	0.23	-0.04	0.44	0.96	0.11	0.26
Slovenia	1990	0.62	0.25	-0.10	0.28	1.15	0.06	0.51
	2002	0.68	0.22	-0.10	0.35	1.18	0.09	0.53
	2010	0.74	0.20	-0.06	0.38	1.20	0.14	0.53
EU-9	**1990**	**0.65**	**0.13**	**0.11**	**0.34**	**1.06**	**0.23**	**0.50**
	2002	**0.61**	**0.16**	**0.09**	**0.36**	**1.15**	**0.31**	**0.46**
	2010	**0.62**	**0.19**	**-0.04**	**0.38**	**1.26**	**0.32**	**0.55**
EU25	**1990**	**0.64**	**0.17**	**0.01**	**0.37**	**1.08**	**0.18**	**0.48**
	2002	**0.63**	**0.20**	**0.01**	**0.40**	**1.17**	**0.22**	**0.50**
	2010	**0.66**	**0.21**	**0.01**	**0.44**	**1.22**	**0.22**	**0.55**
*) 1995 instead of 1990								

Source: EC (2003), Eurostat (2004b)

4.2.1.1 Shifts from heat to power consumption

At first the changes in electricity consumption as a share of total final consumption are investigated in detail. This analysis provides an important basis for identifying shifts from steam to electricity production which might contribute to the deterioration of the conversion efficiency.

In general, policies and measures supporting shifts from power to heat generation or constraining the shifts from heat to power generation are instruments which reduce electricity consumption. Measures may either lead to absolute electricity savings or may initiate shifts from electricity to heat consumption. An example of the first type of measure is a tax and basically all instruments which result in increasing electricity prices. An example of the latter type of measure is the one implemented in 1998 in Sweden which was aimed at the conversion from electric to district heating.

In order to evaluate the effect of these changes on the conversion efficiency, the share of electricity imports has to be taken into account as well. If an increased electricity demand is met by imported electricity, an increase in electricity consumption does not inevitably influence the conversion efficiency of that Member State. Therefore, whether increasing electricity consumption shares of total final energy consumption are coupled with large increases in the electricity import shares of total final energy consumption is analysed.

Changes in the electricity import and export share of total final energy consumption

Increases in imported electricity alone might influence the result of the in-depth analysis of the conversion efficiency – in these cases increases in electricity demand might be covered by other Member States with the result that the conversion efficiency does not deteriorate.

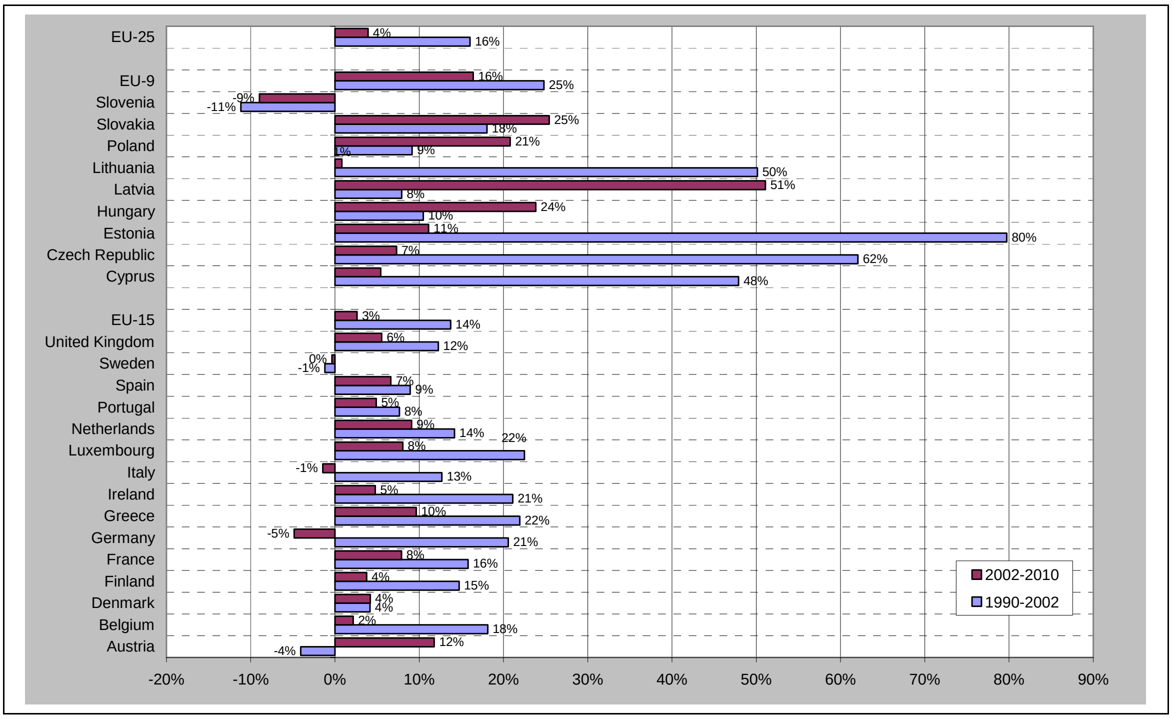
Member States with a slight increase in imported electricity between 1990 and 2010 (< 2 percentage points) are Austria, Germany, Italy, Ireland and Slovakia, higher increases in imported electricity could be noticed in Belgium, Greece, the Netherlands, Portugal, Spain, Sweden and Lithuania. Of those Member States only Slovakia, Italy and the Netherlands show an electricity import share higher than 10% of total electricity consumed.

Between 2002 and 2010, a reduction in electricity export at total electricity consumption is projected between 2002 and 2010 in several Member States (France, Czech Republic, Lithuania, Portugal and Slovakia), only in Luxembourg and the United Kingdom is a slight increase in import and in the Netherlands a more significant increase in imported electricity expected. However, in these Member States the ratio TEC/TFC does not increase significantly (< 1%) between 2002 and 2010. In the remaining Member States there are decreasing trends in import and increasing trends in export respectively. Thus, a further analysis is dispensable for these Member States.

Figure 4.1 shows that a shift towards a higher share of electricity consumption is an overall trend in the EU. In the new Member States – having a lower absolute level of electricity consumption in 1990 and 2002 – this trend is more pronounced than in EU-15, both in the past and in the projections. The trend towards higher shares of electricity consumption seems to be the business-as-usual trend in the European economy.

Comparing the EU trends with those of the conversion efficiency, it can be seen that the increasing share of electricity consumption in the past went hand in hand with a deterioration of the conversion efficiency, while these trends are decoupled in the projections: In spite of a growing share of electricity consumption at total final energy consumption in the EU, the conversion efficiency is projected to improve. Nevertheless it can be identified as one of the largest obstacles to the improvement of the conversion efficiency.

Figure 4.1 *Changes in the total electricity consumption share of total final energy consumption*



Source: *EC (2003), Eurostat (2004b); own calculations*

In the past, the largest changes have occurred in Estonia, the Czech Republic, Cyprus and Lithuania which are the Member States which show by far the lowest absolute share of TEC/TFC in the EU. While Cyprus, the Czech Republic and Estonia almost reach the average of the new Member States in 2002, Lithuania is still significantly below this average. Therefore the projection to stabilise TEC/TFC on that level in Lithuania seems to be ambitious. While in Lithuania energy trading balance (export of electricity) remained more or less constant, in Estonia the share of electricity exported was reduced from -103% in 1990 to -13% in 2002, the increased energy consumption in this period was obviously covered by own production. The latter is true for the Czech Republic as well; the share of export there even increased in parallel to the increase in electricity consumption. As a consequence, the increased electricity consumption affects the conversion efficiency in a deteriorating manner: the increased energy consumption is not covered by imported electricity but by electricity produced in the individual Member State.

Moreover, in Slovenia, Austria and Sweden a significant to slight change from electricity consumption to other final energy consumption has occurred which positively influenced the conversion efficiency. However, analysing the absolute values, these Member States show the highest share of electricity consumption in 1990. In other words, they had the greatest reduction potential; their consumption converges towards the EU-average.

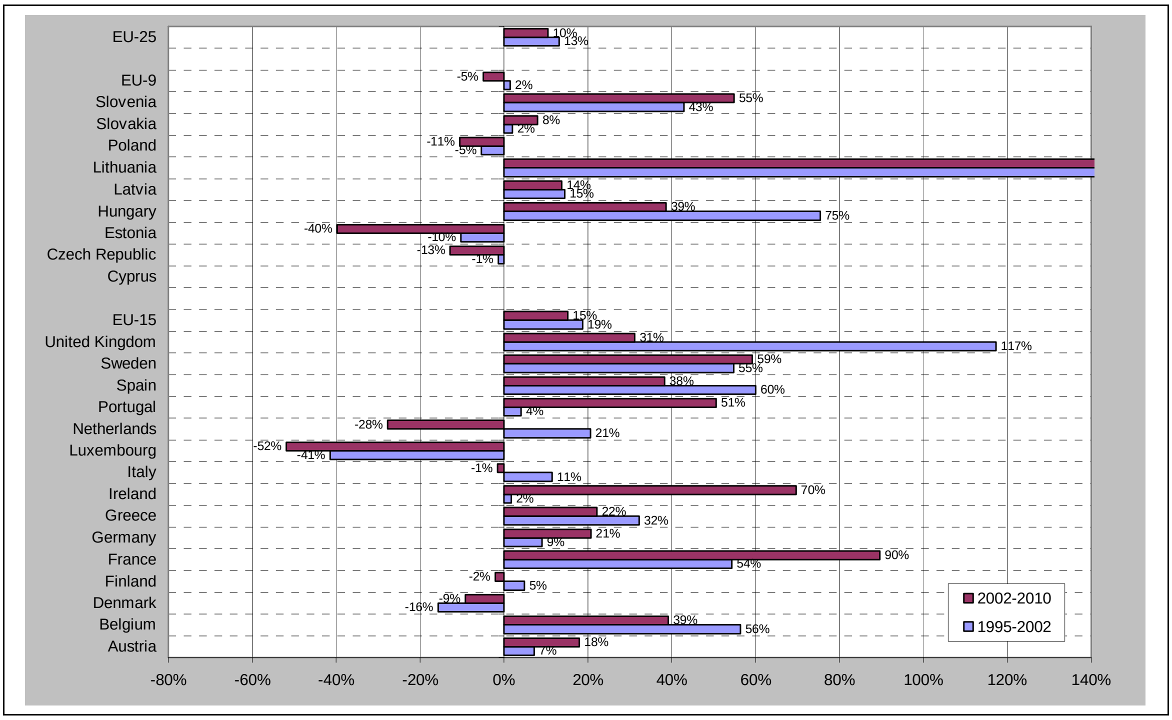
In future, decreases in TEC/TFC are expected in Slovenia, Germany and Italy. In these Member States the conversion efficiency is projected to improve significantly as well (Figure 3.50). Slovenia has a ratio of TEC/TFC which is significantly above the EU-9 average. In Germany and Italy the ratios are slightly under the EU-average, thus more efforts have to be made for the improvements than in Slovenia.

Finland, having the highest electricity consumption share of total final energy consumption in the EU in 2002, will even increase this share in future. Therefore a potential for shifting the energy supply from electricity to heat generation can be assumed. In this way, the projected deterioration of conversion efficiency up until 2010 could be attenuated.

4.2.1.2 Combined heat and power generation

The improvement of the efficiency of electricity and steam generation is one of the most obvious targets for energy suppliers. This goal can, for example, be addressed by increasing the price of primary energy sources through taxes. One of the most important approaches to improve the efficiency of heat and power generation is, however, the promotion of combined heat and power production. As the efficiency gains by the latter policies are not reflected in analysis results if the efficiency of heat and power is analysed separately (section 4.2.1.3), the share of cogeneration at total electricity and steam generation will be focused upon separately in the following.

Figure 4.2 Changes in the CHP electricity share of total electricity generation

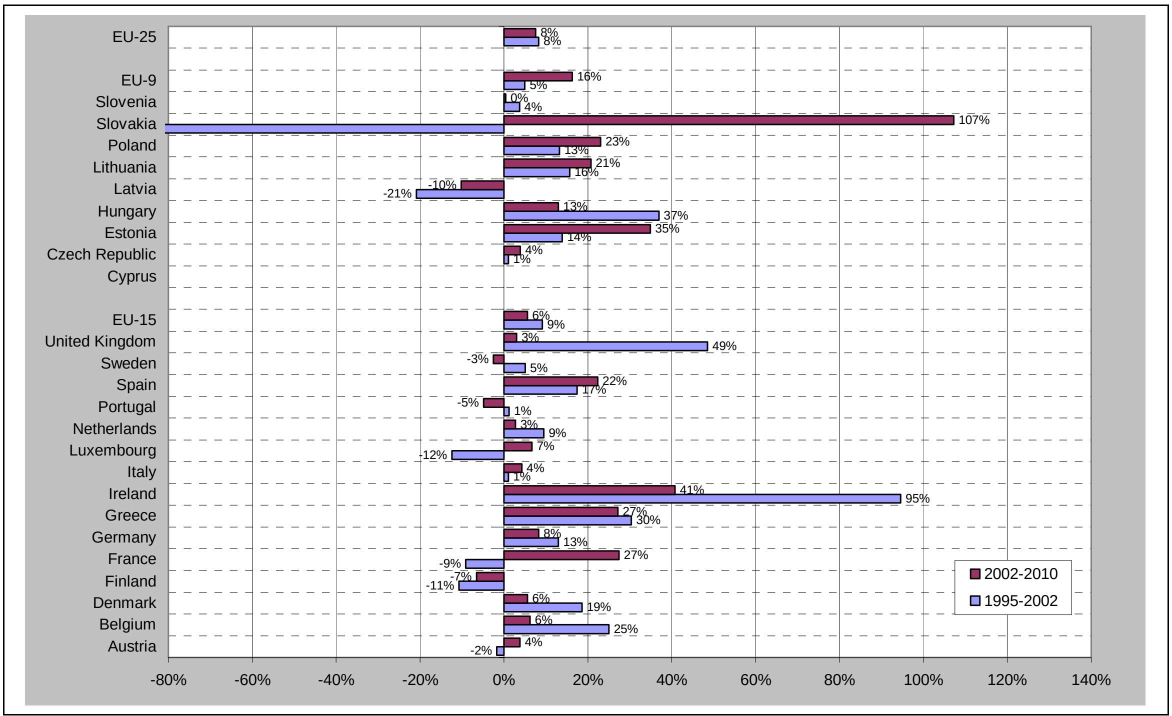


Source: EC (2003); own calculations

Figure 4.2 illustrates the EU-wide trend towards a higher share of CHP although more pronounced in EU-15 than in EU-9. The projections, however, show a different picture: while in the EU-15 a further increase of electricity generation in CHP plants is expected, the substantially higher CHP share in the new Member States will decrease slightly. The projection for the EU as a whole is dominated by the projections for EU-15. Correspondingly, the CHP share will continue to grow, although at a slightly slower pace than in the past.

Between 1995 and 2002, most Member States increased their share of electricity generation in CHP plants. However, in Denmark, the Czech Republic, Estonia, Luxembourg and Poland the CHP share has decreased. But the CHP shares in all theses countries are – despite the decrease – still above the average shares in EU-15 or EU-9. Until 2010 the CHP share is projected to continue to decrease in these countries and also in Finland, Italy and the Netherlands. However, except for Italy and Luxembourg, all these Member States will generate 30% or more of their electricity in CHP plants while only less than 15% of the electricity is generated in CHP plants in the EU as a whole. The strongest growth in the share of electricity generated in CHP plants is expected in Belgium, France, Hungary, Ireland, Portugal, Slovenia, Spain, Sweden and the United Kingdom. All these Member States were well below the average EU-15 or EU-9 shares in 2002 and will still have some potential to improve their shares in 2010, except for Portugal, Spain and Sweden who then will above the EU-15 average. In section 5.3.3 a detailed overview is provided which policies and measures are undertaken to achieve these improvements.

Figure 4.3 Changes in the share of steam generated in CHP plants of total steam generation



Source: EC (2003); own calculations

Finally, Figure 4.3 illustrates the overall trend in the EU towards a higher contribution of CHP plants to total steam generation, both in the new Member States and in EU-15. Between 1995 and 2005, the average share of CHP heat increased from some 50% to almost 55%. According to the projections, it will increase further to almost 60% in 2010, although somewhat more strongly in the new Member States than in EU-15.

Apart from the overall trends, there are six Member States (Slovakia, Latvia, Finland, France, Luxembourg and Austria) in which the share of steam by CHP decreased significantly (Slovakia, Latvia, Finland and France) or slightly (Austria).

While Slovakia, Finland, Austria and Luxembourg produce a significantly higher percentage of their steam by CHP than the EU average, the low share of Latvia and France deteriorated further. While France expects a reverse trend until 2010, in Latvia the share will probably deteriorate further to one of the lowest shares in the EU – therefore a potential for efficiency improvement through CHP can be assumed.

Apart from Latvia, decreases in the share are projected in Finland, Portugal and Sweden. Similar to Latvia, Sweden has also one of the lowest shares of steam generation by CHP in the EU, which will not be improved up until 2010 according to the projections by EC (2003). While the deterioration in Portugal does not lead to a share of steam generation in CHP below the EU-15 average, the decreasing trend in Finland does.

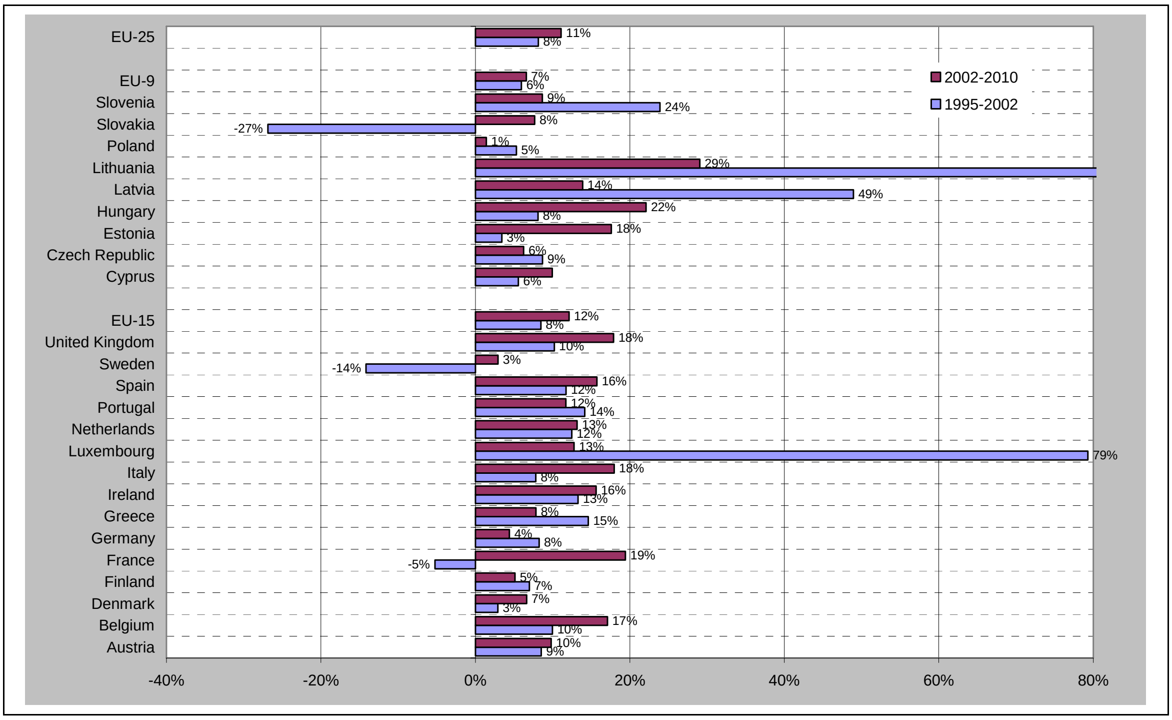
France, Greece, Ireland, Slovakia and Cyprus are the Member States which show by far the lowest steam production by CHP in the EU in absolute terms and are projected to increase their share relatively at most. However, all five Member States will still show a share in steam production by CHP which is far below the EU average in 2010. It could be assumed that the positive trend towards higher shares might be accelerated by policies and measures which promote the use of CHP.

Remarkable progress is also expected in Denmark, Germany, Italy, the Netherlands, the Czech Republic and Hungary. Although the relative increases are minor, in absolute terms these Member States have already the highest shares in the EU in 2002 and will further extend the distance from the EU average up until 2010.

4.2.1.3 Efficiency of heat and power generation

Having analysed the trends and projections regarding the contribution of CHP to total electricity and steam generation, changes in efficiency of heat and power generation in general are focused upon. For the following analysis, it should to be kept in mind that a Member State's overall efficiency of heat and power generation can be improved due to CHP although no significant improvements in efficiency of electricity generation on the one hand, and heat generation on the other hand, have been realised. This is mainly due to the fact that the electrical efficiency of CHP plants is lower than the efficiency of condensing power plants and the heat generation efficiency in CHP plants is lower than in conventional boilers although the overall efficiency (power and heat) is much better.

Figure 4.4 Changes in efficiency of electricity generation



Source: EC (2003); own calculations

Figure 4.4 gives an overview of the relative changes in efficiency of electricity generation. As can be easily seen, there is an overall trend towards efficiency improvements in EU-15 as well as in EU-9 both for the past (1995-2002)[17] and the future (2002-2010).

Between 1995 and 2002, there were only three Member States which had to cope with efficiency losses in electricity generation: Slovakia, Sweden and France. In absolute terms, Slovakia and Sweden have comparatively high efficiencies of electricity generation in 1995; the French one, however is below the EU average. Having deteriorated in the past, the efficiencies of electricity generation in Sweden and Slovakia correspond more or less to the EU-25 average, while the one in Slovakia is still one of the highest in the new Member States. France, however, has the lowest efficiency in electricity generation in EU-15 in 2002; therefore the French projection to increase it by 19 percentage points until 2010 does not seem to be too ambitious.

As already explained in the beginning of this section, significant change in the share electricity generated in CHP plants might influence the electricity generation efficiency if analysed in an isolated manner. Slovakia, Sweden and France are the Member States in which the efficiency of electricity generation deteriorated in the past. In Slovakia, the share of CHP remained more or less constant between 1995 and 2002, (Figure 4.2), thus negative effects on efficiency of electricity supply cannot be expected. Sweden and France show significant relative increases in the share of CHP at total electricity generation, but in absolute terms they have low shares (Sweden (5-8%); France (2-3%)). Therefore it is assumed that the changes in CHP are not responsible for the deterioration of the efficiency of the – separately analysed – electricity generation in these Member States.

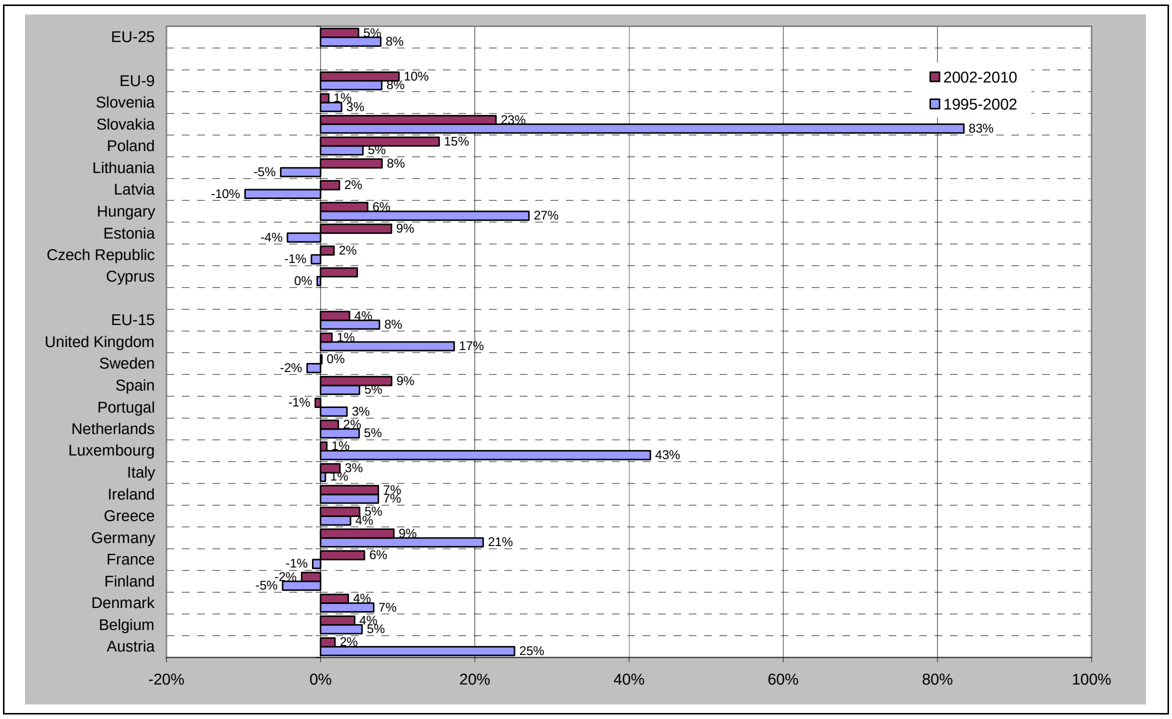
The highest relative efficiency gains in the past occurred in Lithuania, Luxembourg, Latvia and Slovenia. All four Member States had efficiencies far below the EU-25 average. Thus, these improvements are not surprising.

Considering the projections in detail, it can be concluded that Lithuania, Latvia, Hungary, Estonia and France – the Member States with the lowest efficiency in the EU or the largest reduction potential in 2002 – are projected to improve their efficiency most until 2010. The Member States with the highest efficiency in 2002 in the EU, Luxembourg, the Netherlands, Ireland, Denmark and the United Kingdom, have still very ambitious targets, relative improvements of more than 10% (except Denmark with 7%). So they will end up with the highest efficiencies in 2010 as well.

Member States like Germany, Greece and the Czech Republic have efficiencies of electricity generation which are below the EU-15 or the EU-9 average respectively but the projected improvements up to 2010 are rather small compared to the EU Member States with the highest efficiencies. Thus, in these Member States a potential to improve efficiency of electricity generation might exist.

[17] EC (2003) only provides data on fuel input in thermal power plants from 1995 onwards.

Figure 4.5 Changes in efficiency of steam generation



Source: EC (2003); own calculations

Similar to electricity generation, there is an overall continuous trend towards higher efficiencies in steam generation through the whole period considered, both in EU-15 and in the new Member States.

However there are some Member States in which the efficiency in steam generation deteriorated (Latvia, Lithuania, Finland, Estonia, Sweden and the Czech Republic). While in Finland and the Czech Republic very high efficiencies in steam generation could be registered in 1990, in Sweden and Latvia the rather low efficiencies deteriorated further. If the projections of these Member States are additionally taken in account, (stabilisation in Sweden, 2% improvement in Latvia), potential for more ambitious efficiency targets could be assumed here. Finland is one of the few Member States (Finland and Portugal) in which a loss in efficiency of steam generation is expected up until 2010, the absolute level of the efficiency of steam generation will fall, at least in Finland, below EU-average in 2010 – it must be checked if this trend might be attenuated by some effective policies and measures. In Estonia and Lithuania, the efficiency in steam generation were – after the deterioration in the past – well below EU average in 2002; however, according to the projections (Estonia +10%, Lithuania +8%), significant improvements are to be expected.

Nevertheless, the development of the heat generation efficiency might – like the development of the electricity generation efficiency – be interfered by changes in the share of CHP plant. Analysing the relation between CHP and the deterioration of steam generation, it can be concluded that in Finland, Latvia, Sweden and the Czech Republic –

showing either a decreasing trends and projections (Finland, Latvia) or a more or less constant ratio of CHP in the past (the Czech Republic, Sweden), that the efficiency deterioration occurred and will occur (Finland, Latvia) independently from CHP. The influence of CHP on the deterioration of steam efficiency can be assumed, however, for the past in Estonia[18] and in Lithuania[19].

In other words, the deterioration of the steam production in these Member States must be put into the perspective of the overall efficiency of steam and electricity production which was relatively increased by CHP. However the effect of deterioration does not have to be necessarily completely compensated by positive effects of CHP.

The most significant improvements in relative terms were achieved by Slovakia, Luxembourg, Hungary, Austria, Germany and the United Kingdom. Slovakia showed the lowest efficiency ratio in steam generation in the EU in 1990 and in spite of the improvements did so again in 2002. A similar trend is expected in future: although remarkable relative improvements are projected, the efficiency in 2010 will still be one of the lowest in the EU; further potentials can thus be assumed. Denmark, Germany and Luxembourg– having a steam efficiency significantly below EU-15 average in 1995– achieve an efficiency which is significantly higher than the EU-15 average in 2002. The latter is true for the United Kingdom as well. Hungary seems to be an exceptional case; its steam efficiency was the highest in 2002 and is still projected to be the highest in 2010 of all EU Member States.

Other Member States with a high efficiency in steam generation in 2002, Denmark, Italy, the Netherlands and the Czech Republic project further increases, ending up with efficiencies which are even more favourable than the EU-average – further significant potentials cannot be assumed in these Member States.

The efficiency in steam generation in Sweden, France, Greece, Ireland, Cyprus and Latvia were far below the EU-25 average in 2002 in absolute terms and only minor efficiency improvements are projected. Moreover, in these Member States the contribution of CHP plants to Total Steam Generation is relatively small in absolute terms; thus further potentials can be assumed here.

4.2.2 Results

Based on the in-depth analysis of the conversion efficiency, focussing particularly on separating structural and efficiency effects, the following conclusions can be drawn:

The overall trend in the EU is a shift towards a higher share of electricity consumption in total final energy consumption: In the new Member States – having a lower absolute level of electricity consumption in 1990 and 2002 – this trend is more pronounced than in EU-15, both in the past and in the projections. In order to reverse this trend towards

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[18] Increase in absolute terms from 34% to 38%, in relative terms 14%.

[19] Increase in absolute terms from 35% to 41% (past), 41%-49% (projections), in relative terms 16% (past) and 21% (projections).

higher shares of electricity consumption – obviously the business-as-usual trend in the European economy – further policies and measures are needed which either lead to absolute electricity savings or may initiate shifts from electricity to heat consumption.

Comparing the EU trends regarding the electricity consumption with those of the conversion efficiency, it can be seen that the increasing share of electricity consumption in the past went hand in hand with a deterioration of the conversion efficiency, while in the projections these trends are decoupled: In spite of a growing electricity share at total final energy consumption in the EU, the conversion efficiency is projected to improve. Nevertheless, it can be identified as one of largest obstacles to improving the conversion efficiency.

Achievements in efficiency improvements – one of the most obvious targets for energy suppliers – tend to compensate the negative structural impact on the conversion efficiency on EU level. There is an overall EU trend towards higher efficiencies in heat and power generation, both for the past (1995-2002) and the future (2002-2010).

Only three Member States (Slovakia, Sweden and France) had to cope with efficiency losses in electricity generation in the past. Potentials for stronger improvements in future than projected can be assumed in Sweden, France, Germany, Greece and the Czech Republic as these Member States have efficiencies in electricity generation lower than the EU average and they have rather low shares of CHP in electricity generation (except for the Czech Republic). Furthermore, it is striking that Member States with the highest efficiency in 2002 in the EU (Luxembourg, the Netherlands, Ireland, Denmark and the United Kingdom) still have very ambitious targets, so they will end up with the highest efficiencies in 2010 as well.

Against the EU trend, in six Member States a deterioration of efficiency in steam took place (Latvia, Lithuania, Finland, Estonia, Sweden and the Czech Republic). Especially in Sweden and Latvia the rather low efficiencies deteriorated further. If the projections of these Member States and the absolute efficiencies are additionally taken in account, potentials for more ambitious efficiency targets and promotion of CHP could be assumed in Sweden, Latvia, Slovakia, Sweden, France, Greece, Ireland and Cyprus. Similar to the efficiency in electricity generation, there are some Member States (Hungary, Denmark, Italy, the Netherlands and the Czech Republic) which already have high efficiency in steam generation in 2002 and project further increases, ending up with efficiencies which are even more favourable than the EU-average.

The analysis showed, furthermore, that the EU-wide trends and projections towards higher efficiencies in heat and power production go hand in hand with overall trends and projections towards a higher contribution of CHP plants to total electricity and steam generation of CHP. However, while in the EU-15 a further increase of electricity generation in CHP plants is expected, the substantially higher CHP share in the new Member States will decrease slightly, resulting in a growth in EU-25 but at a slightly slower pace than in the past. The average share of CHP heat increased from some 50 to almost 55% between 1995 and 2005 and is projected to grow further to almost 60% in 2010, although somewhat more strongly in the new Member States than in EU-15.

On a Member State level, the analysis showed that, against the EU trend, CHP in total electricity generation has decreased in Denmark, the Czech Republic, Estonia, Luxembourg and Poland and is projected to deteriorate further (Denmark, the Czech Republic, Estonia, Luxembourg, Poland, Finland, Italy and the Netherlands) mainly in Member States (except Italy and Luxembourg) which already have and will have shares above the average values in EU-15 or EU-9 in 2010.

Comparable trends of deteriorating shares in Member States with high ratios of steam generation in CHP could be identified in Slovakia, Finland, Austria and Luxembourg. In contrast, in Latvia and France the low share deteriorated further. According to the projections, potentials for further improvements can be assumed in Latvia and Sweden. In addition, although France, Greece, Ireland, Slovakia and Cyprus project to increase their share relatively at most, they all show a share in steam production by CHP which is far below the EU average in 2010. It could be assumed that the positive trend towards higher shares might be accelerated by policies and measures which promote the use of CHP.

Remarkable progress is expected in Denmark, Germany, Italy, the Netherlands, the Czech Republic and Hungary. They already had the highest shares in the EU in 2002 and will further extend the distance from the EU average up to 2010.

Having analysed in detail the indicators describing the conversion efficiency and the corresponding trends and projections, Table 4.3 summarizes the results. For every Member State the most important influencing factor of the conversion efficiency both for the trends and for the projections is described. Shifts towards higher electricity consumption are separated from efficiency improvements.

Table 4.3 Detailed assessment of changes in conversion efficiency

	Trends (1990/1995 - 2002)	Projections (2002-2010)
Conversion efficiency deteriorates due to…		
efficiency losses and shift towards higher share of electricity consumption	France**	Hungary, Latvia, Austria
a shift towards higher share of electricity consumption	Belgium*, Germany, Greece, Cyprus, Hungary, EU-9	Belgium, Luxembourg, Slovakia
deterioration of efficiency of steam production		Sweden
as shift towards higher share of electricity consumption and efficiency losses of either steam or electricity production	steam: Czech Republic, Estonia***, Lithuania*** electricity: Slovakia	steam: Finland
Conversion efficiency improves due to…		
efficiency gains and shift towards lower share of electricity consumption	Austria	Germany, Italy, Slovenia
a shift towards a lower share of electricity consumption	Schweden**	
improvements of efficiency of electricity and/or steam production	both: Ireland, Netherlands, Portugal, Spain, Poland, electricity: Finland, Italy, mainly steam: Slovenia	both: EU-9, EU-15, Cyprus, Czech Republic, Estonia, Poland, Netherlands, Spain, Ireland, Greece, France, Lithuania, Latvia mainly electricity: United Kingdom
Conversion efficiency remains more or less constant due to…		
improvements of efficiency of electricity and/or steam production	Luxembourg*, United Kingdom, Denmark, Latvia, EU-15	electricity: Portugal

* significant increase in the share of import electricity occurred in parallel
** increase in the share of electricity generated in CHP at total electricity generation as trend in the opposite direction
*** increase in the share of steam generated in CHP at total steam generation as trend in the opposite direction

Source: Own illustration

4.3 Carbon intensity of heat and power production

The carbon intensity of the energy supply is measured by the ratio of CO_2 emissions to total primary energy supply and indicates whether the primary energy structure has developed towards less carbon intensive fuels or not. A downward trend of the carbon intensity can be traced back to the introduction of carbon free energies like renewable energies and nuclear power on the one hand and to a shift to less-carbon intensive fossil fuels like natural gas on the other hand.

4.3.1 Selection of indicators and data sources

In the in-depth analysis below these overlapping trends will be separated and the Carbon Intensity of Fossil Primary Energy Supply (CI FPES) will be investigated further. The following indicators enable trends of renewable and nuclear energies to be extracted from the carbon intensity of fossil energy supply.

$$\frac{CO_2}{TPES} \rightarrow \frac{RES}{TPES};\frac{NES}{TPES};\frac{CO_2}{TPES - RES - NES(= FPES)}(= CI\ FPES);\frac{COAL}{FPES};\frac{GAS}{FPES};\frac{OIL}{FPES}$$

Table 4.4 provides an overview of the input units and data sources used for the detailed assessment of carbon intensity.

Table 4.4 Input units and data sources used for detailed assessment of carbon intensity

Abbreviation	Name	Data sources	
		Trends (1990 - 2002)	Projections (2002 - 2010)
CO2	CO2 emissions	Common Reporting Format 2004	EEA 2004
TPES	Total Primary Energy Supply	Eurostat (2004)	EC (2003)
RES	Primary Energy Supply by Renewable Energies	Eurostat (2004)	EC (2003)
NES	Primary Energy Supply by Nuclear Energies	Eurostat (2004)	EC (2003)
COAL	Primary Energy Supply by Coal	Eurostat (2004)	EC (2003)
OIL	Primary Energy Supply by Oil	Eurostat (2004)	EC (2003)
GAS	Primary Energy Supply by Gas	Eurostat (2004)	EC (2003)

Source: Öko-Institut

Share of primary energy supply by renewable and by nuclear energies at total primary energy supply

The two indicators provide an overview on the carbon-free energy supply which positively influences the carbon intensity of an economy.

Carbon intensity of fossil energy supply:

This indicator reflects the carbon intensity of the fossil energy supply. It is calculated by deducting renewable and nuclear energy sources from the TPES. Changes in carbon intensity of FPES derive from a shift between fossil energy sources.

4.3.2 In-depth analysis of carbon intensity

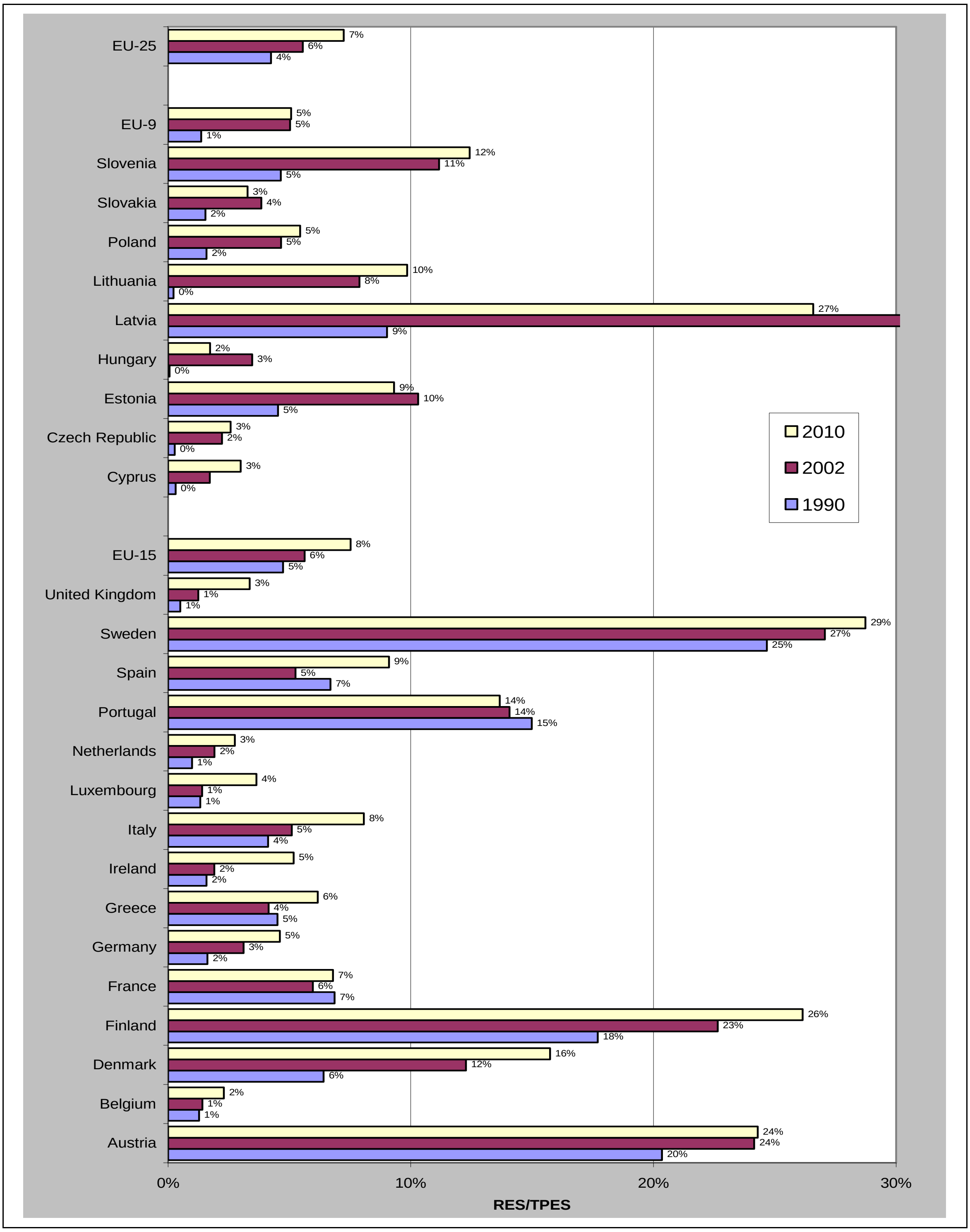
In section 2.4.3, considerable deviations of TPES and FPES data between the different data sources have been identified and described in detail. But despite these difficulties we concluded that basing our analysis of the development of past and future trends on the data sources we had selected as reference data (Eurostat 2004b for past trends and EC 2003 for projections) is justified.

The calculation of the contribution of renewable and nuclear energies to the TPES is unproblematic since both data derive from the same source. The calculation of the carbon intensity of the FPES is somewhat more sensitive because it is necessary to use data from two different sources for the calculation of this indicator. We discussed this problem in more detail in section 2.6 and came again to the conclusion that we can combine both data sources as long as we focus our analysis on the development of this indicator over time (horizontal comparison) but not on the differences of the absolute values between the Member States (vertical comparison).

4.3.2.1 Renewable and nuclear energy supply

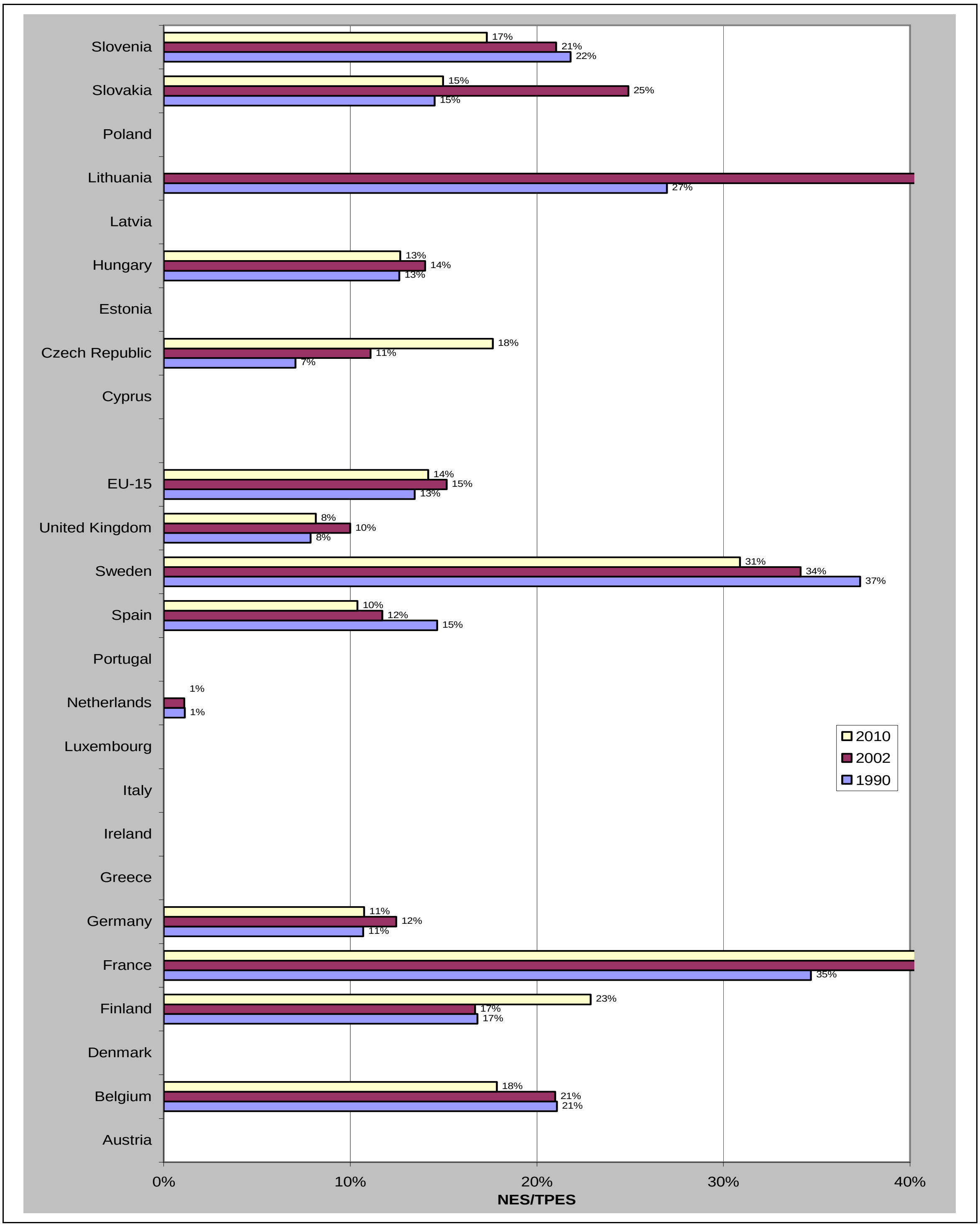
In Figure 4.6 and Figure 4.7, the shares of renewable and nuclear energies at Total Primary Energy Supply are presented. While renewable energies contribute to the Total Final Energy Demand in every EU Member State, nuclear energy is applied only in some of the EU Member States.

Figure 4.6 Share of renewable energies at total primary energy supply in 1990, 2001 and 2010 in EU Member States



Source: Eurostat (2004b), EC (2003)

Figure 4.7 Share of nuclear energies at total primary energy supply in 1990, 2001 and 2010 in EU Member States



Source: EC (2003); Eurostat (2004b)

Table 4.5 Nuclear power policies in the EU Member States

Member States	Number of nuclear reactors			Remarks
	operate	under construction	planned	
Belgium	7	0	0	Have adopted or announced a moratorium. In July 1999, the new government announces the closure of all Belgian nuclear power plants when they reach their 40-years lifetime and introduces a moratorium on reprocessing. By means of the federal act of 31 January 2003, the political authorities have decided to abandon the use of fissile nuclear energy for industrial electricity production. This was done by prohibiting the building of new nuclear power plants and by limiting the operational period of the existing nuclear power plants to 40 years. The phase-out can only be overridden by new legislation or by a Government decision based on a recommendation from the regulator(CREG) if Belgium's security of supply would be threatened by closing the plants.The nuclear phase-out will not help meeting this target, even when taking into account that he nuclear phase-out in Belgium will only start in 2015, after the first Kyoto commitment period.
Czech Republic	6	0	0	Further development of the nuclear power sector is one of the possible ways of meeting the need for electricity after the year 2015.The current energy policy of the Czech Republic does not exclude the construction of new nuclear units in addition to the Temelin NPP, if they are needed. However, in light of the country's large excess of baseload electricity generation capacity, an additional nuclear power plant is very unlikely to be built in the foreseeble future.The Government of the Czech Republic considers nuclear power as an important component of the energy balance. It intends to follow the strategic documents of the European Union, the Green Paper – Towards the European Strategy for the Security of Energy Supply and the Accession Partnership Agreement of the European Union. In doing so, the Czech Republic will comply with the relevant international agreements in the nuclear energy field, including the Nuclear Safety Convention. It recognizes the necessity of continuous upgrading and modernization of the nuclear power sector in the country, as well as strengthening the national safety authority.
Germany	17	0	0	Have adopted or announced a moratorium. The current Federal Government (since September 1998) decided to phase out the use of nuclear power for commercial electricity production.
Spain	9	0	0	Have adopted or announced a moratorium. In 1994, the definitive cessation was decided of the nuclear power plants under the moratorium.The nuclear power capacity will be maintained in the period 2002-2011. There is no strategy about the construction of new nuclear power plants.
Finland	4	1	0	Have not taken a negative decision. In Finland after the granting of the operating licence, the commissioning of the new nuclear plant unit (Olkiluoto 3 on the island of Olkiluoto) could take place in 2009. According to the Statement of Position, there are no safety-related obstacles to granting the construction licence for the nuclear power plant unit. The decision-in-principle now ratified is based on the view that the nuclear power option is the most cost-effective alternative, both in terms of central government finances and national economy, for generation of baseload power within the framework of the Kyoto Protocol.
France	59	0	2	Have not taken a negative decision. Nuclear power is crucial for France. In 2002, nuclear accounted for 43% of total primary energy supply and 79% of electricity generation. Consumption in the Nuclear Fuel Cycle is one of the measures to reduce CO2 emissions. France is planning to build one new reactor. The main objectives are presently to optimize the utilization of existing equipment, i.e., power plants and fuel cycle facilities, design and implement a policy with regard to final disposal of high level radioactive waste, and develop the next generation of reactors improving the use of natural uranium and minimizing waste production.The future role of nuclear should be the subject of a national debate, which would "allow the consequences of possible choices to be examined and all the arguments to be weighed up".
Hungary	4	0	0	No nuclear facilities in Hungary have reached the stage of decommissioning and no policy has been decided on this topic yet. There has not been made any decision on new power plant construction for base load mode operation, so no provisions have been made to start a new nuclear power project in the near future. On a long-term basis, nuclear power and, to a limited extend, domestic coal are the only alternatives for electricity supply.
Italy	0	0	0	Renounced nuclear power after a referendum in 1987. On 14 December 1999, the Italian Government, with an announcement of the Ministry of Industry, has outlined strategic choices and plans to manage the problems connected with the closure of all nuclear activities in the country. These guidelines have been submitted to the Parliament, even if a wide consensus both on political and technical bodies has raised and a high level of confidence about their confirmation should be considered. The decommissioning program according to the new guidelines of the government was defined. The target is to reach the complete radiological release of the site within 20 years.
Lithuania	1	0	0	The first power unit of Ignalina NPP will be de-commissioned in 2005, and the second unit – in 2009, accordingly. National Energy Strategy provides that taking into account global nuclear energy development trends, the latest technologies of reactors and their technical-economic characteristics, a comprehensive study on the continuity of the use of nuclear energy in Lithuania will be prepared in 2003-2004, covering the justification of nuclear safety and acceptability of nuclear energy, includingthe construction of new nuclear power plants (reactors). A study to evaluate possibilities to continue use of nuclear energy in Lithuania, political, social, economical and environmental preconditions in the context of reliability of electricity supply, safety, electricity prices, macro economical expansion, EU politics and international environmental obligations was developed. National Energy Strategy provides that the first unit of Ignalina NPP will be finally shut down by 2005, and the second unit – by 2010.
The Netherlands	1	0	0	The Netherlands Government has initiated various studies and research programmes, especially in the field of nuclear safety and on radioactive waste. In the mean time, nuclear energy is held as viable option for the future, especially in view of increased environmental concerns. No new construction of nuclear plants is foreseen in the near future.
Poland	0	0	?	Commissioning a nuclear power station is also being taken into account by Poland in the new *Energy Policy until 2025*. It is presented as one of the possibilities to meet the ecological requirements of emission levels (GHGs, sulphur dioxide) and diversification of primary energy carriers. Forecast calculations indicate the need to commence nuclear power exploitation in the last 5 years of the period in question. Start – up of the first nuclear power plant before 2020 is considered impossible since the duration of the investment process in the country which hardly has any experience in this scope is estimated for 10 years, and the duration of the social campaign for acceptance of nuclear power generation, preceding the process, for 5 years.
Sweden	10	0	0	Have adopted or announced a moratorium. The "Nuclear Power Decommisioning Act" became law in January 1998. The Act allows the government, within a specified framework, to decide that the right to operate a nuclear power plant will cease to apply at a certain point in time. Such a decision infers the right to compensation by the state for losses incurred.
Slovenia	1	0	0	Slovenia has one nuclear power plant in commercial operation since 1983
Slovak Republic	6	0	0	
The United Kingdom	23	0	0	Have not taken a negative decision. The conclusions of the Government's 1995 nuclear review confirmed the Government's commitment to nuclear power, provided it remained competitive and was able to maintain rigorous standards of safety and environmental protection. However, the Government recognized, against the background of the current electricity market, that providing public sector support for a new nuclear power station would constitute a significant intervention in the electricity market and that current and foreseeable circumstances did not warrant such an intervention. In the absence of new build, the number of nuclear power stations will gradually decrease from to 1 by 2025 and much of the focus of nuclear research will be on decommissioning and clean up.

Source: EU Member States, IEA 2005, Ministry of Economy and Labour (2005)

Figure 4.6 clearly shows that the contribution of renewables deviates substantially between the Member States. In Austria, Finland, Portugal and Sweden the contribution of renewables to the TPES was traditionally rather high, mainly because these Member States dispose of large potentials of hydro energy. In Belgium, Germany, Ireland, Luxembourg, the Netherlands, the United Kingdom, the Czech Republic, Hungary, Lithuania Poland and Slovakia the contribution of renewables in 1990 was at 2% or less well below the average for the EU as a whole (4%).

Since 1990, most Member States have introduced several policies and measures which aim at increasing the use of renewables.[20] Until 2002 the contribution of renewables was more than doubled in all new Member States. But some of the EU-15 Member States also achieved substantial growth in this sector: in the United Kingdom this sector grew by almost 150% in that period; in Denmark, Germany and the Netherlands the growth rate of the renewables share was somewhat smaller but still higher than 90%. In France, Greece, Portugal and Spain the contribution of renewables has, however, decreased, mainly due to the fact that the growth rate of renewable energies was smaller than the growth rate of the TPES.

In several Member States the policies and measures for the promotion of renewables have been intensified since then. Correspondingly, the share of their contribution to TPES will grow further in most countries, particularly in the EU-15 Member States: while the average growth rate was just 19% between 1990 and 2002, the renewables share is expected to grow by 30% up to 2010. In the new Member States, in contrast, the renewables share will on average not grow further since the growth rate of renewable sources is more or less in line with the growth rate of the TPES.

Two fifths of the EU Member States do not apply nuclear energy sources: Austria, Denmark, Greece, Ireland, Italy, Luxembourg, Estonia, Latvia and Poland. France, Sweden and Lithuania are, in contrast, the Member States with the highest contribution of nuclear sources to the TPES. Between 1990 and 2002, the contribution of nuclear sources was increased in most Member States, mainly due to the improvement of existing plants. Only in the Czech Republic was a new reactor commissioned in that period (Temelin).

However, several Member States have decided to gradually phase out (Belgium, Germany and Sweden), or have adopted a moratorium (Spain) on their use of, nuclear energy (Table 4.5). Lithuania had to agree to the decommissioning of its Ignalina nuclear power plant as a condition for its accession to the EU. Correspondingly, the contribution of nuclear energy to the TPES will decline in most of the EU Member States during the period of 2002 to 2010 (Figure 4.7). Only in Finland and the Czech Republic will the share of nuclear energy increase up to 2010. Finland has started the construction of a new nuclear power plant which is planned to be commissioned in 2009. The Czech Republic commissioned the second reactor in the Temelin plant in late 2002. Apart from

[20] A more detailed analysis of the impact of these policies and measures will be presented in section 5.2.

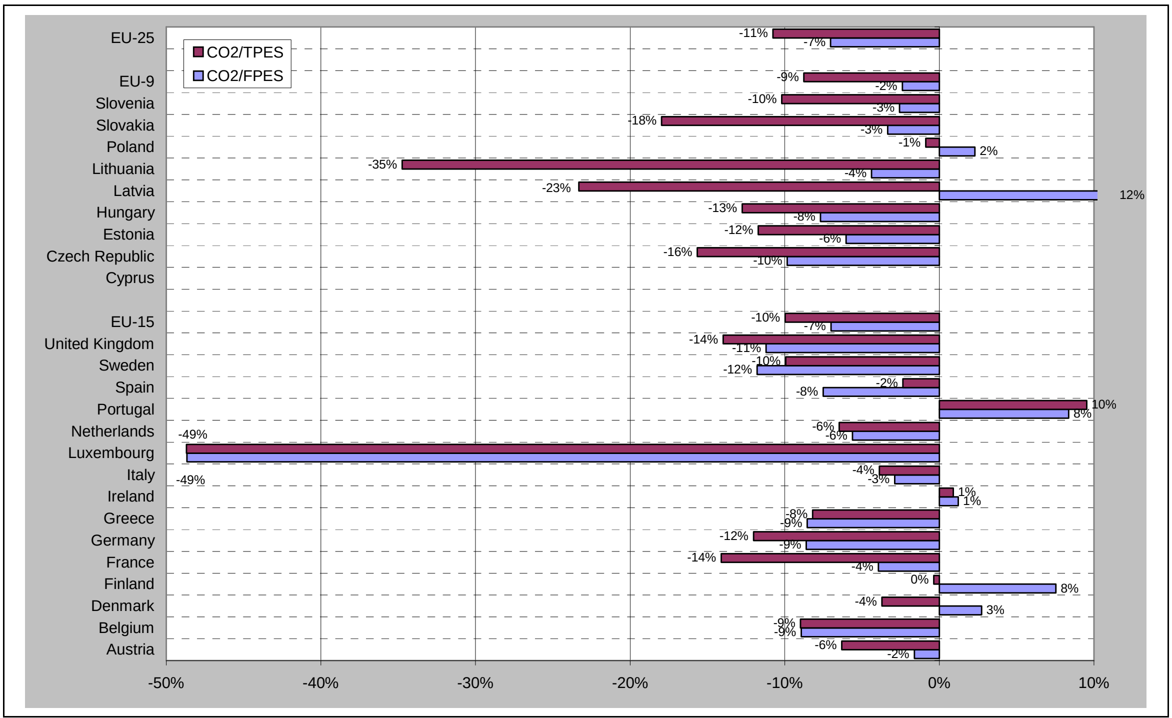
those two countries, only France plans the construction of new nuclear power plants in the future. But since decisions for construction have not yet been taken, it is rather unlikely that those new plants will be commissioned before 2012.

In the EU as a whole, the contribution of nuclear energy increased during the nineties by 16% (EU-15: +13%, new Member States: +36%). In the future, the contribution will decline again by 7% (EU-15: -7%, new Member States: -20%).

4.3.2.2 Carbon intensity of fossil primary energy supply

In section 3.25 it was already shown that most Member States have reduced their carbon intensity of the TPES between 1990 and 2002. Only in Ireland and Portugal was the carbon intensity of the TPES increased. In Figure 4.8, the development of TPES carbon intensity is compared with the FPES carbon intensity. This way whether the overall development was mainly induced through policies and measures which promoted the use of renewable or nuclear energy sources and to which extend it was caused through a shift from rather carbon intensive to less carbon intensive fossil fuels can be identified.

Figure 4.8 Development of the carbon intensity of fossil primary energy supply and of total primary energy supply (1990-2002)



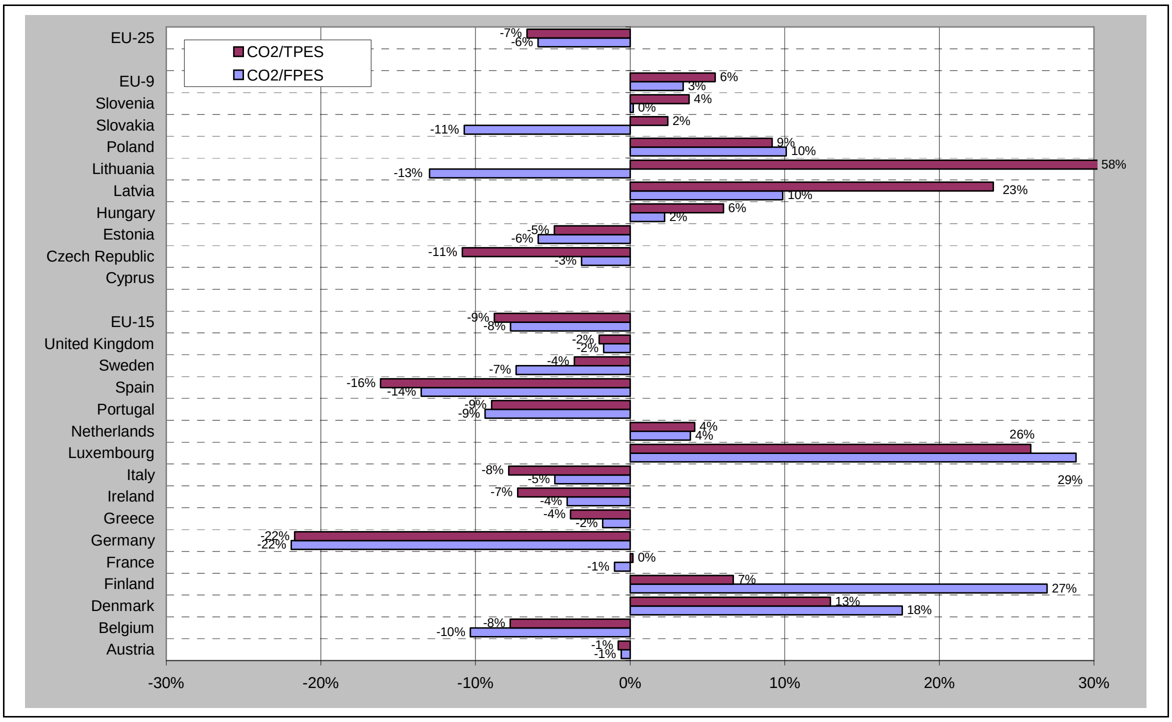
Source: UNFCCC (2005); Eurostat (2004b), EC (2003)

Figure 4.8 reveals that in the past in all but three Member States (Poland, Latvia, Finland and Denmark) the changes in carbon intensity of TPES and those in carbon intensity of FPES followed the same trend. In Poland, Latvia, Finland and Denmark, however, the carbon intensity of TPES improved, while the one of FPES deteriorated in this period. This can be traced back to the overlapping and opposing effects: a shift towards a higher share of renewable energy supply which improves the overall carbon intensity while the carbon intensity of FPES deteriorated. Nuclear power supply did not influence these opposing trends, as the share of nuclear power supply in Finland remained constant in that period and the other three Member States did not make use of that energy source.

In three Member States, Sweden, Spain and Greece the carbon intensity of FPES was reduced more significantly than the one of TPES. In other words, these Member States improved their carbon intensity through a shift to less carbon intensive fuels rather than by exploiting nuclear and renewable energy sources.

In several Member States (Slovenia, Slovakia, Lithuania, Estonia, France, Finland, Denmark and Austria) the carbon intensity of TPES has been reduced in a significantly stronger fashion than the one of FPES. While in Austria, Denmark, Finland, Estonia and Slovenia these differences can be explained by the higher share of renewable energies in 2002, in Slovakia and Lithuania both higher shares of nuclear power and renewable energies were responsible for this development. In France, however, changes are only due to increased share of nuclear power; the share of renewable energy even deteriorated.

Figure 4.9 Development of the carbon intensity of fossil primary energy supply and of total primary energy supply (2002-2010)



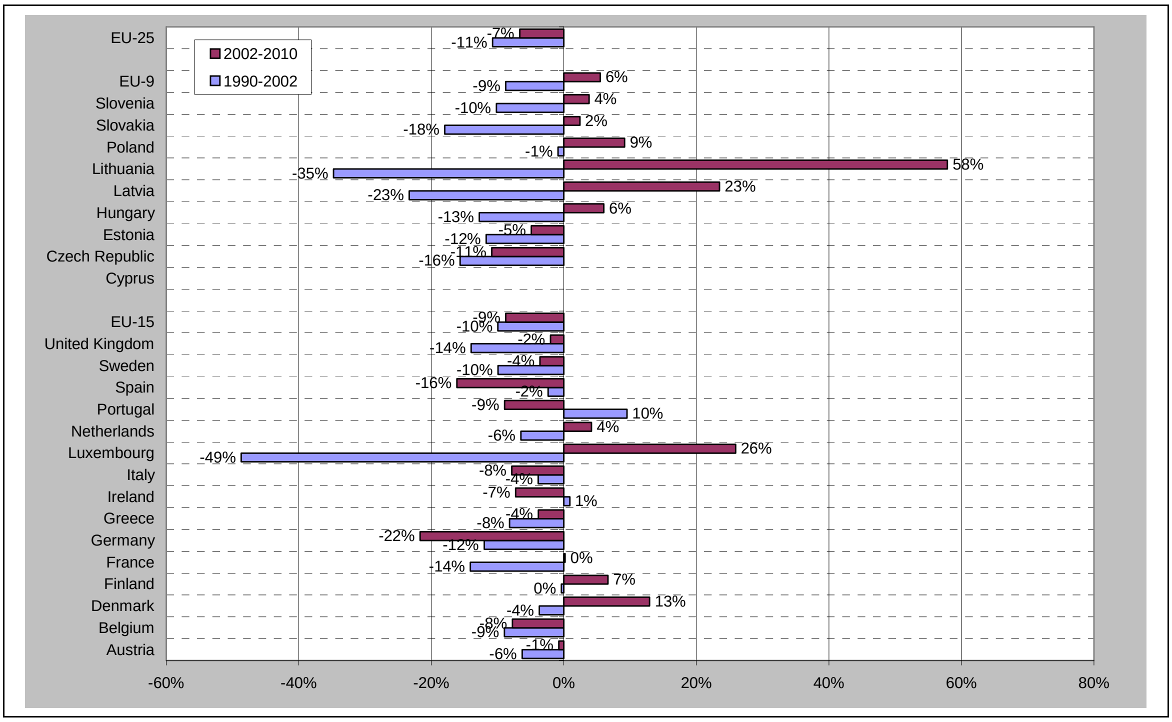
Source: UNFCCC (2005), Eurostat (2004b), EC (2003)

Figure 4.9 provides a comparison of the projected development of the TPES and FPES carbon intensity. Opposing trends can be registered in Slovakia and Lithuania: the carbon intensity of TPES is projected to increase while the one of FPES is projected to decrease. In Lithuania, the Member State in which the opposing projection is most significant, the phase-out of the Ignalina nuclear power plant in 2005 and 2009 substantially overcompensates the effects of the shift to less carbon intensive fossil fuels and of the increase in renewable energy supply. The diverging developments in Slovakia can be explained by a reduced contribution of nuclear power supply: In Slovakia the trend towards an increasing share of renewable energy supply and to less carbon intensive fossil fuels will counteract but will not completely avoid a slight increase in the TPES carbon intensity.

Furthermore, trends of the carbon intensities in the same direction but with large differences are apparent in Latvia, Hungary, the Czech Republic, Sweden, Italy, Ireland, Greece, Finland and Denmark. While the developments in Italy, Ireland, Denmark and Greece can be explained by increasing shares of renewable energies and in Latvia by decreasing shares of renewable energies, in Hungary and Finland increases in the share of both carbon-free energy sources are responsible. In Sweden the decreasing share of nuclear energy, which tends to deteriorate the carbon intensity, is counteracted by a favourable trend in renewable energy supply.

The trends and projection of the FPES carbon intensity are analysed in more detail below. Figure 4.10 gives an overview of changes in the past and those projected until 2010.

Figure 4.10 Changes in carbon intensity of fossil primary energy supply



Source: UNFCCC (2005); Eurostat (2004b), EC (2003)

Figure 4.10 shows that on average the carbon intensity of FPES in all 24 Member States considered was improved by 11% during the period between 1990 and 2002. In the years to come it will further improve, although at a slower pace (-7%), which can be explained by the deterioration of carbon intensity of FPES in the new Member States (+6%).

In absolute terms, the carbon intensity of FPES is significantly larger in the new Member States than in EU-15. While in 1990 the new Member States' carbon intensity was 19% above the one in EU-15, the gap narrowed until 2002 but will increase again. In 2010, the FPES carbon intensity of the new Member States is projected to be 31% higher than the one of the EU-15.

Greece, Germany, Spain, Sweden and Austria are the EU-15 Member States with the highest carbon intensity of FPES in absolute terms in 1990. While in Greece, Sweden and Spain the low share of gas as source of primary energy supply can be made responsible for the high carbon intensity; in Germany the high share of coal takes this role. The carbon intensity improvements in Greece, Germany and Spain can be explained by shifts from coal to gas (in Germany also to oil). In Austria the carbon intensity of FPES improved only slightly as a shift from coal and gas to oil occurred. The favourable trend in Sweden up until 2002 has its origin in fuel shift from coal and oil to gas. However, it is striking that there are other EU-15 Member States with lower absolute levels of carbon intensities in 1990 (Luxembourg, Belgium and the United Kingdom) and higher reduction rates. While Greece still has the highest carbon intensity of FPES in 2002, the one of Germany, Sweden and Spain lies under the EU-15 average due to a very low share of natural gas in the fuel supply, Austria's lies slightly above. In Sweden, Germany and Spain further positive trends are projected; in Austria the positive trend is turning out to be comparatively smaller.

Apart from Greece, the greatest potential to reduce further the carbon intensity of FPES in 2002 is, it can be assumed, in Denmark, Finland, Portugal and Ireland. While a reduction trend is projected in Portugal and Ireland, the carbon intensity is expected to increase significantly in Denmark and Finland with the consequence that these two Member States will end up with by far the highest carbon intensity of fossil energy supply in 2010.

4.3.3 Results

In general the carbon intensity of the TPES can be reduced through an increased contribution of nuclear or renewable energies or through a shift from carbon intensive to less carbon intensive fuels. Figure 4.6 gives an overview of which of these three strategies contributed to the development of the carbon intensity in each of the EU Member States.

During the nineties, most Member States have improved their carbon intensities of the TPES, some of them even significantly. In most Member States this improvement was supported through the increased contribution of renewable energies. In most of the Member States who dispose of nuclear power plants, this trend was also supported by an increased contribution of nuclear energy to the TPES. However, in Belgium, Finland, the Netherlands and Slovenia the contribution of nuclear energy either did not change or decreased slightly. Only Spain and Sweden had to compensate their reduced contribution of nuclear energies by putting more efforts into the other strategies. Most Member States also shifted their fossil energy supply to less carbon intensive fuels. In Denmark, Finland, Ireland, Portugal, Latvia and Poland, however, the carbon intensity of the FPES did not improve but rather deteriorated. Finland, Ireland, Portugal and Poland were also the countries where the carbon intensity deteriorated or was not substantially improved during the nineties.

The picture is somewhat different for the future: The EU as a whole will improve their carbon intensity at the same rate as during the nineties (-0.8%/a). But as the carbon intensity is projected to grow again in the new Member States (+0.8%/a) this rate can only be maintained through stronger improvements in the EU-15 Member States (-1.2%/a).

Only in Finland, France and the Czech Republic will the increased contribution of nuclear energy improve the carbon intensity of the TPES. In Belgium, Germany, the Netherlands, Spain, Portugal, the United Kingdom, Hungary, Lithuania, Slovakia and Slovenia the share of nuclear energy is projected to decline until 2010. To compensate this trend, it is necessary to put additional efforts into the other strategies. Correspondingly, it is projected that the contribution of renewables will increase substantially, particularly in the EU-15 Member States while it is decreasing in some of the new Member States.

Table 4.6 Overview on the strategies applied to improve the carbon intensity

	1990 - 2002				**2002 - 2010**			
	Increased contribution of nuclear energy	**Increased contribution of renewables**	**Shift to less carbon intensive fuels**	**Reduced carbon intensity of the TPES**	**Increased contribution of nuclear energy**	**Increased contribution of renewables**	**Shift to less carbon intensive fuels**	**Reduced carbon intensity of the TPES**
Austria		+	(+)	+		(+)	(+)	(+)
Belgium	0	+	+	+	-	++	+	+
Denmark		++	-	+		+	-	-
Finland	0	++	-	0	+	+	--	-
France	+	+	+	+	+	-	+	+
Germany	+	+	+	+	-	+	+	+
Greece		-	+	+		+	(+)	+
Ireland		+	(-)	(-)		++	+	+
Italy		+	+	+		+	+	+
Luxembourg		+	++	++		++	--	--
Netherlands	(-)	+	+	+	-	+	-	-
Portugal		-	-	-		-	+	+
Spain	-	-	+	+	-	++	+	+
Sweden	-	+	+	+	-	+	+	+
United Kingdom	+	+	+	+	-	++	(+)	(+)
EU-15	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Cyprus		++				++		
Czech Republic	+	++	+	+	++	+	+	+
Estonia		++	+	+		-	+	+
Hungary	+	++	+	+	-	-	-	-
Latvia		++	-	+		-	-	-
Lithuania	+	++	+	+	--	+	+	-
Poland		++	(-)	(+)		+	-	-
Slovakia	+	++	+	+	-	-	+	-
Slovenia	(-)	++	(+)	+	-	+	0	-
EU-9	**+**	**++**	**(+)**	**+**	**-**	**(+)**	**-**	**-**
EU-25	**+**	**+**	**+**	**+**	**-**	**+**	**+**	**+**

Source: Own compilation

The improvement of the carbon intensity of the fossil primary energy supply will be continued in most of the Member States. However, substantial deteriorations are expected in Denmark, Finland, Luxembourg, Latvia and Poland. In Belgium, Germany, Spain, Lithuania and Slovakia the shift to less carbon intensive fuels will, in contrast, be intensified according to the projections.

All in all, one can conclude that particularly Denmark, Finland, Luxembourg, Latvia and Poland should investigate whether there are remaining potentials to improve their carbon intensity of the fossil primary energy supply through a shift to less carbon intensive fuels. According to the projections, the contribution of renewables to the TPES will decline in Portugal, Estonia, Hungary, Latvia and Slovakia. Therefore these countries should explore further potentials for an increased contribution of renewable energies to their TPES.

4.4 Transport

The absolute energy consumption as well as the relative development of the transport section influences the Total Final Energy Consumption in a country and thus the energy intensity (TFC/GDP) as well as the conversion efficiency (TPES/TFC). As the trends and projections of the transport section and their effects on the driving forces mentioned have not been addressed in the analysis in section 2.7, a sectoral analysis is undertaken in the following.

4.4.1 Database, selected indicators and data sources

We compiled a separate database for the transport section. It aimed to include key driving forces on a sectoral level. The database comprises data on the Total Final Energy Demand of Transport, transport activities, CO_2 emissions, data on modal splits and the number of vehicles. Table 4.7 provides an overview of the data sources used for the compilation of the transport database. Furthermore, it is indicated which data source was selected as reference data – the basis for the further analysis in the transport sector.

Table 4.7 Overview of possible and selected data sources

Name	possible and selected data source	Data sources	
		Trends (1990 - 2002)	**Projections (2002 - 2010)**
Final Energy Consumption by Transport/Transport modes	possible	EC (2003)	EC (2003)
	selected	EC (2003)	EC (2003)
Activity by transport modes	possible	EC (2003); Eurostat (2004), Odyssee (2004)	EC (2003)
	selected	EC (2003)	EC (2003)
CO_2 Emission by transport modes	possible	EC (2003); Odyssee (2004)	EC (2003)
	selected	EC (2003)	EC (2003)
Modal Split	possible	Eurostat (2004)	EC (2003) + own calculation
	selected	Eurostat (2004)	EC (2003) + own calculation
Number of vehicles	possible	Eurostat (2004); World Bank (2004); EC (2003), Odyssee (2004)	EC (2003)
	selected	Eurostat (2004)	EC (2003)

Source: Öko-Institut

Table 4.8 summarises the absolute values of the indicators considered. In the first step the trends and projections of the total final energy consumption in transport (TFCT) as a share of TFC are focused upon (Figure 4.11).

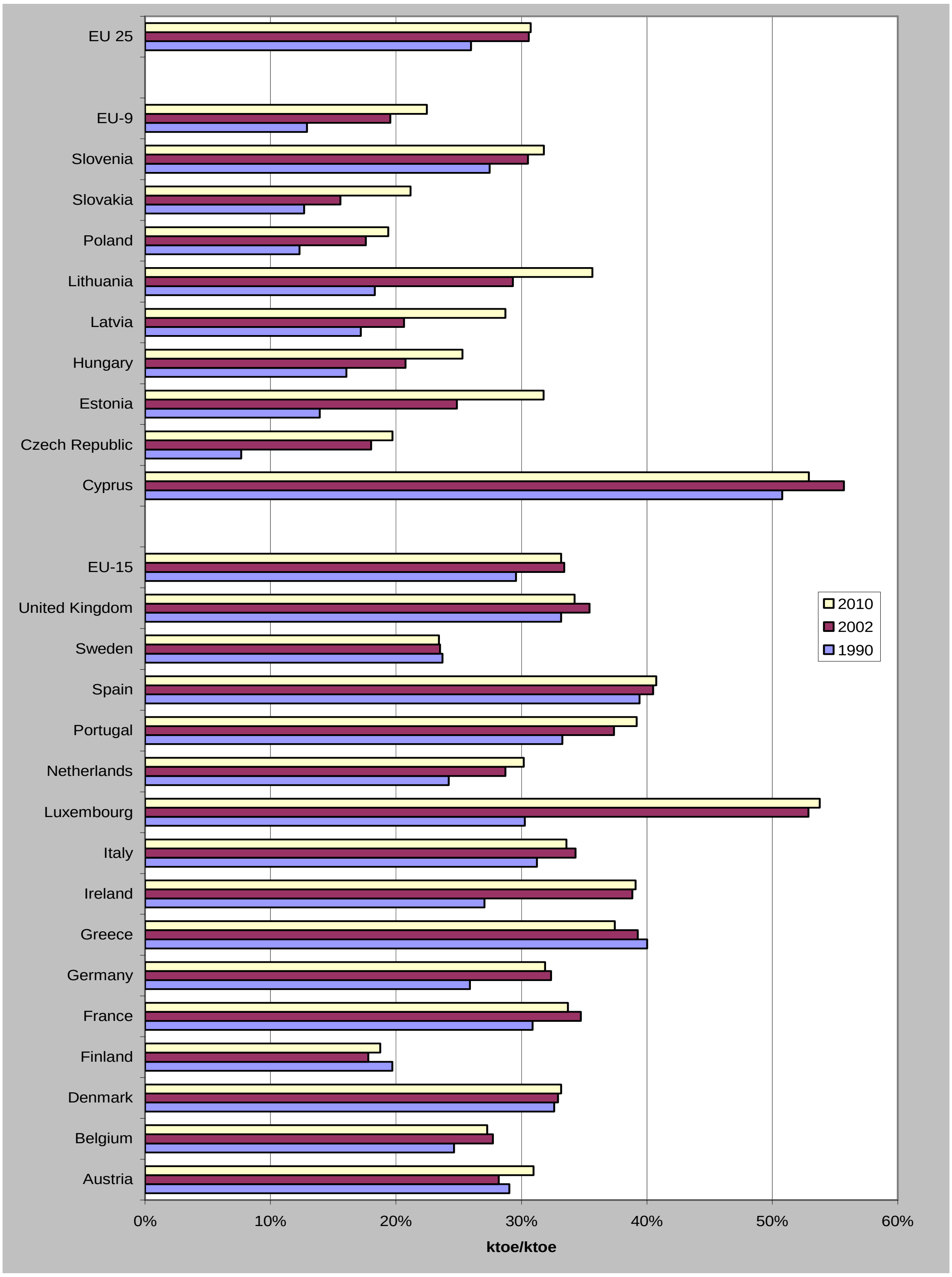
Table 4.8 Transport indicators in 1990, 2002, 2010

		TFCT/ TFC	pkm of cars/ total pkm	TFC of cars [kg oe/ cap]	pkm of cars/ cap	Cars/ 1,000 cap	tkm of trucks/ total tkm	TFC of trucks [kg oe/ cap]	tkm of trucks/ cap	Trucks/ 1,000 cap
	1990	29%	73%	366	8.162	387	58%	245	2.224	33%
Austria	2002	28%	70%	406	8.798	518	59%	340	3.484	43%
	2010	31%	70%	391	9.242	554	62%	414	4.258	54%
	1990	25%	80%	399	8.970	388	64%	239	2.513	34%
Belgium	2002	28%	78%	418	10.380	461	70%	353	3.306	51%
	2010	27%	78%	401	10.855	479	72%	423	3.970	62%
	1990	33%	70%	319	9.308	309	79%	278	2.662	56%
Denmark	2002	33%	72%	375	12.698	353	84%	301	3.398	71%
	2010	33%	71%	368	13.642	374	85%	333	3.761	78%
	1990	20%	72%	460	10.293	389	70%	232	5.287	53%
Finland	2002	18%	72%	447	10.973	421	69%	257	5.621	62%
	2010	19%	72%	438	11.780	448	73%	319	6.993	77%
	1990	31%	80%	349	10.350	415	75%	273	3.427	80%
France	2002	35%	81%	387	12.235	488	80%	341	4.720	94%
	2010	34%	82%	381	13.224	519	82%	393	5.455	109%
	1990	26%	78%	456	8.635	485	62%	168	2.803	21%
Germany	2002	32%	77%	463	9.030	543	72%	233	4.496	33%
	2010	32%	78%	484	10.325	611	76%	288	5.571	41%
	1990	40%	53%	181	4.820	171	60%	187	1.076	73%
Greece	2002	39%	52%	244	7.157	319	67%	242	1.832	106%
	2010	37%	49%	231	7.380	299	69%	327	2.475	137%
	1990	27%	70%	263	5.161	227	83%	169	1.112	41%
Ireland	2002	39%	71%	428	9.199	366	86%	436	1.892	60%
	2010	39%	70%	433	10.286	402	88%	583	2.537	80%
	1990	31%	71%	307	9.218	483	71%	201	2.390	41%
Italy	2002	34%	74%	392	12.053	582	72%	249	3.434	60%
	2010	34%	75%	385	12.934	637	74%	299	4.129	74%
	1990	30%	74%	1.321	10.546	503	67%	926	3.367	30%
Luxembourg	2002	53%	74%	1.767	11.851	636	77%	1.840	5.718	49%
	2010	54%	74%	1.619	12.003	641	76%	2.414	7.619	66%
	1990	24%	82%	335	9.354	368	45%	195	2.132	37%
Netherlands	2002	29%	78%	335	9.690	420	52%	286	3.070	63%
	2010	30%	77%	341	10.801	460	55%	362	3.902	79%
	1990	33%	59%	152	4.083	187	82%	140	1.588	79%
Portugal	2002	37%	73%	229	8.687	360	88%	319	2.081	173%
	2010	39%	71%	244	10.123	405	89%	417	2.737	219%
	1990	39%	69%	196	5.666	309	64%	248	2.033	60%
Spain	2002	41%	69%	260	8.496	457	76%	397	3.440	99%
	2010	41%	67%	272	9.734	512	77%	487	4.225	120%
	1990	24%	73%	466	10.050	421	50%	217	3.186	36%
Sweden	2002	24%	70%	452	10.501	453	57%	259	3.934	45%
	2010	23%	68%	415	10.542	454	64%	322	4.890	57%
	1990	33%	83%	404	10.446	375	67%	181	2.492	47%
United Kingdom	2002	35%	80%	422	10.918	434	68%	211	2.938	50%
	2010	34%	79%	419	11.924	477	69%	252	3.526	61%
	1990	**30%**	**72%**	**353**	**8.794**	**361**	**66%**	**209**	**2.601**	**48%**
EU-15	**2002**	**33%**	**73%**	**391**	**10.340**	**454**	**72%**	**283**	**3.717**	**71%**
	2010	**33%**	**72%**	**393**	**11.369**	**485**	**74%**	**344**	**4.510**	**87%**

		TFCT/ TFC	pkm of cars/ total pkm	TFC of cars [kg oe/ cap]	pkm of cars/ cap	Cars/ 1,000 cap	tkm of trucks/ total tkm	TFC of trucks [kg oe/ cap]	tkm of trucks/ cap	Trucks/ 1,000 cap
Cyprus	1990	51%	62%	231	6.122		100%	480	6.404	0%
	2002	56%	61%	358	7.395	364	100%	490	7.775	155%
	2010	53%	60%	355	7.493	402	100%	508	8.058	176%
Czech Republic	1990	8%	66%	107	5.848		43%	106	2.918	0%
	2002	18%	75%	195	6.756	351	71%	163	3.876	29%
	2010	20%	77%	227	8.019	418	76%	199	4.743	35%
Estoinia	1990	14%	43%	149	3.258		39%	263	2.872	0%
	2002	25%	64%	174	4.569	361	43%	208	3.690	76%
	2010	32%	65%	226	5.978	463	56%	337	5.977	120%
Hungary	1990	16%	66%	145	4.612		47%	92	1.461	0%
	2002	21%	66%	172	4.800	255	70%	112	2.009	37%
	2010	25%	68%	234	6.685	346	75%	168	3.001	54%
Latvia	1990	17%	40%	67	2.853		24%	104	2.193	0%
	2002	21%	79%	169	6.036	244	26%	90	1.990	46%
	2010	29%	81%	203	7.410	299	39%	181	4.002	91%
Lithuania	1990	18%	53%	138	3.325	0	28%	165	1.986	0%
	2002	29%	81%	162	3.860	356	45%	126	1.963	30%
	2010	36%	85%	221	5.378	497	56%	208	3.241	50%
Poland	1990	12%	48%	78	2.704	187	33%	61	1.059	0%
	2002	18%	68%	121	4.081	475	58%	88	1.926	48%
	2010	19%	72%	149	5.142	338	64%	113	2.480	62%
Slovak Republic	1990	13%	45%	140	2.544	283	23%	112	1.014	0%
	2002	16%	70%	194	4.649	283	39%	78	1.130	25%
	2010	21%	78%	253	6.240	344	55%	132	1.912	43%
Slovenia	1990	27%	49%	209	4.448		45%	165	1.753	0%
	2002	31%	85%	554	11.267	460	49%	97	1.171	31%
	2010	32%	85%	618	13.255	538	64%	161	1.953	52%
EU-9	**1990**	**13%**	**52%**	**105**	**3.516**		**43%**	**92**	**1.555**	**0%**
	2002	**20%**	**72%**	**162**	**4.873**	**350**	**56%**	**109**	**2.219**	**53%**
	2010	**22%**	**74%**	**200**	**6.162**	**405**	**65%**	**149**	**3.009**	**76%**
EU-24	**1990**	**26%**	**62%**	**311**	**7.896**		**63%**	**189**	**2.423**	**29%**
	2002	**31%**	**70%**	**353**	**9.442**	**398**	**63%**	**254**	**3.471**	**61%**
	2010	**31%**	**70%**	**362**	**10.542**	**437**	**68%**	**313**	**4.271**	**80%**

Source: EC (2003), Eurostat (2004b)

Figure 4.11 *Changes of the energy demand for transport as a share of the total final energy consumption*



Source: *EC(2003), Eurostat (2004b)*

Figure 4.11 illustrates that in Cyprus and Luxembourg the Total Final Energy Consumption is predominantly influenced by transport. In Luxembourg, tankering is responsible for the high energy demand by transport. There was significant growth between 1990 and 2002 but up until 2010 Luxembourg's share is expected to remain at the 2002 level.

Between 1990 and 2002, a growing share of energy demand by transport at total final energy consumption was an EU-wide trend. In the European Union as a whole and in EU-15 a trend reversal is projected: the share of EU-24 is expected to remain stable, the one in EU-15 is projected to decrease slightly. In the new Member States – on average – a significantly lower share of growth than in the past is projected. However, on average the share in EU-9 was significantly lower than in EU-15 – a process of convergence is obvious. A decrease in the share of energy demand by transport at total final energy consumption has taken place only in Finland, Greece and Austria in the past. While Finland has the lowest share of all EU-15, Austria's share ranges at EU-15 average, the one of Greece was the highest in 1990.

The significant trend reversals in most of the EU-15 Member States (Germany, France, Belgium and the United Kingdom) and the stabilisation of the share on the 2002 level after strong increases in the past (Luxembourg, Italy and Ireland) and the significantly lower growth rate in the new Member States will be analysed in more detail in the following sections.

In the next analysis, step trends and projection of further transport indicators are illustrated in order to provide a differentiated picture of driving forces for energy demand in this sector. In this analysis, transport includes energy consumption in road transportation, national civil aviation, railways, national navigation, and other transportation. Thus the transport sector covers a wide spectrum of transportation modes with fundamentally different characteristics. In general, two types of transport activities are to be differentiated, the passenger and freight transport activities, which are only to a limited extent comparable.

To draw conclusions on trends and projections, the challenge consists in choosing representative indicators. As most of the policies and measures in this sector address only one mean or transportation, indicators on a more disaggregate level than the sectoral level seem to be advantageous. Sectoral aggregated indicators as, for example, the share of Total Transport Consumption at Total Final Energy Consumption (Figure 4.11) are not appropriate for a detailed assessment of the possible starting points for policies and measures.

The most significant driving forces of energy consumption and CO_2 emissions from transport are transport volumes on roads (passenger and freight transport). Road Transport is by far the largest energy consuming transport mode. In 1990 (2002) its energy consumption accounted for 84% (82%)[21] of total transport-related energy consumption.

21 Percentages based on EC (2003)

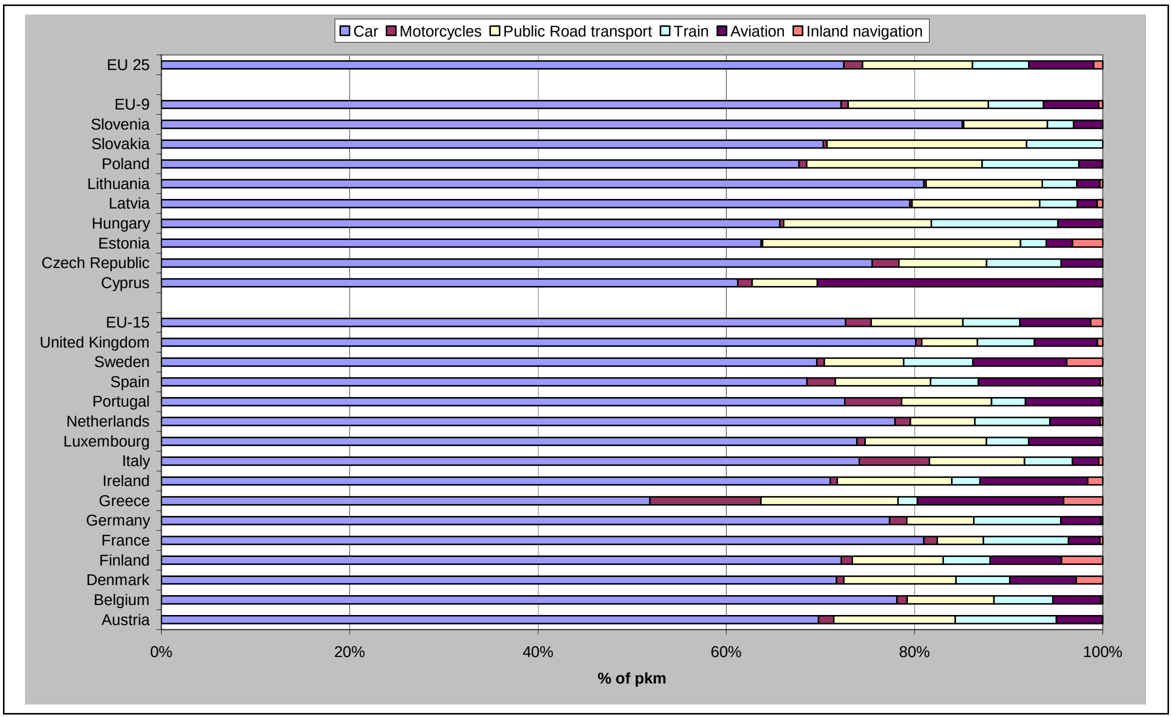
Therefore this type of transportation is focused upon in the further analysis. Trends and projections of passenger cars and freight transport in trucks will be analysed separately.

4.4.2 Passenger transport on road

In 2002 the EU passenger transport on road was responsible for 76% of the total energy consumption in passenger transport, with a continuous decreasing trend from 1990 (80%) up until 2010 (75%). Figure 4.12 reveals an overview of the modal split of passenger transport in 2002. 74% of the passenger kilometres in 2002 were covered by private cars, 11% by public road transportation, 6% by train and 7% by aviation.

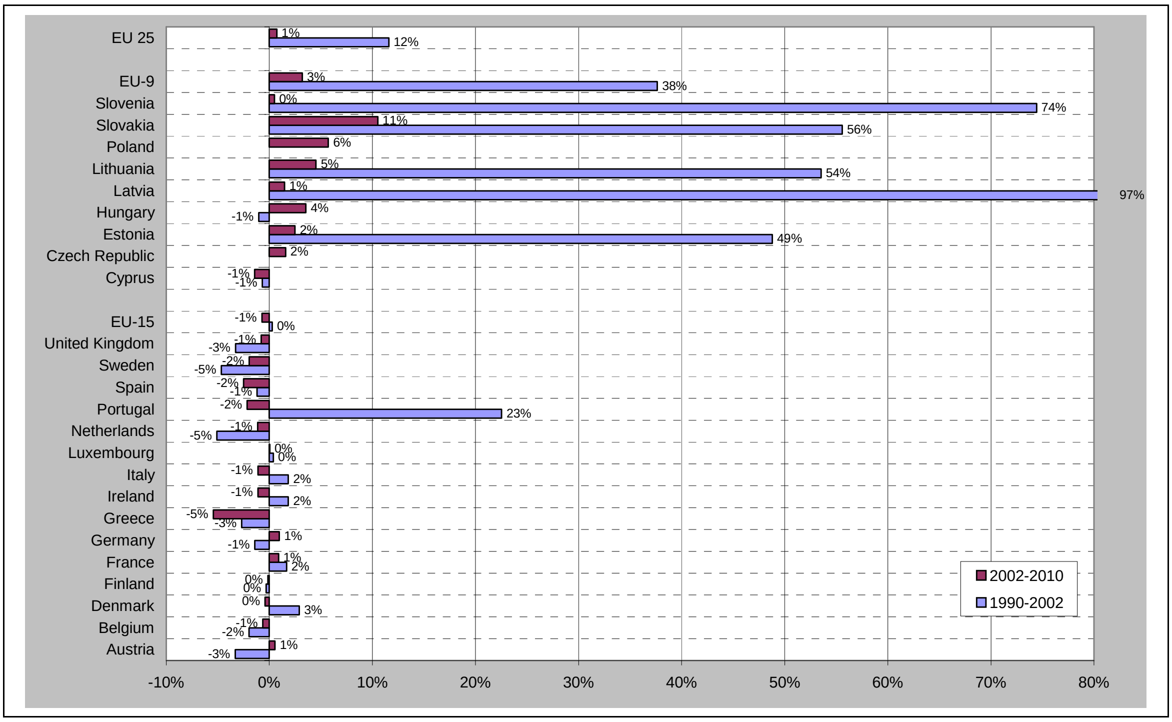
In the EU-15 Member States the share of cars at the modal split is only slightly higher than in the new Member States. However, within the country groups there are large differences. In spite of lower shares by cars at the modal split in the new Member States on average, the highest shares of the EU overall are in Slovenia and Lithuania. Almost as high as in these two Member States are the shares in Latvia, the United Kingdom and France. If the modal splits in these Member States are further investigated it can be concluded that in the Member States mentioned which belong to EU-15, the share of public transport (public road, train) is comparatively low. While in Slovenia, Lithuania and Latvia as well as in Estonia the share of train transport can almost be neglected, the United Kingdom and France show the lowest values of public road transport in the EU. On this basis it can be assumed that in the Member States with comparatively high shares of car at the modal split, potential for further policies and measures in the field of public transport and train exists.

Figure 4.12 Modal split of passenger transport in 2002



Source EC (2003)

Figure 4.13 *Changes in modal split of passenger transport: share of car in total pkm*

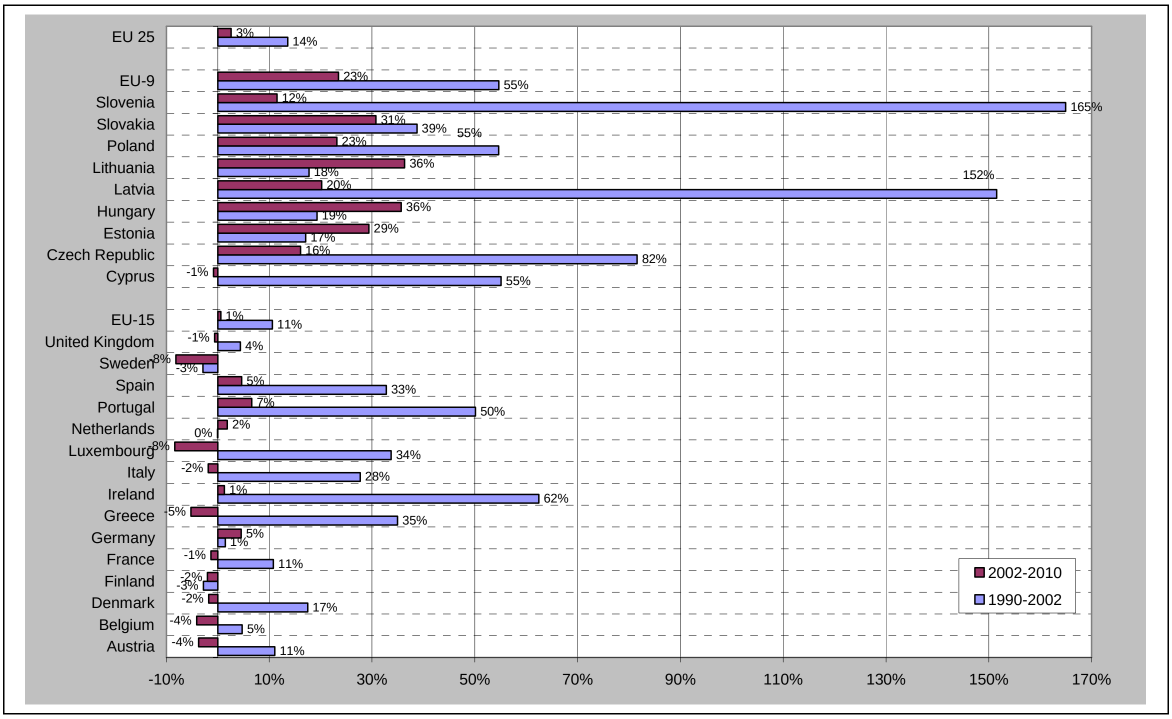


Source *EC (2003)*

Figure 4.13 presents the changes in the share of car transport in total passenger kilometres (pkm). As can be seen the trends and projections oppose diametrically in EU-15 and the new Member States. Furthermore it is obvious that there have been significant changes in the past while the changes are expected to be minor in the future. While in 2002 the share of car transport at total pkm was more or less the same in the new Member States and the EU-15 Member States, in 1990, there was a totally different picture. Figure 4.13 illustrates that in the last decade the share of car in total pkm experienced very high grow rates in the new Member States and medium shrinking rates in the EU-15. In the new Member States the share of car transport in total pkm was 52% (27% public road transport, 15% train), in EU-15, however, 72% (11% public road transport, 7% train). Up until 2010 the share in the new Member States does not only converge to the one of EU-15 Member States (72%), it will be even higher (74%). In most of the EU-15 Member States a stabilisation of the share is expected, with the exception of Greece which projects a reduction of 5% although Greece already has the lowest share of car transport in total transport pkm in the EU in 2002.

Although there have been significant decreases in the share of car in total pkm in EU-15, Figure 4.13 does not reveal trends and projections of the absolute energy consumption by cars. As the transport demand in total grew in the past (Figure 4.11), changes of the modal split may counteract or support the growing energy demand. Figure 4.14 reveals that in spite of shifts regarding the modal split, the energy consumption increased in most of the Member States.

Figure 4.14 Changes in energy consumption of passenger cars per capita



Source EC (2003)

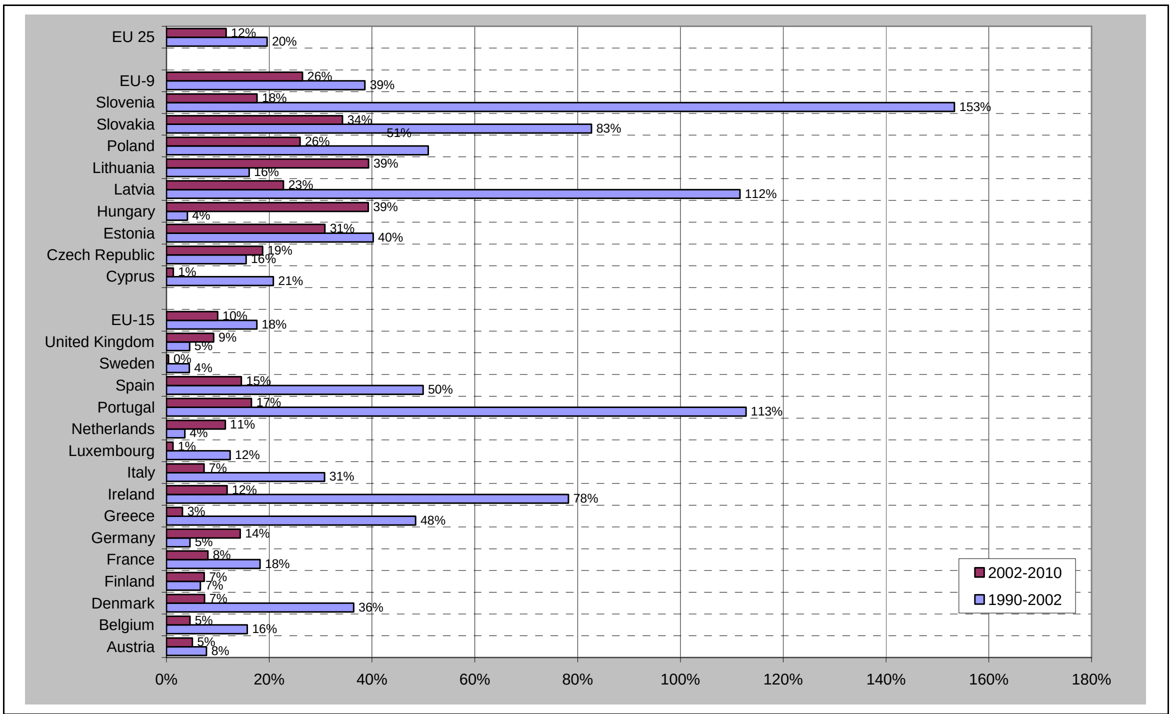
The highest growth rates in the share of car transport at total transport in the new Member States between 1990 and 2002, which occurred in Latvia and Slovenia, go hand in hand with the highest growth rates in energy consumption of cars per capita. While Slovenia has the second highest absolute energy consumption of passenger cars per capita in the EU in 2002 and projected for 2010, Latvia has the lowest in the EU in 1990. Therefore potentials for counteracting the high emission growth can be assumed in Slovenia rather than in Latvia.

While the per-capita consumption in most of the Member States is expected to increase further up until 2010, reductions or stabilisation are projected for Sweden, Luxembourg, Greece, Belgium and Austria. These reduction and stabilisations, however, are taking place in Luxembourg, the Member State which has the highest per-capita consumption of all EU Member States in 2002 (also in 2010), in Sweden, Belgium and Austria which show a level slightly above the average in EU-15 in 2002 and Greece, the Member State with the lowest level in EU-15 in 2002 (and in 2010). Against this background, the reductions in Greece seem to be the most ambitious ones.

Analysing the absolute level of energy consumption of passenger cars per capita in further detail, it can be recognized that the share in the new Member States is by far significantly lower than in EU-15: the per-capita consumption in 1990 of the new Member States amounts to only 30% of that in EU-15 in 1990, 42% in 2002 and 51% in 2010. In conclusion, assuming that the per-capita energy consumption of the new Member States will converge towards the one of EU-15, the reduced growth rate projected is still ambitious.

The changes in energy demand in passenger cars are strongly influenced by the overall kilometres travelled (Figure 4.15). In contrast to the per-capita energy consumption, it is projected that the passenger kilometres in private cars per capita will increase further throughout the EU. In conclusion, the reduction or stabilisation of the per-capita energy demand in private cars in Sweden, Luxembourg, Greece, Belgium and Austria can be explained by efficiency gains rather than by a reduction in transport performance.

Figure 4.15 Changes in passenger-kilometres in private cars per capita

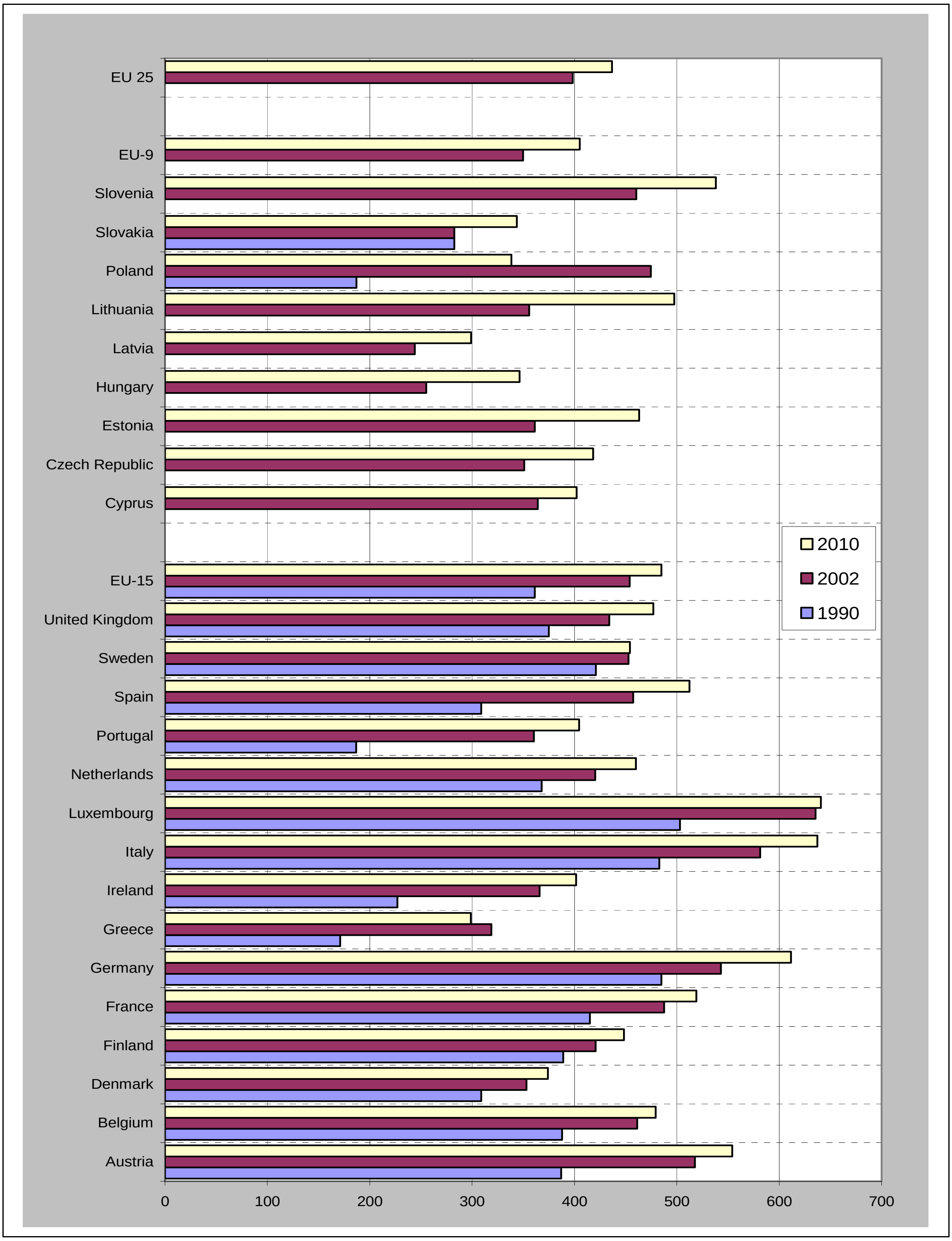


Source EC (2003)

Moreover the car fleet per capita (Figure 4.16) could give some hints as to whether saturation of energy consumption by private cars is to be expected. Figure 4.16 shows that Poland and Greece are the only Member States which expect a trend reversal by having a lower share of cars per 1000 capita in 2010 than in 2002. Poland has – after the strongest relative growth in the past – the highest share in 2002; in Greece, however, the trend reversal is rather surprising as the share of cars per 1000 capita is well below the EU average in all three years considered. Due to the fact that there is an overall trend towards a higher share of cars per 1000 capita, both for the past and for the future, it can be concluded that the market is not saturated yet. Policies and measures addressing decisions on car purchases are very important and effectual in these growing markets.

A strong relative increase in the share of cars per capita in the past can be recognized in Portugal, Greece, Spain, Ireland and Austria. In absolute terms, however, with the exception of Austria, these Member States had the lowest share of cars per 1000 capita in 1990 in EU-15.

Figure 4.16 Cars per 1000 capita



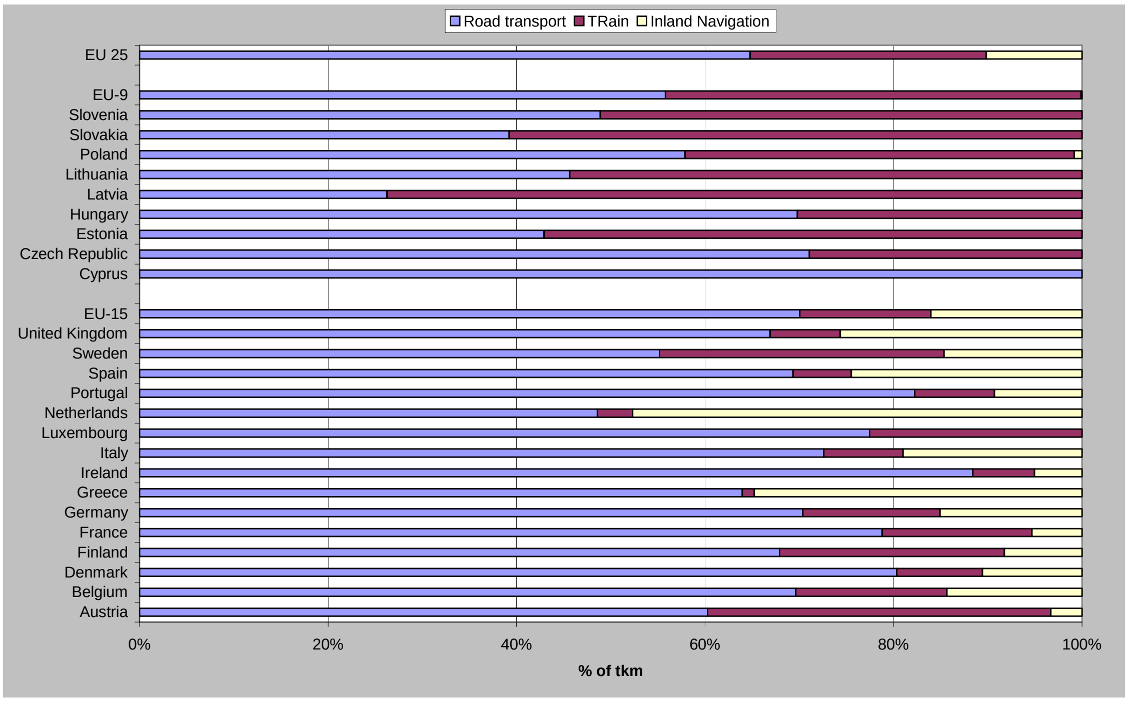
Source Eurostat (2004b), EC (2003)

4.4.3 Freight transport

In 2002, freight transport on road was responsible for 91% of the energy consumption at freight transport in the EU, with a continuous increasing trend from 1990 (91%) up until 2010 (95%). Figure 4.17 reveals an overview of the modal split of passenger transport in 2002. It can be easily seen that 61% of the tonne kilometres in 2002 were covered by trucks, 21% by train and 9% by inland navigation.

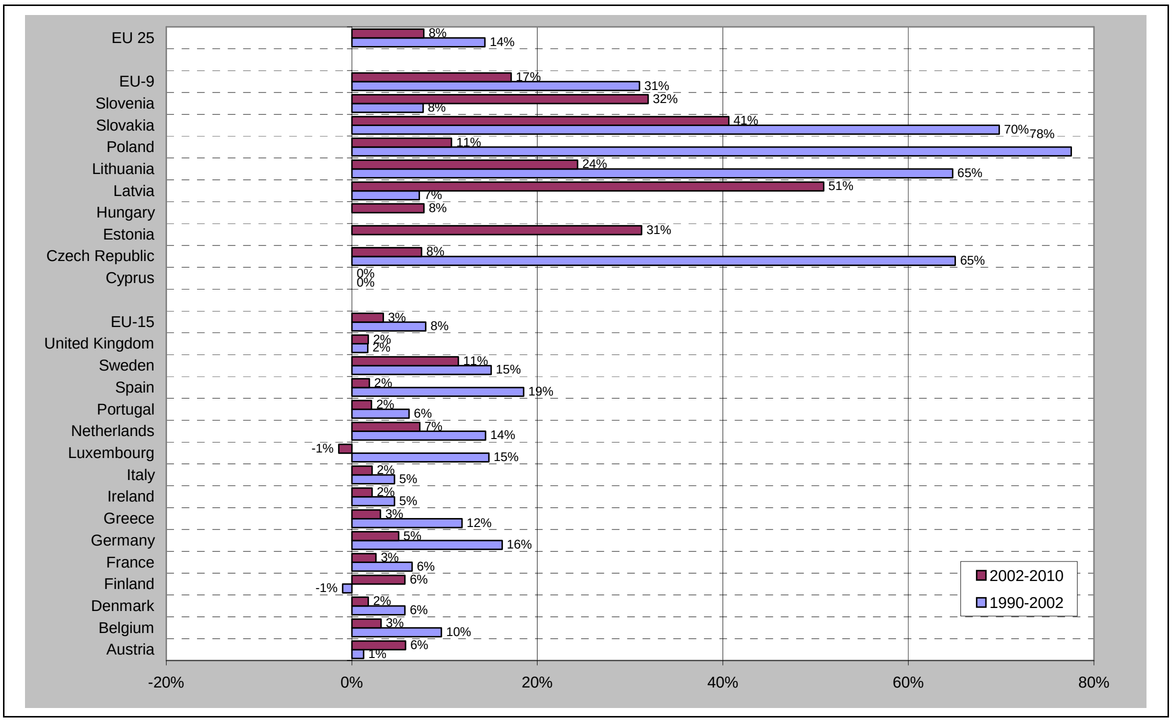
The share of road at the modal split is significantly higher in the EU-15 Member States than in the new Member States. However, within the two country groups there are large differences. The highest shares occur in Cyprus, Ireland and Portugal, the lowest by far in Latvia (less than EU-9 average), but also in Slovakia and Estonia. In the Netherlands, inland navigation plays a significant role, with the result that the share by road is the lowest in EU-15.

Figure 4.17 Modal split of freight transport in 2002



Source: EC (2003)

Figure 4.18 Changes in modal split of freight transport: share of road in total tkm



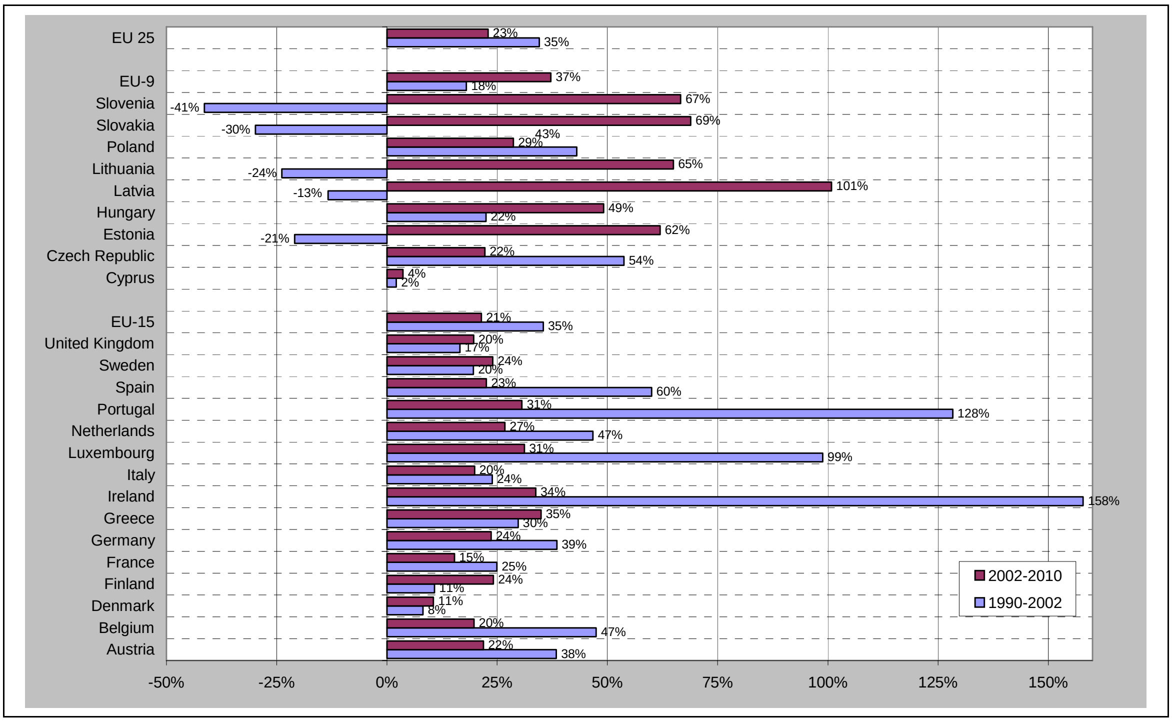
Source: EC (2003)

While in Figure 4.17 the modal split in one year (2002) was presented, Figure 4.18 illustrates the changes in the share of road transport in total tonne kilometres (tkm). There was an overall growth in the share of road transport in the past – with a significantly higher growth rate in the new Member States than in EU-15.

According to the projections for 2010 the percentage of road freight transport will continue to increase much more strongly in the EU-10 than in the EU-15 Member States but at a slower pace.

The share of energy consumption of road freight transport in total freight transport energy consumption was only decreased in Finland in the past. Luxembourg is the only Member State where a small decrease is expected in the future.

Figure 4.19 Changes in energy consumption of road freight transport per capita



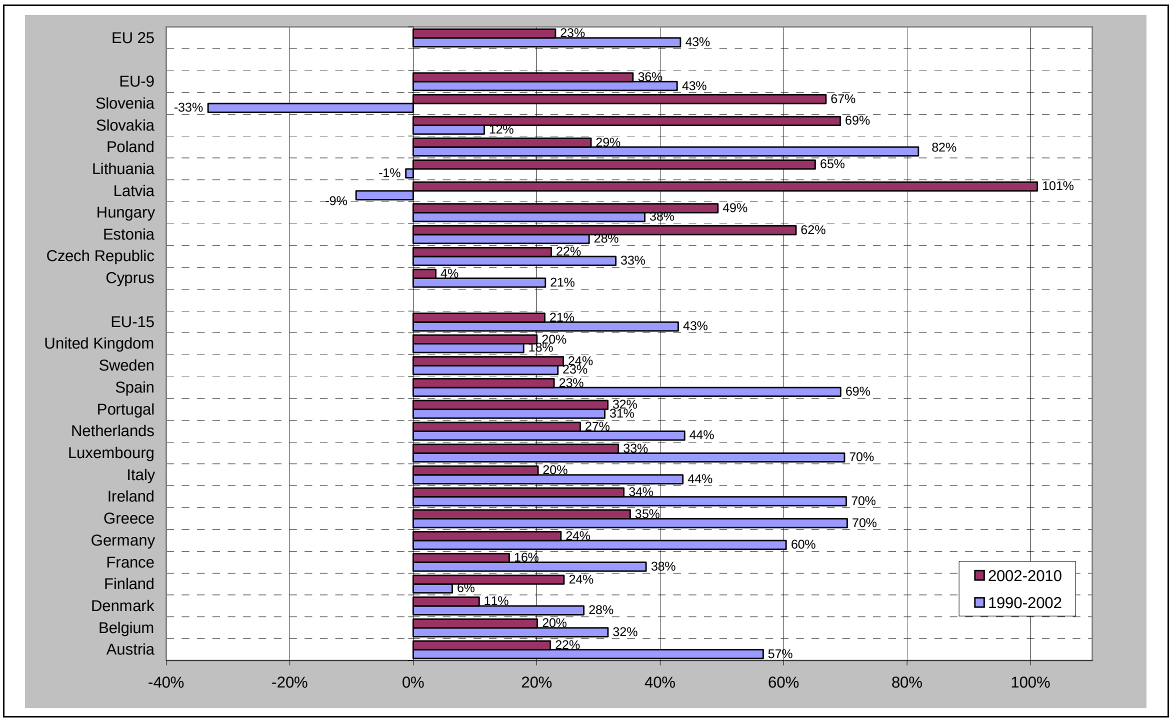
Source: EC (2003)

There is an overall EU trend towards higher energy consumption of road freight transport per capita (Figure 4.19). While in the past a reduction of the share could be achieved in some of the new Member States (Slovenia, Slovakia, Lithuania, Latvia and Estonia), the growth projections are uniform in all EU Member States. Looking at the absolute level of the energy consumption of road freight transport per capita in the new Member States with shrinking rates, it can be seen that these Member States had a per-capita energy consumption by freight transport which was above (in Estonia, by far above) the EU-9 average in 1990. In all these Member States, however, the reduction between 1990 and 2002 cannot be stabilized; in all Member States significant growth is expected again.

In absolute terms, the EU-9 average of energy consumption of road freight transport per capita is lower than in EU-15 in 1990 by far. While in the past the EU-15 average grew stronger than even that of the new Member States, it is expected to be vice versa in future. However, in 2010 the per-capita energy consumption in the new Member States still amounts only to 43 % of that in EU-15.

Only in three of the five new Member States (Slovenia, Lithuania and Latvia), in which a reduction of the per-capita energy consumption of road freight transport could be identified for the past, the changes go hand in hand with reductions of total tkm in this time period (Figure 4.20).

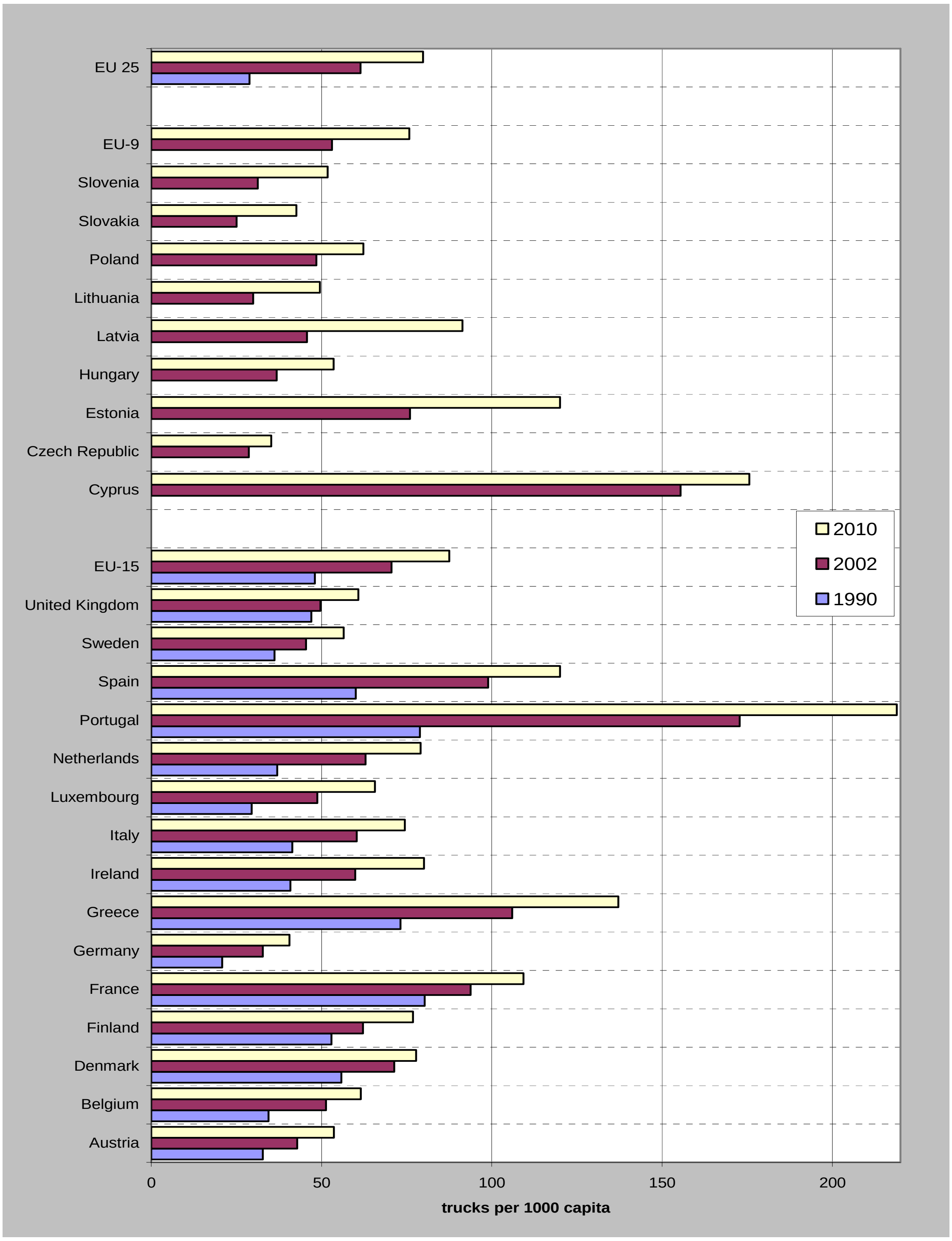
Figure 4.20 Changes in road freight transport in tkm



Source EC (2003)

The increasing freight transport on road is covered by a growing number of trucks. It is striking that Portugal even doubled its ratio of trucks per capita between 1990 and 2002, having the highest share both in 2002 and projected for 2010. Furthermore, Spain, Greece and France have a relatively high share of trucks per capita. There are still less trucks per capita on average in the new Member States, but the share converges continuously towards the EU-15 average.

Figure 4.21 Trucks per capita



Source Eurostat (2004b), EC (2003)

4.4.4 Results

The trends of selected transport indicators show that in most of the EU Member States (except Finland, Greece and Austria) the transport sector counteracted other savings in TFC by significant growth in energy demand. In Finland, however, the decrease in the share of energy demand by transport at TFC is remarkable: Against the overall trend Finland had the highest decrease in the EU although it already had the lowest share of energy demand by transport at TFC in EU-15 in 1990.

Regarding the future, in the EU-15 Member States a significant trend reversal (Germany, France, Belgium and the United Kingdom) or the stabilisation of the share of energy demand by transport at TFC on the 2002 level after strong increases in the past (Luxembourg, Italy and Ireland) is expected. In the new Member States, significantly lower growth rates than in the past are projected.

Regarding the share of cars at the modal split in 2002 there are no significant differences anymore between EU-15 and the new Member States in 2002. The highest shares of cars at modal split occurred in Slovenia, Lithuania, Latvia, where a potential for more passenger transport in trains is assumed and in France and the United Kingdom where the share of public transport on road is comparatively small. If the changes in the share of car in total passenger kilometres are considered, however, it can be assessed that in the past and up until 2010 a process of convergence is taking place between the new Member States and EU-15 with growth rates in the new Member States and small shrinking rates in EU-15.

The changes in modal split in the EU-15, however, could not – at least in the past – attenuate the growing energy demand of passenger cars. Potential for counteracting the high emission growth can be assumed in Slovenia which has the second highest absolute energy consumption of passenger cars per capita in the EU in 2002 and additionally a high growth rate in per-capita energy demand is projected. Greece, however, has the lowest level in EU-15 in 2002 and the highest shrinking rate in per-capita consumption is projected.

In contrast to the per-capita energy consumption, it is projected that the passenger kilometres in private cars per capita will increase further throughout the EU. Concluding the reduction or stabilisation of the per-capita energy demand in private cars in some EU-15 Member States (Sweden, Luxembourg, Greece, Belgium and Austria) can rather be explained by efficiency gains than by a reduction in transport performance.

The growing energy demand in passenger transport is going hand in hand with an increasing share of cars per capita – the market is not yet saturated: Poland and Greece are the only Member States which expect a trend reversal by having a lower share of cars per 1000 capita in 2010 than in 2002. Poland has – after the strongest relative growth in the past – the highest share in 2002, however, in Greece the trend reversal is rather remarkable as the share of cars per 1000 capita is well below the EU average in all three years considered.

In 2002 freight transport on road was responsible for 91% of the energy consumption at freight transport, with a continuously increasing trend from 1990 (91%) up until 2010 (95%). While in 2002 the share of car in passenger transport was similar in EU-15 and the new Member States (at least on average), the share of road freight transport at modal split is significantly higher in the EU-15 Member States than in the new Member States.

In the past there has been an overall growth in the share of road transport in total freight kilometres – in the new Member States with a higher growth rate than in EU-15. This trend will be continued in the future, however, at lower growth rates.

Between 1990 and 2002 a decrease in road freight transport kilometres in combination with lower energy consumption of road freight transport can only be registered in Slovenia, Latvia and Lithuania, in all other Member States growth in road freight transport kilometres has taken place. Moreover the per-capita energy consumption by road freight transport as well as the road freight transport kilometres are expected to experience further growth in all EU Member States.

In absolute terms in 1990, the EU-9 average of per-capita energy consumption of road freight transport is by far lower than in EU-15. While in the past the EU-15 average even grew stronger than that of the new Member States, it is expected to be vice versa in future. However, in 2010 the per-capita energy consumption in the new Member States still amounts only to 43 % of that in EU-15.

The increasing freight transport on road is covered by a growing number of trucks. It is striking that Portugal even doubled its ratio of trucks per capita between 1990 and 2002, having the highest share both in 2002 and projected for 2010. Furthermore, Spain, Greece and France have a relatively high share of trucks per capita. There are still less trucks per capita on average in the new Member States, but the share converges continuously towards the EU-15 average.

These results show that processes of convergences between the new and EU-15 Member States are taking place in energy consumption of road freight and passenger transport. Based on the projections, the overall trend towards higher per-capita energy consumption going hand in hand with increasing freight and passenger kilometres in road transport cannot be reversed up until 2010. In other words, efficiency gains by technological progress are not sufficient to reverse the growth in energy demand for road mobility.

The stabilisation of the road fleets cannot be achieved up until 2010, both the number of cars per 1000 capita and the number of trucks per 1000 capita are projected to grow – in the new Member States with a significantly larger growth rate than in EU-15.

Shifts of modal splits resulting in a decrease in the share of road at total transport, which can be noticed in some of the Member States, can only be assessed as positive if the substitution to less energy intensive transport modes takes place, if the share of aviation is growing instead, and the energy and emission balance continues to deteriorate.

In conclusion, the growing energy demand in the transport sector is obviously one of the largest obstacles for total emission reductions.

5 Effects of selected policies and measures

In work package 4, the effects of selected policies and measures are investigated in detail. The analysis is focused on widely-applied national measures as well as common and coordinated policies on the EU level. The main focus of the analysis is laid on the effectiveness of policies and measures in the past and on the projected contribution in further emission reductions. The aim of the analysis is to develop methods and to provide an informative basis on which the effects of policies and measures can be evaluated with more reliability.

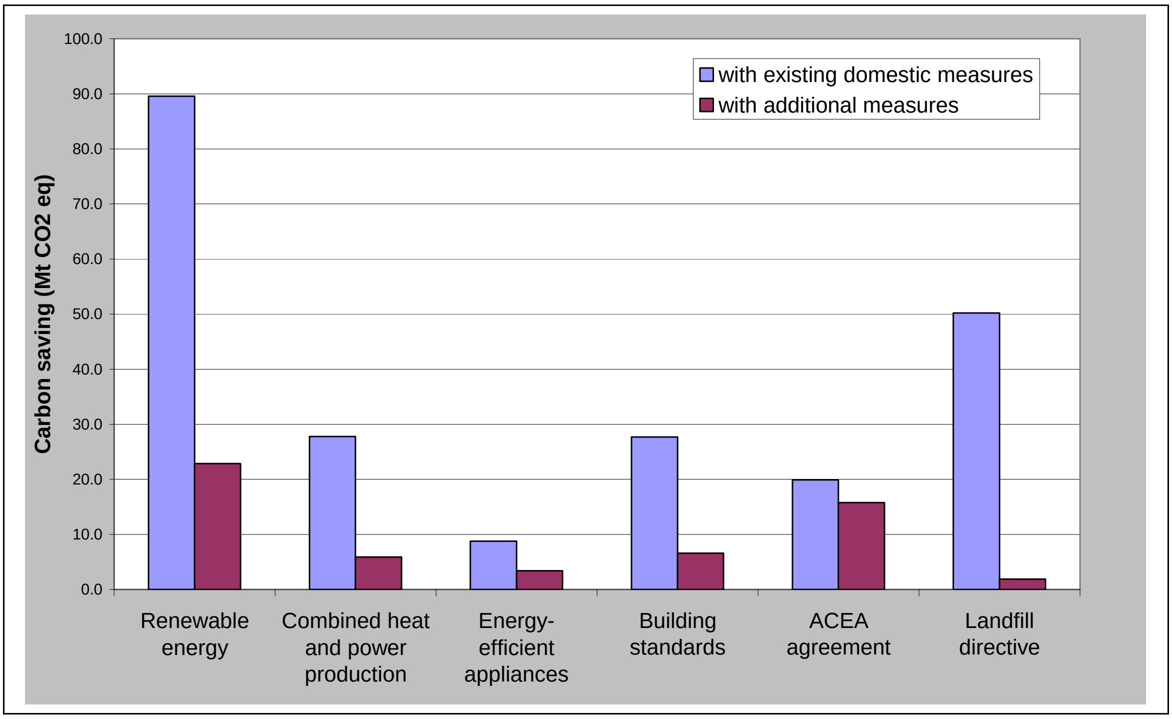
5.1 Identification of policy areas for the case study

In the first step, the policy areas for the case study have to be selected. In this regard the aggregated savings for the six key policies in the 'with existing domestic measures and with additional domestic measures scenario' in EU-15[22] provide important hints (Figure 5.1). The six key policies reported by the Member States are based all on common and coordinated policies in the European Union.[23]

[22] The EEA evaluates the projected emission savings by policies of EU-15 in the analysis of greenhouse gas emission trends and projections in Europe (EEA 2003). The evaluation in Figure 5.1 is based, however, only on the reporting of 11 out of 15 Member States as some Member States did not report their GHG savings by policies to the EEA.

[23] Only 11 of 15 Member States reported their GHG savings by policies to the EEA.

Figure 5.1 *Aggregated savings for the six key policies in the with existing domestic measures and with additional domestic measures scenario in EU-15*



Source: EEA (2004); EC (2003)

Figure 5.1 shows that major reduction potentials are assumed to be in the energy and waste sector (CRF source category 1 and 6).

In 2004 the energy sector contributed 81% to total GHG emissions in the EU-25 and is therefore by far the largest emitting sector. The sector's contribution grew in the past; its share of total GHG emissions amounted to 79% in 1990. Policies and measures related to the renewable energies are projected to contribute by far at most to the emission reduction in EU-15 both with "existing measures" as well as with "additional measures", followed in the energy sector by the intensified use of combined heat and power production, building standards and energy efficient appliances. The key policy in the transport sector, a sub-sector of energy according to the greenhouse gas reporting under UNFCCC, is the voluntary agreement of the European Automobile Manufacturers Association ("ACEA agreement"). It is assumed to significantly influence the emission reductions both by existing measures and by additional measures.

While the policies and measures in regard to renewable energy use, combined heat and power production and energy efficiency are selected for case studies, the ACEA agreement in not considered in detail. This decision was taken as the progress of this policy is influenced primarily by the large automobile manufacturers and their individual strategies rather than by the policies in the Member States. An evaluation of the progress is undertaken regularly jointly by the ACEA and the EU Commission Services (ACEA 2003).

The share of greenhouse gas emissions from the waste sector at total emissions in EU-25 was 3.4% in 1990 (not considering LULUCF) with a declining trend. In 2003 it contributes only 2.5% to the total emissions (not considering LULUCF). Although the share of the sector is minor, it plays an important role with regard to policies and measures and future reduction potentials. The EU-15 Member States projected that domestic measures with regard to the landfill directive (Directive 1999/31/EC on the Landfill of Waste) will contribute the second most to further emission reductions up until 2010. While the domestic measures are projected to contribute significantly, additional measures are rarely mentioned in this regard. The projected reduction potentials in the new EU Member States are not illustrated but it can be assumed that the landfill directive has a larger potential even relative to the EU-15, as landfilling is a common practice in EU-10 and the Landfilling Directive is not implemented as completely in the new Member States as in the EU-15.

5.2 Renewable energy supply

The promotion of CO_2-free renewable energy sources (RES) is one way of fulfilling the obligation from the Climate Convention. The development of the use of RES seems to inevitably be able to meet ambitious greenhouse gas emission reduction targets.

5.2.1 Instruments for promoting and supporting RES

RES need support and some special treatment because of the fact that energy produced from these sources often cannot compete with energy produced from fossil fuels. Therefore Member States have developed and introduced special instruments to support RES. The types of support schemes can be divided into direct and indirect ones. Some of them are designed to stimulate the supply of renewable energy and others affect the demand. There are three main instruments for RES promotion: feed-in tariffs, quota system and tenders. They are also connected with some subsidies and tax programmes. In the following, the possible instruments are highlighted.

5.2.1.1 Direct instruments

The direct instruments can be categorised as instruments related to research, development and demonstration (RD&D), investments, production and consumption. Table 5.1 reveals which financial and non-financial measures fall under these categories.

Table 5.1 Direct instruments of support for RES

Direct instruments for RES support	**Financial measures subsidies, loans, grants and fiscal measure**	**Non finacial measures**
RD&D	Fixed government RD& D subsidies Grants for demonstration, development, test facilities etc. Zero (or low) interest loans	
Investments	Fixed government investment subsidy Bidding system on the investment subsidy/grant Subsidy on switching to renewable energy production or on the replacement of old renewable energy Zero (or low) interest loans Tax advantage for renewable energy investments Tax advantage on (interest on) loans for renewable energy investments	Negotiated agreements between producers andgovernment
Production	Feed-in tariffs at a fixed level set by the authorities Bidding system on the feed-in tariffs necessary to operate on a profitable base Tax advantage on the income generated by renewable energy	Quota obligation on production
Consumption	Tax advantage on the consumption of renewableenergy	Quota obligation on consumption

Source: ECN (2003a)

On the basis of the theoretical categorisation, the relevance of the policy instruments for the European Union is described in the following (ECN 2003a):

- *RD&D support*: This kind of support is widely used in the EU to stimulate development and markets of RES. Technology research and development helps to improve cost and reliability performance, as well as demonstration projects to familiarise target users with technologies concerned.
- *Investment support*: Investment subsidies are the oldest and still very common type of RES support. The term 'investment support' is used for fixed investment subsidies, grants and for fiscal measures on investment. Investment support is especially important in the initial phase of an investment. Such subsidies usually cover 20-50% of eligible investment costs. It takes place by the means of rebates on general energy taxes, rebates from special emission taxes, proposal for lower value added tax (VAT) rates, tax exemption for green funds and fiscal attractive depreciation schemes.

- *Feed-in tariffs (FIT)*: The term feed-in tariff is used both for regulatory, minimum guaranteed price per unit of produced energy to be paid to the producer, but also for a premium on market electricity prices. The level of the tariff is usually set for a number of years to give the investors security on income of for a substantial part of the project lifetime. Feed-in support schemes rely on regulatory measures for cost allocation, but also often include government funded subsidies on the production. Feed-in tariffs are very common in EU countries. They consist of guaranteed premium prices and in combination with a purchase obligation by the utilities. They give high price certainty to investors.

  A feed-in tariff can be based on the avoided costs of the utility or on the end price for the consumer. The level of tariff need not have any direct relation with either costs or price, but can be chosen at a level to motivate investors for use of renewable energy sources.

  FIT are preferential technology-specific tariffs mandated by the regulator. They are addressed to domestic RES generators only and mean feeding into grid of the Member State concerned. FIT are fixed per operator and may be revised. This kind of RES support is specially applied in such Member States as Germany, France, Spain, the Netherlands, Greece, Portugal, Denmark and Luxemburg.

- *Bidding procedures/RES tendering support*: Bidding procedures form an interesting scheme for either investment support or for production support. These schemes are commonly also based on regulatory measures for cost allocation, and can therefore be a non-financial measure for government.

  These procedures can be used to select beneficiaries for investment support or production support or for other limited rights, such as sites for wind energy. The criteria of bidding are set before each bidding round, they can concern technical quality, socio-economic impact, geographic and environmental concerns. In each bidding round the most cost-effective offers will be selected to receive the subsidy. As a result, this mechanism leads to the lowest cost options. The bidding can be also differentiated into bands of different technologies and renewable energy sources.

  The government awards power purchase contracts by way of tenders for a certain aggregate volume of eligible RES per tender to RES project developers who submit the lowest kWh ask price. Currently, this kind of support exists in Ireland only. The UK has shifted from a tender-based programme to a Renewable Portfolio Standard System. A similar situation took place in France, where the government has announced the replacement of the wind-power tender programme by a FIT system.

- *Quota system/Renewable Portfolio Standard*: A quota system, also commonly known as Renewable Portfolio Standard (RPS), can be categorised as a non-financial measure. A quota can be set on production or consumption.

  In the case of this instrument, the government sets the framework within which the market has to produce, sell or distribute a certain amount of energy from renewable energy sources. The obligation can be imposed either on consumption or on production. Quotas are usually tradable between companies to avoid market distortions.

It is a requirement for consumers or retail suppliers to source a minimum percentage of their electricity consumption from eligible renewably-generated electricity. RPS has been introduced in the UK, Belgium (Flanders, Walloon), Italy and Sweden.

- *Fiscal stimulation:* This type of support is meant to increase the attractiveness of RES-E deployment by providing exemption or rebates on certain indirect taxes as a function of the quantity of eligible RES-E produced or consumed. So far such a support has been applied in the Netherlands and Finland.
- *Negotiated agreements:* The implementation of negotiated agreements can be either voluntary or obligatory. They are commonly preferred to gain involvement and commitment of main actors, without the necessity of regulation.
- *Stimulation of RES consumption by price reduction:* The stimulation of consumption through price incentives can be achieved by lowering the price to consumers of Renewable Energy, which is a direct policy instrument, or be increasing the price for non-renewable energy relative to that from renewable sources, which is an indirect form of stimulation.

  The price of energy from RES to consumers consists of price of production, transmission and supply of costs, and taxes. A reduction in taxes for renewable energy sources can make a large difference in price comparison between renewable and non-renewable energy for energy consumers.
- *Guarantees of origin, Green Certificates:* Green certificates do not form a separate instrument but can be used for the marketing and monitoring of green electricity and financial flows within various policy schemes. They are commonly used in the Quota System. It helps to reduce compliance costs. Renewably-generated electricity can be certified and it is possible to verify compliance with Renewable Portfolio Standard.

Some Member States in the EU apply different instruments for distinct technologies; others propose two or more policy instruments for one technology – depending on the size of the project. Usually the Member States introduce more than one support instrument.

5.2.1.2 Indirect policy instruments

The regulations that do not target renewable energy sources directly but focus on other sectors are called indirect policy instruments. To this group belong such measures as stimulation of efficient energy use or emission reduction in industry sector. They contribute to the development of use of RES, but were not originally intended to do so as such.

- *Public awareness:* The creation of a positive attitude towards renewable energies is the first step to development of such a market. Information campaigns are essential to raise public environmental awareness, among all in the field of the use of renewable energy sources. They contribute to the development of public acceptance of such initiatives. The basis for RES development are the natural and geographical conditions but the better informed society is, the easier RES projects can be carried out and support can be introduced. Such a tendency can be noticed among Member States, for example the Member States with a high share of RES (Germany, Austria, Sweden, the Netherlands) are characterised as ones with high environmental public awareness.

A supportive public opinion towards RES influences the market, both directly (creation of larger demand) and indirectly (stimulation of demand and supply by the commercial sector with PR motivation).

- *Disclosure of energy sources:* The Directive 2003/54/EC concerning common rules of the internal market in electricity regulates inter alia the disclosure of energy sources. Electric bills for end users should contain information about the electricity mix offered. When customers can see that they receive energy from nuclear or coal plants, they may change to another company that offers green electricity. Austria has already introduced a disclosure system of energy sources, in Germany it will be regulated by the EnWG which entered into force recently (ENWG 2005).
- *Energy or CO_2 tax on fossil source:* Energy or CO_2 taxes increase the cost of fossil energy source and thus improve the relatively competitive position of RES. This may not have an effect in the short-run since RES are still not competitive with fossil sources. However, in the long-run, if the tax is increased continuously while the generation costs of RES are decreasing, this instrument may boost the use of RES substantially.

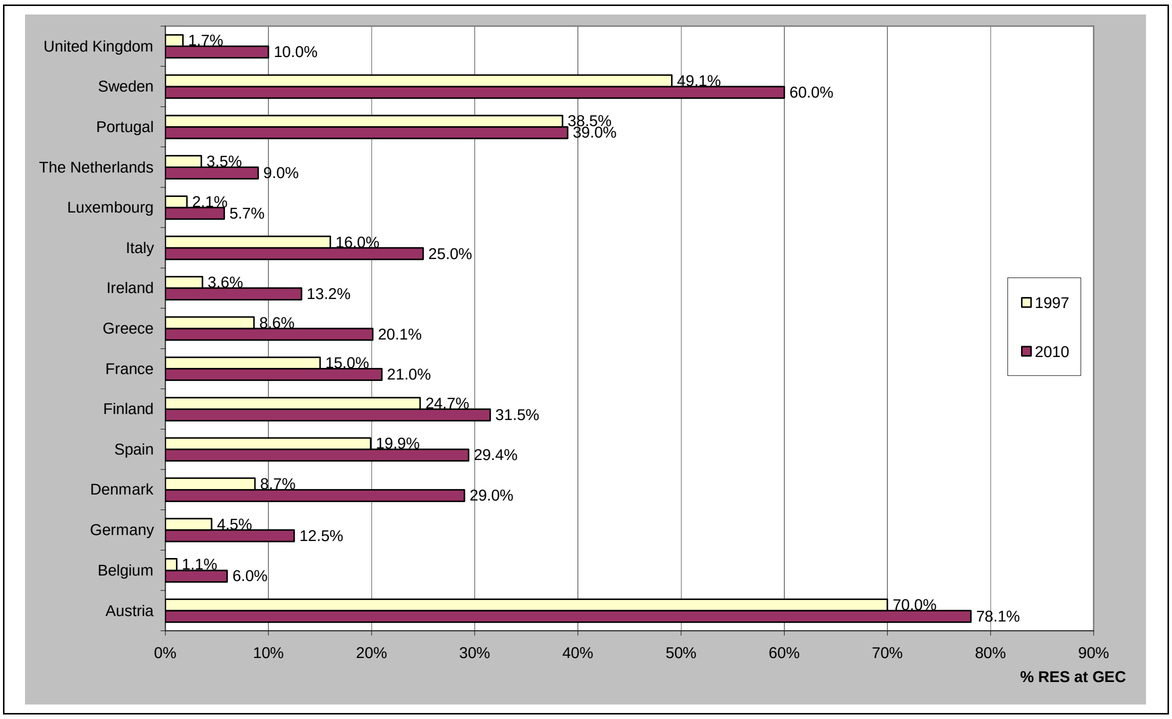
5.2.2 Renewable energy policy in the EU

For reasons of security and diversification of energy supply, of environmental protection and of social and economic reason, the promotion of electricity produced from renewable energy sources is a high priority in the European Union (Preamble of Directive 2001/77/EC). RES are to play an important role in CO_2 emission reduction in the European Community as they are either carbon-free or, in the case of biomass, a non-fossilised carbon energy supply. According to the Directive 2001/77/EC, the RES consists of wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.

The EU Directive 2001/77/EC is the most essential common and coordinated policies with regard to RES support that imposes the obligation to increase the share of renewable energy sources in energy production. Each Member State received its individual target which is based on the share of RES production at Gross Electricity Consumption

(GEC)[24] in the year 1997 (EU-15), or on the RES supply in the year 1999 (EU-10) respectively. The targets have to be fulfilled by the year 2010.

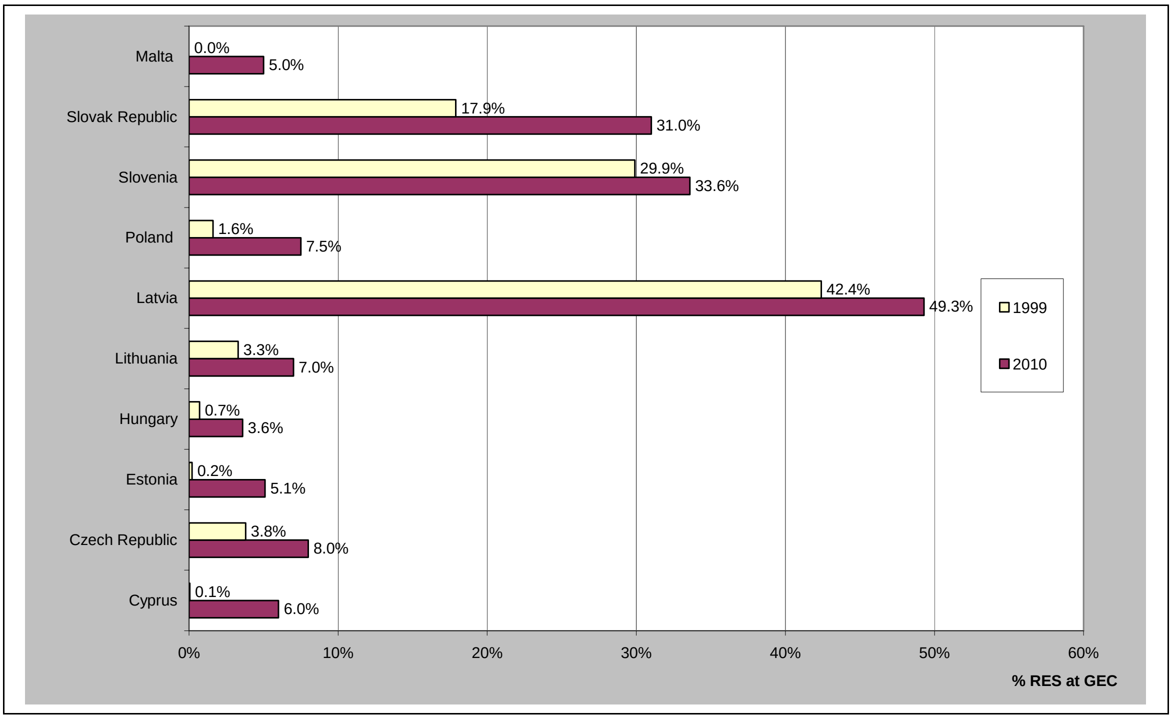
Figure 5.2 National indicative targets of electricity produced from RES as a share of GEC according to Directive 2001/77/EC in EU-15



Source: Directive 2001/77/EC

24 Gross electricity consumption is defined as domestic electricity production plus imports minus exports.

Figure 5.3 *National indicative targets of electricity produced from RES as a share of GEC according to Directive 2001/77/EC in the new EU Member States.*



Source: Reiche (2002a)

If the EU Member States achieve their national targets by implementation of adequate policies and measures, the share of electricity from renewable energy sources in EU-15 at total electricity production will amount to approximately 22%. Taking the obligations of the new Member States additionally into account, the share of renewable energy of EU-25 will reach 21% in 2010.

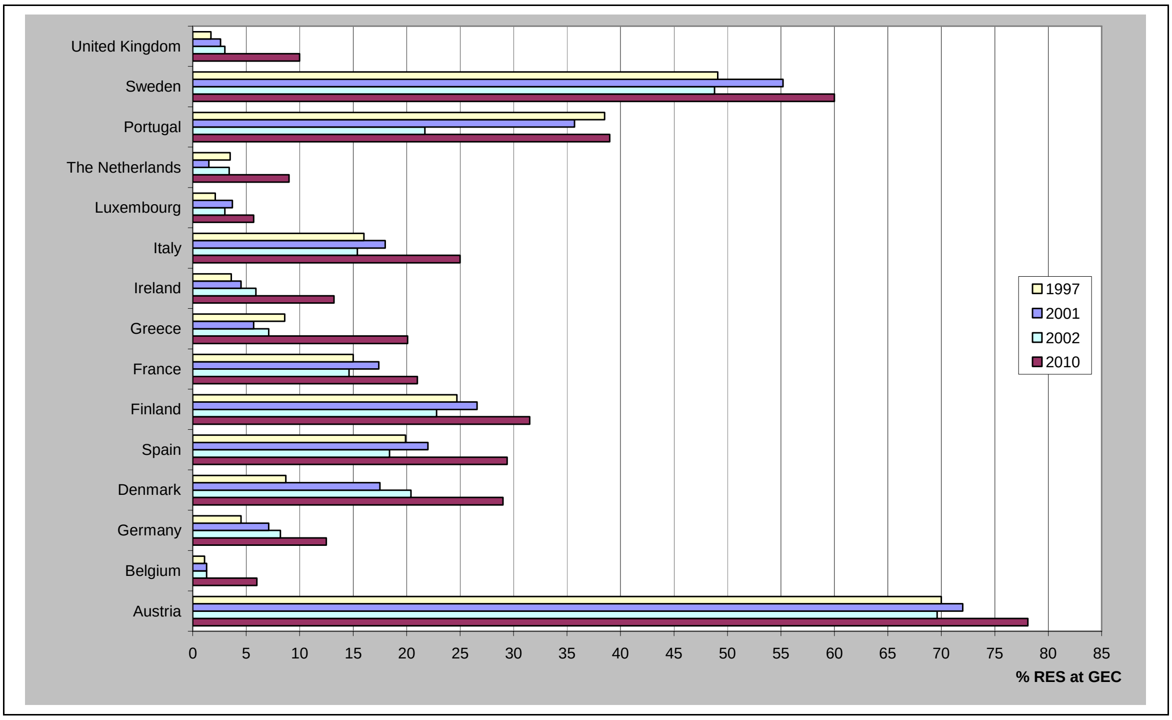
In order to meet the targets, Member States have to introduce instruments to support the increase of the use of renewable energy sources. The European Commission has developed a report on progress in realisation of the targets established in Directive 2001/77/EC based on submissions of the EU-15 Member States (EC 2004).

Analysis of the progress reports reveals that policies and measures that are currently in place are insufficient to achieve the overall EU target; it is expected that a share of only 18-19% in 2010 will be obtained compared to 14% in 2000. One of the reasons for this discrepancy appears to be that a number of Member States have not yet introduced effectual policies in line with their targets adopted. With the measures that have been put in place, it is projected that the share of renewable energy sources in the EU-15 will amount to 10% in 2010. In the case of the new Member States, the progress will be evaluated only in 2006. Therefore, the assessment of the realisation of the targets in the new Member States by the European Commission has not yet taken place.

According to the Progress Report by the Commission (EC 2004), only four Member States are currently on track to meet the target: Denmark, Germany, Spain and Finland. While the United Kingdom, the Netherlands, Ireland, Belgium, France, Sweden and Austria are more or less on track, the European Commission comes to the conclusion that considerable efforts are still needed to reach the target in Greece and Portugal.

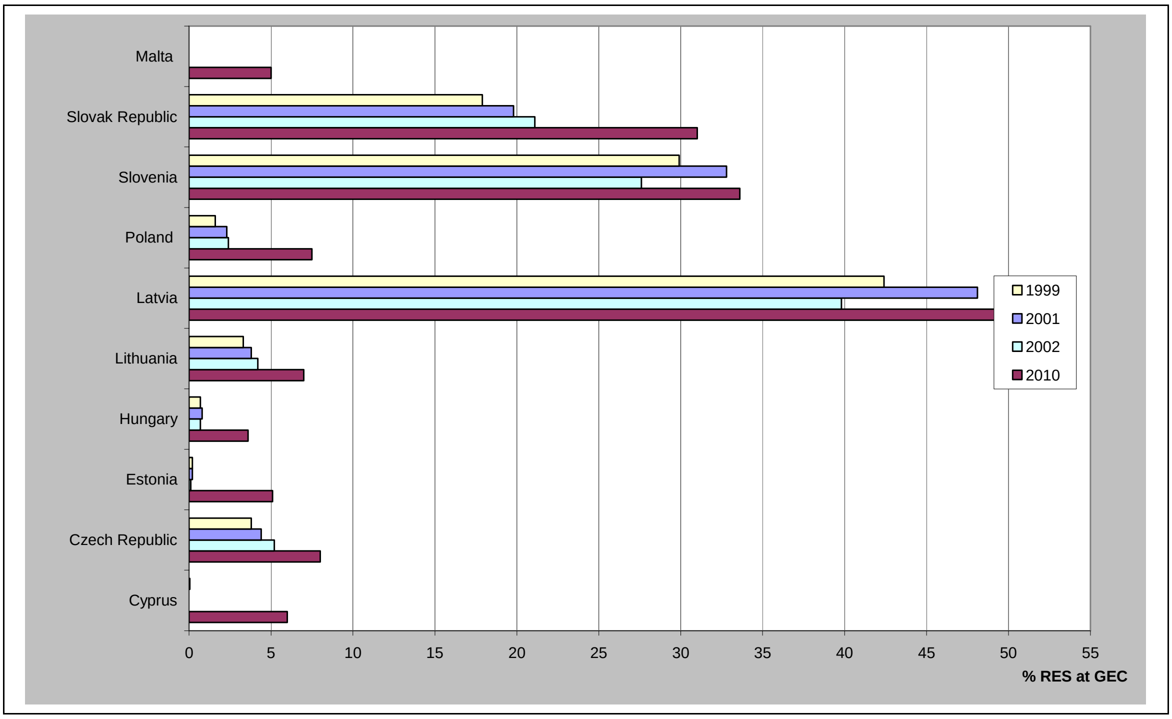
Independently from the Progress Report by the European Commission, the Netherlands Energy Research Foundation (ECN), under the direction of the Dutch Ministry of Economic Affairs, compiled a database consisting of data on renewable electricity in the 25 EU Member States plus Norway in the years 2001 to 2003 (ECN (2004)). The goal of the compilation of this database was also to obtain more insight into the level of realisation of the renewable electricity consumption target of 2010 established in the Directive 2001/77/EC. Figure 5.4 and Figure 5.5 illustrate quantitatively the progress towards the target by the EU Directive 2001/77/EC in the EU-15 Member States and the new EU Member States. Data from 2003 is not depicted as in several Member States data on electricity from some types of renewable energy sources have not been published and consequently the data would not reflect the real progress. Further details can be taken from ECN (2004).

Figure 5.4 *Contribution RES electricity production to GEC in 1997, 2001, 2002 and target by EU Directive 2001/77/EC in the EU-15 Member States*



Source *ECN (2004)*

Figure 5.5 *Contribution RES electricity production to GEC 1999, 2001, 2002 and target by EU Directive 2001/77/EC in the new EU Member States*



Source *ECN (2004)*

The sole illustration of the share of RES electricity production to Gross Electricity Consumption in 1997, 2001 and 2002 indicates past achievements but does not reflect further projections which are strongly influenced by the effect of policies and measures planned and implemented. On the occasion of the EU Directive 2001/77/EC, EU Member States have initiated measures for supporting renewable energies; however, it is not guaranteed that the effect of the policies and measures is already visible in the 2001 and 2002 data. In other words, the effect does not have to be linear but can also be low in the beginning and high in the end. Nevertheless the deviation of the actual realisation from the hypothetic linear trend in realisation indicates roughly if the Member States are on track.

In the Progress Report of the European Commission, both the realisation of the absolute share up until 2003 and the policies and measures implemented are taken into account for assessing the progress. Table 5.2 provides an overview of the results of the Progress Report of the European Commission and some analysis results regarding the deviation of the actual realisation from the hypothetic linear trend in realisation based on the data by ECN (2004).

Table 5.2 EU-15 Member States' progress in meeting the targets of Directive 2001/77/EC

Member States	Deviation from hypothetic linear reduction trend (1997-2010)		Progress towards target			Assessment of progress by European Commission
	2001	2002	+	+-	-	
Austria	-1%	-5%		x		Austria has a good perspective for growth. Such a development is facilitated by the feed-in tariffs introduced in January 2003, however not excluding a streamlining of the support scheme with additional efficiency requirements.
Belgium	-50%	-56%		x		Since 2002, Belgium has a new green certificate system. For the moment this does not show visible results
Denmark	2%	8%	x			Denmark, if it maintains its active approach, is likely to achieve the 2010 target as early as 2005. Denmark has increased the share of electricity from renewable sources from 8.9% in 1997 to 20% in 2002
Spain	17%	24%	x			Spain is successful in wind power generation but its biomass policy needs to be given higher priority.
Finland	-4%	-22%	x			In Finland's national report, the contribution of electricity from renewable energy, passed from 7 TWh in 1997 to 10 TWh in 2002 excluding hydro. Although 2002 was a bad year for hydropower in Finland, the evolution of biomass has been impressive in the recent years.
France	-1%	-17%		x		France recently put in place a new tariff system. The attractiveness of the tariffs is, however, reduced by the upper limit of 12 MW for each project. This particularly affects wind energy. In addition, long approval procedures and grid connection problems remain major obstacles.
Germany	3%	-16%				Germany has increased the share from 4.5% in 1997 to 8% in 2002 (national target of 12.5%) with wind generation growing from 3 TWh in 1997 to 17 TWh in 2002 (equal to 3% of the total electricity consumption in 2002).
Greece	-53%	-45%			x	So far, the development of electricity from renewable energy has been held back in Greece. Administrative barriers prevent exploitation of the high potential that exists both in wind, biomass and solar.
Ireland	-31%	-19%		x		Ireland has set up a support system through tendering but there are big difficulties in connecting wind electricity to the grid.
Italy	-4%	-21%				
Luxembourg	15%	-14%				
Netherlands	-71%	-39%		x		The Netherlands have actively invested in a new policy although the full results still have to materialise.
Portugal	-8%	-44%			x	Portugal has increased its non-hydro production of electricity from renewable energy by only 1 TWh since 1997. Further 14 TWh are still needed to be achieved for the national target.
Sweden	5%	-8%		x		Sweden implemented a green certificate system in May 2003. Electricity generation from renewable energy rose hardly at all in Sweden between 1997 and 2002. But signals from 2003 are much better.
United Kingdom	-39%	-39%		x		United Kingdom has actively invested in a new policy although the full results still have to materialise.

Source: EC (2004), ECN (2004), own calculation

Of the four Member States which are on track according to the EU Commission, only two Member States (Denmark and Spain) realised a higher reduction than the hypothetic linear trend both in 2001 and 2002, Germany did so at least in 2001. Finland made considerable efforts in biomasses and due to the bad year of hydropower the efforts by policies and measures are not visible in the data of 2002. Greece and Portugal are not on track to realise their target according to the European Commission; however, Belgium, the Netherlands and the United Kingdom show a similar deviation from the hypothetic linear reduction trend in 2002. According to the Commission, however, the latter two invested in a new policy, the full results of which still have to materialise.

5.2.3 Assessment of policies and measures in the EU Member States

Member States undertake many differentiated polices and measures in order to comply with their targets under Directive 2001/77/EC and to achieve the emission reduction targets under the Kyoto Protocol. However, before analysing the policies and measures in detail, the major obstacles in RES promotion are summarized.

The development of renewable energies faces similar obstacles in many Member States. One of the most important of them is their lack of ability to compete with fossil fuels without subsidies. Furthermore, natural conditions and resources as well as the economic situation of a Member State play a key role. In the following, Member States with similar types of obstacles concerning the development of renewable energies are presented.

Conflicting interest and policies with security of supply and fossil fuels resources:
There are national subsidies to coal in France, Germany, Spain, the United Kingdom, Poland and the Czech Republic. The Netherlands and the United Kingdom have access to gas and oil in their own territories.

Lack of appropriate natural conditions:
In Denmark and Belgium, potential for hydropower is negligible; in Sweden there are unfavourable conditions for solar energy.

Conflicting or competing interests with nuclear power:
Austria, Portugal and Denmark have no nuclear power and are very successful in RES; currently the United Kingdom, France and Finland are the only EU-15 Member States which continue to support nuclear power, the other Member States have either decided to phase it out or they did not use this energy source in the past. In the long run, it can be assumed that the phase out tends to have a positive impact on the development of RES.

Low public awareness: especially in the new Member States

Insufficient financial resources: especially in the new Member States

Insufficient technologies and high costs: especially photovoltaic energy in comparison with hydropower, wind or biomass

Insufficient and fragmentary legal framework: especially in the new Member States

Problems with grid capacity: occur in France, Sweden, Portugal and Greece

High price of energy: conventional energy sources do not pay their full external costs and are subsidised on top of the bargain

Long permit procedure: this administrative burden may be relevant in Greece, Luxembourg, the Netherlands and the United Kingdom

Political situation: weak position of green parties, for example in Denmark and Germany, Green Parties insisted on phasing out on nuclear power and in France they support promotion of RES

To begin the analysis, the policies and measures with regard to renewable energies reported in the third National Communications and the GHG Monitoring Decision (280/2004/EC)[25] with the expected reduction effects are presented in an overview (Table 5.3).

Table 5.3 Policies and measures in regard to renewable energy supply and CHP

Member State	**Policy Name**	**Start**	**Reduction effect in 2010 [Mt CO_2]**
Austria	Public support for renewable energy projects and district heating	1997	0.7
	Energy tax rebates for CHP	1996	
	Preferential framework conditions for CHP		0.5
	Efficient energy recovery from waste		
Belgium	Green certificates	2001	
	Eligibility of producers and consumers of green electricity	2000	
	Priority access to the network for green electricity		
	Financing CHP installations		
	Subsidies for CHP installations		
	Reductions in tariff for the clients of CHP installations		
	RUE/electricity Fund	1996	
	Demonstration projects (Flemish Region): Information and public awareness (energy efficiency and RES)		
Czech Republic	New Energy Act		
	The Act on energy management	2001	
	Measures to decrease emissions of greenhouse gases introduced jointly: Modernisation of a CHP plant in the automobile company of skoda Mlada Boleslav in cooperation with German Government	1996	0.179
Denmark	Prioritisation of electricity from CHP plants		
	The biomass agreement on use of wood chips as fuel: 0.2-0.4 Mt wood chips per year used in primary CHP production		0.247 (coal) 0.148 (gas)
France	Substituting Traditional Power Stations with Gas Combined Cycles (GCC) and Co-generation	1999	14.7
	Development of Co-Generation and Wind Energy: A target of 4 GW of co-generation was posted for the period 1995-2010. The aim of the development of wind energy, under the “Eole 2001” plan, was to install a production capacity of 250 to 500 MW between now a		
Hungary	Energy efficiency Programme 1999: inter alia, increasing combined heat and power generation	1999	

25 Reports under the GHG Monitoring Decision (290/2004/EC) available as of 15th June 2005 were taken into account.

Member State	Policy Name	Start	Reduction effect in 2010 [Mt CO_2]
Ireland	CHP: Government policy to promote the deployment of CHP in Ireland resulted in the doubling of installed capacity during the 1990s. This was stimulated mainly by the incentives under the Alternative Energy Requirement (AER) scheme and the Irish Energy Centre's (now SEI) Energy Efficiency Investment Support Scheme. At the end of 2000, installed CHP capacity was 122 MW, contributing 2% of Ireland's electricity requirements. However, this CHP growth during the nineties has come to a virtual halt with little recent additional capacity. This is due in part to changing market conditions and increased risks to investment. Specifically, the large increase in the price of gas available to fuel CHP plants at a time when the prices of electricity from competing conventional electricity generating plants have been effectively capped has made the economics of gas fired-CHP less attractive.	2001	0.25
	Renewables: The national target, as set out in the Green Paper on Sustainable Energy (September 1999), was to add 500 MW of new renewable energy-based electricity generating plant by 2005. This target has been increased, subject to EU State Aid approval, by an additional 140 MW onshore and specific categories of biomass-fed CHP(28 MW) and two 25 MW projects in offshore wind category. The latter two category projects are to be built by 2006.	1999	
	Green Paper on Sustainable Energy (September 1999): Building a biomass-fed CHP (28MW)	1999	
	Electricity (Supply) (Amendment) Act 2001: Electricity consumer may purchase electricity from a licensed CHP supplier. However, this initiative has not resulted in an increase in the uptake of CHP in Ireland and the main constraint surrounding CHP remains		
Italy	Resolution of the Authority for Electricity and Gas no. 42/02		
	Implementation Law 10/91: ENEA and FIRE courses and information on energy efficiency. DSM measures: heat pumps and cogeneration		
	Cogeneration of small/medium size plant with production capacity between 10-20 TWh		0.8-1.5
Latvia	Bio diesel fuel as a internal combustion fuel in small scale co-generation plants		
	Wider use of co-generation		
The Netherlands	Promotion of combined heat and power (CHP)		
Portugal	Co-generation: Application of the proposed Directive on co-generated electricity. Target of 18% throughout EU by 2010.		0.5
	Use of Energy Potential and Rationalisation of Consumption: Increase installed capacity, by 250 MW, of power production facilities based on renewable energy sources; 90MW of new installed capacity in cogeneration		Savings of 30,000 toe resulting from energy efficiency and rational use of energy
Poland	strategy of organisational and technological decentralisation of power engineering systems: * investment policy * development of small CHPs * development of local markets - local resources (RES and others) * assumptions and plans of communes: Development of local energy markets, increase of RES share, development of small CHP sources, stimulation of activities in communes - as a result, significant growth of energy use efficiency is expected.	1997, 1998, 2000	
	Modernisation of conversion of the 2nd Power Station into Urban Combined Heat and Power Station	1996	0.4 kt
	Construction of a heating system main 2x800 connecting the 1st and the 2nd CHP	1996	0.085 kt
Spain	Programme for energy saving and efficiency, co-generation and renewable energy of Castilla and León: energy saving, substitution of mineral oil products, diversification, renewable energy (except of wind and solar)		
	Royal Decree 2,818/1998, of 23 December on the production of electric power by plants using renewable fuels or energy sources, waste and cogeneration.		

Member State	Policy Name	Start	Reduction effect in 2010 [Mt CO_2]
Germany	Maintenance, modernisation and expansion of heat-power cogeneration (including small cogeneration systems), and introduction of fuel cells on the market: Agreement between the Federal Government and German industry on reduction of CO_2 emissions and promotion of heat-power cogeneration, as a supplement to the climate-protection agreement of 9 November 2000 and the Act on heat-power cogeneration (Kraft-Wärme-Kopplung)	2002	23
	Intensified introduction of state-of-the-art systems for buildings: Creation of initiative for intensified use of state-of-the-art systems such as condensing boilers, small heat-power cogeneration systems, fuel cells, connection to district heating networks, modern measurement and control systems, etc.		
Greece	Promotion of natural gas: Law 2773/99	1999	6.4
	Improvements in the conventional power generation system: Promotion of combined heat and power system: Setting up district heating system in northern Greece		0.025
	Further penetration of CHP plants in the industrial and tertiary sectors		
Slovak Republic	Fuel switching: Public industrial CHP, DH and services		
	Utilisation of combined cycles: Industrial CHP		
United Kingdom	Exemption of Good Quality CHP from the climate change levy	2001	
	Eligibility for enhanced capital allowances offering tax incentives to companies investing in energy saving technologies, including Good Quality CHP	2001	
	Exemption of CHP plant and machinery such as turbines and engines from business rating	2001	
	A 15 percent target for Government departments to use CHP- generated electricity		
Slovenia	Promotion of electricity production from Renewable Sources and CHP Generation		
Austria	Public support for renewable energy projects and district heating	1997	0.7
	Energy tax rebates for CHP	1996	
	Preferential framework conditions for CHP		0.5
	Efficient energy recovery from waste		
Belgium	Green certificates	2001	
	Eligibility of producers and consumers of green electricity	2000	
	Priority access to the network for green electricity		
	Financing CHP installations		
	Subsidies for CHP installations		
	Reductions in tariff for the clients of CHP installations		
	RUE/electricity Fund	1996	
	Demonstration projects (Flemish Region): Information and public awareness (energy efficiency and RES)		
Czech Republic	New Energy Act		
	The Act on energy management	2001	

Source: *Third National Communications under UNFCCC, EU Member States, Reports under GHG Monitoring Decision (280/2004/EC) available until 15th June 2005*

The different types of policies and measures can be divided into fiscal, economic, regulatory, voluntary agreement, planning, information, research and other instruments. Table 5.4 presents the types of polices and measures undertaken and reported by the individual Member States.

Table 5.4 Number and policy type of policies and measures reported in the third National Communications

	Policy Type									
	eco-nomic	edu-cation	fiscal	infor-mation	planning	regula-tory	res-earch	voluntary/ negoti-ated agree-ment	other	**Total**
Austria	2			1		2			1	**6**
Belgium	5			1	1	2				**9**
Czech Republic						2				**2**
Denmark	5				1		2			**8**
Estonia	1		1			1				**3**
Finland	2	1	2	1						**6**
France	7		1	2	1	1	2			**14**
Germany	3					3		1		**7**
Greece	6					6				**12**
Ireland	1				2					**3**
Italy	1				1	2				**4**
Latvia	6				1	2	3			**12**
Netherlands	1		1			1		1		**4**
Portugal	1					1				**2**
Slovakia						1				**1**
Slovenia	2					2			1	**5**
Spain	10		7		1	7			7	**32**
Sweden	5		2		1					**8**
United Kingdom	2					2				**4**
Total	**60**	**1**	**14**	**5**	**9**	**35**	**7**	**2**	**9**	**142**

Source: Third National Communications under UNFCCC, EU Member States

In the following, the policies and measures are categorised and analysed more in detail. The assessment of the policies and measures is based on other data sources (ECN et al. 2005, Reiche 2002a, 2002b).

Table 5.5 Instruments for promoting renewable energy sources in the EU Member States

Member States	Feed-in tariff	Quota obligation	Tenders	Exemption from energy taxes/tax relief	Parts of the Revenue of energy taxes finance RES	Environmental funds
Austria	x	x	x	x	x	
Belgium	x	x				
Cyprus				x		
Czech Republic	x			x		x
Germany	x				x	
Denmark	x			x		
Estonia	x			x		x
Spain	x			x		
Finland	x			x		
France	x		x	x		
Greece	x			x		
Hungary	x			x		x
Ireland			x			
Italy	x	x		x		
Lithuania				x		x
Luxembourg	x			x		
Latvia	x		x	x		x
The Netherlands	x			x	x	
Poland		x		x		x
Portugal	x			x		
Sweden	x	x		x		
Slovenia	x			x		x
Slovak Republic				x		x
The United Kingdom		x			x	
Malta				x		

Source: ECN et al. (2005), Reiche (2002a), Reiche (2002b)

The success of the development of renewable energies use depends on specific construction of applied tools and instruments which offer investors long-term security. One of such instruments is the FIT system. The other widely applied instruments are tax refund and differentiated investment support.

5.2.3.1 Feed-in tariffs

FIT are regarded as one of the most effective tool in RES promotion. Several Member States (Germany, Spain, Portugal and Luxembourg) decided to introduce FIT for different renewable energy technologies. The Member States decide individually which RES should be covered by feed-in tariff system and to what extent a given technology should be supported. In Austria the range of support depends also on the federal regions (Länder).

Feed-in tariffs turned out to be very successful in the wind sector in Germany, Denmark and Spain. However, there are also Member States (Finland, Greece) with FIT in the wind sector which are not as successful as the three mentioned before. FIT systems are initiated to offer investors a long-term security – in Germany, for example, for 20 years.

Currently, this instrument is criticised for being costly, inefficient, for distorting competitive pricing and for being not compatible in the long run with the creation of a single liberalised electricity market in Europe. Some Member States (Italy, Sweden) have therefore decided to give it up and to introduce a quota system instead.

Table 5.6 Feed-in tariffs: sectors concerned and range of support in EU15

Member States	Sector	Range of support prices	Others
Austria	Range	6.37 - 40.82 ct/kWh, for Solar PV 40.82 ct/kWh and 6.37 ct/kWh for w ind	RES-E do not include w aste.he generator receives in addition to the price of electricity receives a support price in the form of feed-in tariff. Varied tariffs in different Länder.
	Biomass, Geothermal, Hydro, Solar PV, Wind		
Belgium	Range	4.25 – 12.5 ct/kWh	
	Biomass, small hydro, Solar PV, Wind		
Germany	Range	4.03 - 7.03 ct/kWh	Renew able Energy Law 2003
	Biomass, Small hydro (<=5MW), Solar PV, Wind	for solar PV48.55 ct/kWh	
Denmark	Range	5.06 – 6.73 ct/kWh	The price does not include the price of electricity
	Biomass, Geothermal, Small hydro (<=10MW), Solar PV, Tidal, Wind onshore		
Spain		2.17 – 3.01 ct/kWh for solar PV it is 27.1 ct/kWh	
France	Many technologies		Based on electricity Law 2000
Greece		Different prices – depend on category: Independent pow er producers and auto producersLaw 2773/99:5.6 – 7.2 ct/kWh Law n2244/94:1.6 – 6.0 ct/kWh	Independent pow er producers receive up to 90% of retail price. Auto producers receive up to 70%. Contracts for 10 years
Italy	Range	5.3 – 12.5ct/kWh	Subsidy for higher investment is paid 8 years and depends on the source of renew able energy.Utilities pay a price consisting of avoided fuel costs and a subsidy for the higher investments RES-E generators have to make.
	Biomass	12.5ct/kWh	
	Small hydro (<3MW)	5.3ct/kWh	
	Solar PV	12.5ct/kWh	
Luxembourg	Biomass,Solar PV, Wind	3.0 ct/kWh	Producers receive in addition a bonus of 11.2 ct/kWh for average peak load deliveries during the three principal annual peak load periods.
The Netherlands	Range	… - 6.8 ct/kWh for these mentioned technologies the support is the highest	Guaranteed for maximum 10 years. Since 2003
	Small stand-alone biomass installations, Hydro, Solar PV, Wave, Tidal energy, Wind offshore		
Portugal	Range	2.7 – 34.7 ct/kWh	Since 1999
	Biomass, Geothermal, Small hydro, Solar PV, Wind		
Sweden		0.97 – 1.95 ct/kWh	

Source: ECN et al. (2005), Reiche (2002b)

Table 5.7 Feed-in tariffs: sectors concerned and range of support in the new Member States

Member States	Sector	Range of support prices	Others
Czech Republic			Since 2002, market price of electricity 2.88 €ct/kWh (exchange rate as of June 3rd 2003)
	Biogas	7.99€ct/kWh	
	Biomass	7.99€ct/kWh	
	Geothermal energy	9.59€ct/kWh	
	Small hydro (<10MW)	4.79€ct/kWh	
	Solar PV	19.18€ct/kWh	
	Wind	9.59€ct/kWh	
Estonia	All RES		New tariffs since 2003, available till 2013. Tariffs calculated from the consumer prices for residential customers.Hydro and biofuelled plants the tariff is paid for 7 years, w ind and other RES for 12 years
Hungary		6.6 cts/kWh (on average in April 2003)	Since 2003. Premium price for "product" for producers, compared to conventional sources. Tariffs for 8 years. Do not apply for facilities under 0.1 MW capacity. Different tariffs for peak and peak-off period.
Latvia	Biogas (<=7MW)		Since 1998
	Geothermal		
	Small hydro (<=2MW)		
	Solar PV		
	Wave		
	Wind (<=2MW)		
Slovenia			New system since 2002. Difference betw een the market price and the feed-in tariff is covered by netw ork charges, paid by all electricity consumers. Feed-in tariffs are renew ed once a year.
	Biomass (up to 1 MW and above 1 MW)		
	Small hydro (up to 1 MW and 1-10 MW)		
	Geothermal		
	Solar (up to 36 kW and above 36kW)		
	Wind (up to 1MW and above 1 MW)		

Source: ECN et al. (2005), Reiche (2002a)

The designs of FIT systems vary from Member State to Member State. In Germany, for example, the feed-in tariffs are based on generation costs of various renewable energy sources. In Spain, however, producers of renewable energy receive a premium feed-in tariff additionally to the market price of electricity. In Denmark FIT are differentiated by the type of renewable energy technology.

5.2.3.2 Quota obligation

Recently more and more attention is paid to the quota obligation system to support RES. This instrument supports renewable energy generation by increasing the demand for that type of energy supply. The design of quota obligation system can vary considerably. In most cases, energy consumers have to comply with that obligation. However, usually these obligations are fulfilled by the energy suppliers instead. Only in the case of Italy is the approach different, since the energy generators have to comply with the obligation. Within the system, penalties for non-compliance are established.

The quota systems are introduced only in Member States in which a successful FIT system did not exist. The first Member State to implement a quota system was the United Kingdom in 2002, followed by Belgium (Flanders, Walloon) and Italy. More recently, Sweden and Poland have adopted this type of instrument as well.

The quantitative obligations show a broad bandwidth, varying from 0.8% (Flanders, 2002) up to 15.4% (United Kingdom, 2015) and 16.9% (Sweden, 2010). The possibility of banking usually exists within the systems. However, borrowing, with the exception of Sweden, is not allowed. A minimum price was established in Sweden only.

The quota system replaces the previous bidding system in the UK and investment and production subsidies for renewable energy technologies in Sweden. The introduction of quota system in Sweden is to increase the production of electricity from RES by 10 TWh from 2002 to 2010. The certificates can be traded in Sweden with a guaranteed minimum price established by the Swedish Energy Agency. This price will drop to zero over the next five years. Design elements of the existing quota systems are summarized in Table 5.8.

Table 5.8 Key elements of quota systems in the EU Member States

Element	UK	Sweden	Walonia	Flanders	Italy
Starting date	1 April 2002	1 May 2003	1 January 2003	1 January 2002	1 January 2001
Obliged actors	Licensed electricity suppliers	All electricity use except manufacturing process use in energy intensive industry	Suppliers	Suppliers	Producers and importers
Quantitative obligation	3% in 2002 increasing to 15.4% in 2015	7.4% in 2003 increasing to 16.9% in 2010	3% in 2003 increasing to 7% in 2007	0.8% in 2002 increasing to 6% in 2010	2% annually
Eligible resources	RES-E, incl. Existing hydro <=20MW, hydro >20MW only new plants	Wind, solar, wave, geothermal, biomass and peatHydro if <1.5MW and large hydro under certain conditions.	RES-E and CHP based on avoided CO2 emissions	All RES-E but no CHP, no residual waste and combined processing with residual waste	RES-E but no hydro pump plants
Banking	Up to 25% of the obligation	unlimited	5 years	5 years	No information provided
Borrowing	Not allowed	TRECs produced in the first three months of each year can also be used to meet the obligation of the previous year	Not allowed	Not allowed	No information provided
Penalty for non-compliance	2002/3 - GBP 30.00, 2003/4 - GBP 30.51, 2004/5 - GBP 31.39, 2005/6 - GBP 32.33	150% of average certificate price, 2004 –175 SEK(19.4€), 2005 –240 SEK(26.6€)	2003 – 125€	2004 – 100€, 2005 – 125€	No information provided
Certificate price	January 2004 - GBP 48, January 2005 - GBP 47	March 2003 - 160SEK, March 2004 - 240SEK, March 2005 - 212SEK, March 2006 - 219SEK, March 2007 - 228SEK	2003 - 85.25€, 2004 - 91.87€	2002 - 73.85€, 2003 - 91.18€, 2004 - 108.46€	2002 - 84.2€, 2003 - 82.4€

Source: ECN (2005b)

5.2.3.3 Tax refund and tax exemption

Tax refund exemption belongs to a very popular instrument of renewable energies support. This instrument usually applies to more than one renewable technology. However, in Austria, Denmark, Hungary and Malta only one technology is covered by this measure. Seven EU Member States established VAT rate reduction (of a few percent) which covers solar energy only (Hungary, Italy and Malta), several technologies (Slovakia) or all types of renewable energies (Portugal).

Exemptions from income tax were introduced in France, Italy and Slovakia. These exemptions refer to specific investments, such as investments in overseas territories of France or solar projects in the building sector in Italy. In Slovakia biogas, hydropower, solar and wind installations are covered by this type of instrument.

Table 5.9 Tax exemptions and refunds for RES in the EU Member States

Member States	Technology concerned	Tax refund/exemption
Austria	Biomass	Reduced rate of 10% VAT
Denmark	Wind (onshore)	Deduction from taxable profits of between 60 – 100%
Estonia	Hydro, Wind	Exemption from value added tax (this has to be abolished in 2007 due to joining the EU in 2004)
Spain	Biomass, Small hydro, Solar PV, Solar thermal, Wind	Reduced interest rates
Finland	Small hydro, Wind power, Wood and wood based fuel	Tax refund at the end of the year of between 0.42 and 0.69 ct/kWh. RES are exempt from the carbon-based scheme.
France	Renewable electricity investments in overseas territories	Unlimited income tax exemptions
Greece	Purchase of installations and installation of renewable systems and gas systems	75% deduction and tax exemptions for individuals, for private companies up to 100%
Hungary	Solar collectors	Decreasing of the VAT rate from 25% to 12%
Italy	Heat supplied by the district heating systems fuelled by biomass to buildings locate din a very severe climatic conditions	Tax break of 1.03ct/kWh
	Solar thermal	Reduced VAT rate - 10% for systems exploiting solar energy for the heat supply
	Solar thermal projects in the building sector	36% of personal income tax
Luxembourg	All RES, Investments in certain RES-E technologies	60% deduction from taxable profits, 4.5% interest rate reduction
The Netherlands	Investments in RES-E	May be deduced from taxable profit
Portugal	All RES-E	Reduced interest rates and reduced VAT rates
Sweden	All RES-E	Exemption from CO2 tax
Slovak Republic	Biogas generating equipment, Heat pumps, Small-scale hydro with installed capacity up to 1MW and up to six years of operation, Solar equipment, Wind power plants, Operation of equipment for the production of biodegradable substances for which the duration of decomposition is less than half of that for comparable substances, Geothermal equipment and combined heat and power production equipment with installed capacity of up to 10 MW	Exemption from income tax for natural and legal persons in case of operation of such an installationIt is proposed to increase the range of hydropower up to 10 MW
	All RES equipment	Proposed VAT reduction from 14% to 10%
Malta	Import of solar systems	Reduction of the rate of VAT from 15% to 5%

Source: ECN et al. (2005), Reiche (2002a), Reiche (2002b)

5.2.3.4 Investment support

Investment support in the field of renewable energies is widespread in many of the EU Member States (17). It usually applies to more than one technology and especially to technologies that need substantial support, such as solar energy. The subsidies range from 10 to 100% of investment costs.

Table 5.10 Investment support for RES in EU-15

Member States	Technology concerned	Range of investment support
Austria	Biomass, Geothermal, Solar PV, Solar thermal, Wind	Subsidies up to 30% of total investment costs
	Small hydro	Maximum support is 25% of total investment costs
Belgium	Biomass, Small hydro, Solar PV,	Flanders – subsidies 15-50% of total investment costs
	Biomass, Small hydro, Wind	Waloon – subsidies of 15% of total investment costs
	Solar PV	National level - subsidies of 25% of total investment costs
Germany	Biomass, Small hydro, Solar thermal, Solar PV, Wind	The 2000 million DM programme and the Nutzung erneuerbare Energiequellen programme grant total amountsThe 250-MW-Wind Programme provides subsidies up to 25% but not more than 46016 € plus operatin subsidies up to 3.1 ct/kWh fed into the public gridUnder the Nachwachsende Rohstoffe program, a subsidy of up to 50 % (60% in the East) of investment costs for demonstration projects in the agricultural non-food sector is granted.The BMU-Programm zur Förderung von Demonstrationsvorha provides loans up to 70% of the investment costs of RES-E demonstration projects at a currency of 30 years. For the first 10 years, the interest rate is 4.9% (1998), after that it will be dependent of capital market conditions.
Denmark	Biomass, Solar PV, Wind	Investment subsidies of 15-30% for standardised RE equipment, up to 50% for development projects
	Tidal electricity	Subsidies of 30-100% of total investment costs
Spain	Solar thermal, Solar PV	Investment subsidy coveringa maximum 50% of total investment. Investment subsidy 263-553 cents €/WP. In both cases, funds are made available on a year-by-year basis.
Finland	Biomass, Small hydro, Solar PV, Wind	Subsidies of 30-40% of total investment costs
France	Biomass, Solar PV, Wind	Subsidies up to 70% of total investment costs
	Wood-fired biomass plants	Subsidies up to 30% of total investment costs
Greece	Biomass, Geothermal, Small hydro, Solar thermal, Solar PV, Wind	The New Operational Programme for Energy (and Development Laws 1892/90substituted by Law 2601/98) provided investment subsidies of between 38-57%
Luxembourg	Biomass, Geothermal, Small hydro, Solar thermal, Solar PV, Wind	Under a set of regulations (Skeleton Law 27.7.93, Grand-ducal Regulation 5.8.93, Ministerial reglementation 6.12.94 and PEEC Programme 11.8.1996) investment subsidies covering 25% of total investment costs (in some instancesthe support can be raised by 5% in case the investment takes place in a defined geographical area).
The Netherlands	All RES	Investments in RES-E may be deduced from taxable profit. The rate from 1997 to 2001 varied from 40% to 52% of the total investment (with a maximum ofapproximately 22.5 M€). Nowadays, 55% of the investment can be written off(deducted from taxable profit) in the first fiscal year, with a maximum of 99 M€ per project (EIA - Energie Investerings Aftrek). Until 2002, an accelerated depreciation of investment (VAMIL) was also aimed at RES-E promotion (except Waste). A 35% deduction applies to investments in RES-E and it is deducted from taxable profits.
Portugal	no information provided	Several programmes and regulations envisage investment subsidies of between 30% and 60% of total investment costs to RES-E (MAPE-POE: Portaria nº 383/2002;198/2001;1219/2001, ENERGIA (Ministry of Economy) DN - 11- E/95 and SIURE (Incentives System for the Rational Use of Energy)). In some cases 50% of the subsidy is a refundable loan (3 to 4 years cadence). The other 50% is given as a non-refundable subsidy. Total investment costs must be larger than 50.000 € (at least for small hydro, wind and geothermal).
Sweden	Small hydro, Wind	Investment subsidies of between 15% and 25% of total investment.
	Biomass-fired boilers (individual housing)	Subsidy from 440€ to 300000€
The United Kingdom	Biomass, Wind offshore	Several investment subsidies, such as the New Opportunities Fund,giving 40% subsidy.

Source: ECN et al. (2005), Reiche (2002a), Reiche (2002b)

Table 5.11 Investment support for RES in new EU Member States

Member States	Technology concerned	Range of investment support
Cyprus	Substitution of conventional fuels with renewables in industry, agriculture, hotels	Subsidy up to 30% of total investment costs (max 52000€)
Czech Republic	Different projects, Biomass, Solar collectors	State subsidies up to 15-30% of the total investment costsSubsidy from State Environmental Fund of up to 60% of the total investment costsVarious subsidies to small RES projects
	Tidal electricity	Subsidies of 30-100% of total investment costs
Estonia	no information provided	Investment subsidy system in preparation
Finland	Biomass, Small hydro, Solar PV, Wind	subsidies of 30-40% of total investment costs
Hungary	no information provided	Investment subsidies from preferential credits of up to 30% of whole investment.
Poland	All RES	Preferential loans
Slovenia	Biomass installations, Solar-heating installations	Subsidies up to 50% of total investment value
	Biomass-fired boilers (individual housing)	Subsidy from 440€ to 300000€

Source: ECN et al. (2005), Reiche (2002a), Reiche (2002b)

5.2.4 Reduction effects by policies and measures

Although most of the Member States report policies and measures in the field of renewable energy supply, there are few EU Member States which provide estimates on the corresponding reduction effects in CO_2 eq. (Table 5.3). In order to evaluate quantitatively the reduction effects indicated by the Member States in their third National Communications, emission reductions which are related to the targets of the Directive 2001/77/EC are assessed. The latter can be identified based on the assumption that every additional kWh produced by renewable energies will displace a kWh produced by fossil and nuclear energies, thus saving emissions corresponding to the average CO_2 emission per kWh of the fossil and nuclear energy supply in the individual Member States.

Table 5.12 Assessment of realised and expected emission reduction effects by the Directive 2001/77/EC

	Gross Electricity Consumption (GEC)			Generation from RES			Share of RES in GEC		
	1997	2002	2010	1997	2002	2010	1997	2002	2010
	- TWh -						- % -		
Austria	54,5	58,8	70,2	38,2	40,9	54,8	70,0	69,6	78,1
Belgium	78,3	82,6	98,4	0,9	1,1	5,9	1,1	1,3	6,0
Denmark	34,6	35,1	40,0	3,0	7,2	11,6	8,7	20,4	29,0
Finland	73,8	83,9	92,8	18,2	19,1	29,2	24,7	22,8	31,5
France	416,2	448,9	568,1	62,4	65,5	119,3	15,0	14,6	21,0
Germany	510,4	536,2	616,8	23,0	44,0	77,1	4,5	8,2	12,5
Greece	42,5	50,9	75,8	3,7	3,6	15,2	8,6	7,1	20,1
Ireland	18,8	23,3	33,1	0,7	1,4	4,4	3,6	5,9	13,2
Italy	277,5	310,0	353,0	44,4	47,7	88,2	16,0	15,4	25,0
Luxembourg	6,4	6,1	8,4	0,1	0,2	0,5	2,1	3,0	5,7
Netherlands	95,7	108,8	134,1	3,4	3,7	12,1	3,5	3,4	9,0
Portugal	35,8	45,3	57,8	13,8	9,8	22,5	38,5	21,7	39,0
Spain	179,2	214,8	304,6	35,7	39,5	89,6	19,9	18,4	29,4
Sweden	140,5	148,7	159,5	69,0	72,6	95,7	49,1	48,8	60,0
United Kingdom	345,7	366,4	452,6	5,9	11,0	45,3	1,7	3,0	10,0
Cyprus	3,0	3,6	4,2	0,0		0,1	0,1		0,1
Czech Republic	56,5	58,2	72,4	2,1	3,0	5,8	3,8	5,2	5,8
Estonia	6,8	6,8	9,5	0,0	0,0	0,5	0,2	0,1	0,5
Hungary	36,0	37,2	48,7	0,3	0,3	1,8	0,7	0,7	1,8
Latvia	5,9	6,3	8,5	2,5	2,5	4,2	42,4	39,8	4,2
Lithuania	9,3	8,5	11,1	0,3	0,4	0,8	3,3	4,2	0,8
Poland	124,6	120,9	170,3	2,0	2,9	12,8	1,6	2,4	12,8
Slovakia	25,0	25,7	37,0	4,5	5,4	11,5	17,9	21,1	11,5
Slovenia	11,1	13,2	15,6	3,3	3,6	5,2	29,9	27,6	5,2
Sources	*4*	*3*	*3*	*1, 4, 5*	*3*	*1, 2, 5*	*1, 5*	*3*	*1, 5*

	Average carbon intensity (without RES)			Emission reduction effect		
	1997-2002	2002-2010	1997-2010	1997-2002	2002-2010	1997-2010
	- t CO_2/GWh -			- Mt CO_2 -		
Austria	689,4	578,0	685,5	1,6	9,5	11,5
Belgium	283,4	276,5	283,7	0,1	1,4	1,4
Denmark	771,2	724,3	820,7	3,0	3,7	6,6
Finland	437,0	411,2	431,9	0,4	4,4	4,8
France	60,0	57,7	59,9	0,2	3,2	3,4
Germany	571,7	557,8	582,7	11,7	19,3	30,9
Greece	971,0	898,5	963,7	0,0	11,2	11,3
Ireland	724,1	694,6	732,5	0,5	2,2	2,7
Italy	613,1	576,3	611,0	1,9	24,7	26,9
Luxembourg						
Netherlands	567,2	550,3	566,9	0,2	4,7	4,9
Portugal	676,5	601,4	604,2	-2,4	7,7	5,9
Spain	449,5	417,3	445,6	1,6	22,3	24,2
Sweden	90,0	79,0	89,8	0,3	2,1	2,4
United Kingdom	455,0	437,8	457,9	2,2	15,7	17,9
Cyprus	787,3	775,3	787,1	0,0	0,1	0,1
Czech Republic	819,9	807,5	825,8	0,7	2,3	3,0
Estonia	1.292,3	1.259,2	1.291,7	0,0	0,6	0,6
Hungary	609,1	600,0	609,1	0,0	0,9	0,9
Latvia	1.040,2	952,9	1.019,2	0,0	1,7	1,8
Lithuania	286,6	282,3	287,9	0,0	0,1	0,1
Poland	1.116,2	1.086,2	1.120,7	1,0	11,1	12,0
Slovakia	405,9	378,2	413,4	0,4	2,5	2,8
Slovenia	572,0	547,7	563,2	0,2	0,9	1,1
Sources	*6, 7*	*6, 7*	*6, 7*	*7*	*7*	*7*

1) Directive 2001/77/EC, 2) EC (2003), 3) ECN (2004), 4) Eurostat (2004), 5) Reiche (2002a), 6) WRI (2005), 7) own calculations

Source: Eurostat (2004), ECN (2004), EC (2003), Reiche (2002a), WRI (2005)

The Gross Electricity Consumption, the Electricity Supply by Renewable Energies and the related share of Electricity Supply by Renewable Energies at Gross Electricity Consumptions for all EU Member States for the years 1997 (EU-15), 1999 (new Member States), 2002 (EU-25) and the projections for 2010 (EU-25) are compiled on the basis of diverse data sources (Eurostat (2004), ECN (2004), EC (2003)) (Table 5.12). Then the absolute amounts of electricity produced by RES in the base years, in 2002 and the projected amount for 2010 are determined.

In order to quantify the emission reduction, the carbon intensities of the fossil and nuclear energy supply in the individual Member States are taken into account. WRI (2005) provides carbon intensities of the total energy supply in 2001, which was adjusted to fossil and nuclear energy supply by taking into account the share of renewable energy supply in 1997, 1999, 2002 and 2010. Different average carbon intensities are identified for the periods 1997/99- 2002, 2002-2010 and 1997/99 – 2010. Based on these data the reduction effect of the target according to Directive 2001/77/EC in 2010 compared to 1997 (EU-15) and to 1999 (new EU Member States) could be determined (Table 5.12).

In Table 5.13 the quantified emission reduction effects by policies and measures reported in the third National Communications are related to the reduction effects by the Directive 2001/77/EC. It becomes obvious that policies and measures with quantified emission reductions reported in the third National Communications by Austria, Spain and the United Kingdom contribute only to a small degree (<10%) to the total reduction effect of the target by the EU Directive. However, in Spain and the United Kingdom emission reduction effects are not indicated for all policies and measures reported.

Moreover, in other Member States (Germany, France and Slovenia) the expected reduction effects by policies and measures reported in the third National Communications by far exceed the reduction effect of the target by the Directive. At least in Germany and France this can possibly be explained by the fact that some of the policies and measures reported in the third National Communications arose before 1997. Nevertheless, it can be assumed that the emission reduction effects reported in the National Communications can only be attained in these Member States if the targets of the Directive will also be achieved: the reduction effects reported in the third National Communications are rather ambitious.

Table 5.13 *Assessment of quantified emission reduction effects of policies and measures reported in the third National Communications*

	N° of measures with quantified emission reduction effects (total N° of measures reported)	Starting year of measures with quantified emission reduction effect	Reduction effect 2010 [Gg CO_2]	Reduction effect (EU Target) in 2010 compared to 1997 [Mt CO_2]	Reduction effect (EU Target) in 2010 compared to 1999 [Mt CO_2]	Share of quantified emission reduction effect at EU target [%]
	National Communications			Own Calculations		
Austria	4 (4)	1997, 1999, 2003, n.a.	0,7	11,5		6
Belgium			n.q.	1,4		
Czech Republic			n.q.		3,0	
Denmark	1 (4)	1986	3,4	6,6		52
Estonia			n.q.		0,6	
Finland	1 (3)	1999	4,5	4,8		94
France	4 (8)	1994, 1996, 2000, n.a.	4,5	3,4		130
Germany	2 (4)	1993, n.a.	50,0	30,9		162
Greece	2 (2)	1993, n.a.	2,2	11,3		20
Ireland	1 (2)	1999	1,0	2,7		37
Italy	3 (4)	2000, n.a., n.a.	12,6	26,9		47
Latvia			n.q.		1,8	
Netherlands	1 (1)	n.a.	2,5	4,9		50
Portugal			n.q.	5,9		
Slovakia	1 (1)	n.a.	2,5		2,8	88
Slovenia	3 (4)	n.a.	2,3		1,1	206
Spain	1 (11)	n.a.	1,9	24,2		8
Sweden			n.q.	2,4		
United Kingdom	1 (2)	n.a.	1,5	17,9		8
n.a.: not available, n.q.: not quantified						

Source: *Third National Communications under the UNFCCC, EU Member States, own calculations based on ECN (2004), WRI (2005), EC (2003), Eurostat (2004), Directive 2001/77/EC*

The Member States which are not on track to reach their target under the Directive 2001/77/EC according to EC (2004) (Table 5.2), Greece and Portugal, do not report ambitious policies and measures in their third National Communication. The two measures reported in the Greek third National Communications amount to only 20% of the emission reduction target by the Directive, although one of the measures already started in 1993 and already took effect before the base year of the Directive. Portugal, however, reported only the target of the EU Directive as policy in the third National Communication, the way the target will be achieved is not addressed.

5.2.5 Conclusions

All Member States initiated direct or indirect instruments as polices and measures in order to fulfil the target of Directive 2001/77/EC, the most essential common and coordinated policies in regard to RES support that imposes the obligation to increase the share of renewable energy sources in energy production in the European Union. However, analysis of the progress reports reveals that policies and measures currently in place are insufficient to achieve the overall EU target, it is expected that a share of only

18-19% in 2010 is obtained instead of the targeted 22%. One of the reasons for this discrepancy appears to be that a number of Member States have not yet introduced effectual policies in line with their adopted targets. According to the Progress Report by the Commission (EC 2004), only four Member States are currently on track to meet the target: Denmark, Germany, Spain and Finland. While the United Kingdom, the Netherlands, Ireland, Belgium, France, Sweden and Austria are more or less on track, the European Commission comes to the conclusion that in Greece and Portugal, considerable efforts are still needed to reach the target.

Almost all Member States report policies and measures in their third National Communication with regard to renewable energies. However, the number of introduced polices and measures as well as their effectiveness varies considerably. In Germany, Slovenia and France policies and measures with quantified emission reduction effects reported in the third National Communication assumed to have larger reduction effects than expected by targets of the Directive 2001/77/EC. The assessment by EC (2004) that Greece and Portugal are not on track to achieving their target under the Directive 2001/77/EC is somewhat confirmed by the reporting in the third National Communication: concrete policies and measures are not mentioned (Portugal) or the measures reported are not expected to have comparable emission reduction effect as the target under the Directive should show (Greece).

As far as the types of instruments are concerned, feed-in tariffs are still the most common one. However, currently some Member States tend to give it up and introduce the quota systems which are regarded to be a better measure. Simultaneously, fiscal measures, such as tax refund, exemption and investment support (subsidies, loans) exist as a very common tool in many countries, both in EU-15 and in the new Member States.

Among the Member States which, according to the Directive 2001/77/EC, are obliged to increase the use of renewable energies most significantly are: Denmark (+20%), Greece (+11.5%), Sweden (+10.9%) and Ireland (+9.6%), Spain (+9.5%). However – of these Member States – only Denmark and Spain are currently on path to meet the target. Taking into account the number of polices and measures undertaken, they are not among the countries with the largest number of instruments introduced. In conclusion, it can be stated that the effectiveness of instruments is much more important than their quantity.

Due to the lack of appropriate data (progress report or detailed description of policies and measures in the third National Communication), it is difficult to estimate the progress of new Member States in this field. The progress reports should be submitted in 2006. However, the data on renewable energy use for the years 2001-2002 are usually accessible. Among the new Member States which have to increase the use of RES to the most considerable extent is, first of all, Slovakia (+13.1%), followed by Latvia (+6.9%) and Poland (+5.9%). It is difficult to estimate whether they are likely to meet their targets. Due to fluctuation in every year, it is difficult to state on the basis of accessible data in what direction the trend is moving.

5.3 Combined heat and power energy supply

Combined Heat and Power (CHP) (also called cogeneration) is the simultaneous generation of usable heat and power in a single process. The most important advantage of such energy production is the efficiency. Conventional power generation has an efficiency of only 35%to 45%; up to 65% of the energy potential is released as waste heat. CHP makes use of some of this heat. The combined efficiency of heat and electricity generation from CHP schemes is typically 80 to 90% and 80% for heat-only boilers. Additional benefits can be realised if the CHP scheme uses low emission fuels including natural gas or renewables as opposed to coal or oil (EEA 2001).

The savings from cogeneration are optimised by achieving the highest electrical efficiency, whilst at the same time meeting the heat demands of the host heat consumers from the available heat generated in the process (COGEN 2001). The heat produced by CHP plants is used by industry, commerce and household sector.

As far as the environmental issues are concerned, one of the most important benefits of the use of cogeneration is lower CO_2 emission to the atmosphere than if heat and power are generated separately. It is believed that the savings in carbon dioxide vary from 100kg /MWh to more than 1000kg/MWh (EDUCOGEN 2001).

As cogeneration can deliver significant reductions in GHG emissions, it is one of the most important technologies available for Europe to achieve its Kyoto targets: “Promotion of high-efficiency cogeneration based on a useful heat demand is a Community priority given the potential benefits of cogeneration with regard to saving primary energy, avoiding network losses and reducing emissions, in particular of greenhouse gases” (Preamble of the Directive 2004/8/EC).

5.3.1 CHP Policy in the EU

In 1997 the European Commission developed a Communication on the promotion of cogeneration in which it calls for doubling of cogeneration production from 9% to 18% of European energy production by 2010 (COM(97)514 final). This target is indicative and not binding. Projections show that meeting this target is expected to lead to avoided CO_2 emissions of over 65 Mt CO_2/year by 2010.

In terms of installed capacity, the share of electricity produced by cogeneration processes rose to 10% in the EU in 2001. Large differences however are to be noted amongst the Member States with variations of the shares between 2% and 60% of the electricity production.

In 2004 a new Directive on CHP (Directive 2004/8/EC) entered into force. The Directive 2004/8/EC aims at providing a framework for the promotion of CHP in order to overcome existing barriers, to advance its penetration in the liberalised energy market and to help mobilising unused potentials. As the indicative target value from the 1997 strategy is out-dated, the Directive does not include targets. Instead the Directive urges Member States to carry out analyses of their potential for high efficiency cogeneration. It defines such terms as CHP product (electricity, heat fuel) and high efficiency cogeneration (as cogeneration providing at least 10% energy savings compared to separate production). It also obliges the Member States to enable certification of high-efficiency CHP, to analyse their potential for high-efficiency CHP and to outline a strategy to realise this potential. This Directive must be transposed into national laws by 21st of February 2006. The need for development of CHP sector also results from the Directive 2001/77/EC, Directive 2003/87/EC and the Directive 2002/91/EC.

The national energy and environmental policy and the legislative framework concerning CHP sector are mainly driven by EU directives, especially in the new Member States. Recent EU incentives are beneficial to the industry but national implementation varies from country to country (Euroheat and Power 2005).

5.3.2 Current Situation in CHP sector in the EU Member States

The current situation in the CHP sector in the EU Member States is much more difficult to assess than in the field of renewable energies and waste management as the indicative target of the EU Directive is not further disaggregated for each Member State, a progress report on the development of CHP has not been elaborated and complete and actual data on electricity and steam production in CHP in EU-25 is rarely available. Table 5.14 and Table 5.15 provide an overview of the share of electricity and steam production in CHP in EU-15 and EU-9 based on EC (2003).

Table 5.14 Percentage of electricity and steam production in CHP in EU-15

	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Luxembourg	Netherlands	Portugal	Spain	Sweden	United Kingdom	EU-15
									%							
Electricity in CHP																
1995 (EC 2003)	21.4	3.7	69.0	33.5	1.8	9.0	2.1	1.5	13.4	10.2	36.3	9.0	5.9	5.4	3.6	15.1
2002 (EC 2003)	22.9	5.8	58.2	35.3	2.8	9.8	2.7	1.5	14.9	34.8	43.9	9.2	9.3	8.3	7.7	17.8
2010 (EC 2003)	27.1	8.1	52.8	34.4	5.3	11.8	3.4	2.5	14.7	10.2	31.7	14.1	13.0	13.3	10.2	16.8
Steam in CHP																
1995 (EC 2003)	58.8	36.7	57.3	62.5	28.8	58.0	21.4	11.9	69.2	67.5	70.0	64.0	42.8	21.3	43.2	47.6
2002 (EC 2003)	57.8	45.9	67.9	56.0	26.3	65.5	27.5	23.4	69.9	63.2	76.5	64.8	49.9	22.4	64.3	52.1
2010 (EC 2003)	60.0	48.8	71.8	52.2	33.3	71.0	35.5	32.7	72.8	67.5	78.7	61.7	61.5	21.9	66.2	55.7

Source: EC (2003), Euroheat and Power (2005), COGEN (2005)

Table 5.15 Percentage of electricity and steam production in CHP in the new Member States and in average in EU-25

	Cyprus	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Poland	Slovakia	Slovenia	EU-9	EU-25
						%					%
Electricity in CHP											
1995 (EC 2003)	0.0	35.2	52.8	10.0	25.5	3.8	36.5	10.4	6.3	22.6	17.7
2002 (EC 2003)	0.3	34.9	88.3	17.0	29.5	24.9	34.6	10.5	8.8	31.1	22.4
2010 (EC 2003)	1.2	30.3	52.8	24.4	33.3	59.3	30.9	11.4	13.9	32.2	22.2
Steam in CHP											
1995 (EC 2003)	0.0	63.0	34.3	54.7	29.4	35.1	47.8	85.9	50.7	50.1	48.5
2002 (EC 2003)	6.0	63.6	39.0	75.2	23.3	40.6	54.3	12.3	52.8	45.9	49.9
2010 (EC 2003)	19.2	66.1	52.7	84.7	20.9	49.0	66.6	26.2	52.8	54.8	55.4

Source: EC (2003), Euroheat and Power (2005), COGEN (2005)

CHP electricity production is well represented and widespread in the Netherlands, Finland, Luxembourg, Austria and in Denmark, the latter having the by far highest share in the EU, although the Danish share shows a continuous decreasing trend between 1995 and 2010. France, Greece and Ireland have, in contrast, the lowest shares of CHP electricity production in the EU. Sweden, the United Kingdom, Spain, Portugal, Italy, Belgium and Germany are also well under the EU-15 average regarding the share of CHP electricity production.

In the heat production, according to EC (2003), Finland, the Netherlands and Italy have been the European cogeneration leaders in 1995; in 2002 and projected for 2010 the highest shares were and are expected in the Netherlands, Denmark and Italy, followed by Germany and Luxembourg. In contrast, steam production in CHP is not widespread in France, Greece, Ireland and Sweden.

According to EC (2003), the shares of electricity produced in CHP in the new Member States are higher than in EU-15 in all three years considered. Electricity from CHP is well established in the Czech Republic, Poland and in Estonia. In the new Member States the highest share of CHP in steam production is registered in Hungary, the Czech Republic, Poland and Slovenia, cogeneration in form of district heating is widespread. In 1990 the share in steam produced in CHP was higher in the new Member States than in EU-15, in 2002 it is vice versa.

Obstacles of the development of CHP

The development of CHP faces different obstacles in the EU Member States. The most important ones are described in the following (Euroheat and Power 2005, DGFER 2004, WADE 2005, EEA 2001).

Lack of special law regulation concerning CHP only: Such situation can be noticed in many Member States, both EU-15 and EU-10. Only Austria and Germany developed a special act on cogeneration and in a few other countries (Denmark, Estonia, Lithuania) exist a law concerning district heating.

Climatic conditions leading to a low heat demand: Southern EU Member States (especially Greece)

Bureaucracy

France is one of several Member States (also in Greece, Italy and Portugal) where lengthy bureaucratic procedures to put a CHP plant into operation are disincentive to investors. The process in France requires a conformity certificate, a declaration of compliance with environmental requirements, a permit to build and a grid connection.

Monopolistic electricity utilities/unfavourable conditions for decentralised structures

This obstacle is apparent in Greece, Germany and the United Kingdom. In Germany, the major generating companies have been consolidated and continue to hold considerable power, discouraging growth in cogeneration, in the United Kingdom little incentive for distribution companies to encourage the uptake of decentralised energy is given. Further liberalisation of the energy markets should remove this barrier as it increases decentralised generation through greater access to electricity supply grids. Removing monopoly control will also increase the uptake of auto-production in industrial sectors.

Generation overcapacity in energy sector
This obstacle occurs in Slovakia, Latvia and France. In the latter Member State, nuclear power remains dominant in electricity production.

High gas prices and/or low energy prices
France, Poland, United Kingdom, Germany (low wholesale electricity prices over the last few years). Liberalisation tends to lead to lower fuel and thus electricity prices, counteracting the development of CHP which is relatively capital intensive.

Poor long term confidence in the market for investors and insufficient incentives for small CHP schemes
France, United Kingdom

5.3.3 Assessment of polices and measures in the EU Member States

Cogeneration should be encouraged and supported as clean technology as it saves primary energy sources and reduces emissions to the atmosphere in comparison with separate heat and power generation. Some Member States (Austria, for example) have established support for CHP development before the Directive 2004/8/EC entered in to force. For other Member States, the EU Directive was a main driver for supporting CHP. Possible instruments to support CHP comprehend inter alia regulatory instruments like the purchasing obligation, economic or fiscal instruments like tariff support, discounts or tax exceptions, capital incentives, investment aid or grants, direct price support schemes, informative instruments which can be combined with economic instruments like green certificates, political targets or Research and Development programmes (R&D). Starting the analysis, the policies and measures in regard to cogeneration reported in the third National Communications and the GHG Monitoring Decision (280/2004/EC) with the expected reduction effects are presented (Table 5.3, p. 176).

Table 5.16 provides an overview of the different types of measures undertaken in the individual Member States.

Table 5.16 Number and policy types of measures in CHP sector in the EU Member States

Member State	Total	Policy Type								
		economic	education	fiscal	information	planning	regulatory	research	voluntary/ negotiated agreement	other/ category not identifiable
Austria	**5**	2		1			1			1
Belgium	**9**	5		1	1		2			
Czech Republic	**3**						2			1
Denmark	**2**	2								
France	**3**	1		1						1
Germany	**5**	1			1		1	1	1	
Greece	**4**	2					1			1
Hungary	**1**									1
Ireland	**5**	1				1	2			1
Italy	**3**				1		1			
Latvia	**2**	2								
Poland	**8**	1	1		1	1	1	1		2
Portugal	**2**	1								1
Slovenia	**2**	1					1			
Slovakia	**2**									2
Spain	**2**	1					1			
The Netherlands	**1**			1						
UK	**3**			3						
Total	**61**	**20**	**1**	**7**	**4**	**2**	**13**	**2**	**1**	**11**

Source: Third National Communications under UNFCCC, EU Member States

In the following, policies and measures undertaken by the Member States are categorised and analysed in more detail based on other data sources. Table 5.17 provides detailed information by Euroheat and Power (2005) about measures taken by the EU Member States.

Table 5.17 CHP support mechanisms in the EU Member States

Member States	Purchasing obligation	Tariff support	Discounts/tax exemptions	Capital incentives	Targets	Other/Comments
Austria	x	x				Feed in tariff is linked to CHP electricity (4 €/MWh)
Czech Republic	x	x				Electricity price including a bonus for decentralised systems
Germany	x	x	x			Bonus for CHP electricity depending on the technology and size until 2010
Denmark	x	x	x	x		Fixed prices for the back pressure CHP in district heating with voluntary CHP coproduction
Estonia		x				Guaranteed price level in 7 years
Finland			x	x		Energy taxation funds and subsidies for RES CHP
France	x	x				
Hungary	x					Purchasing obligation and guaranteed price for capacities below 50 MW
Italy	x					Support for RES
Lithuania						One third of the district heating investments is dedicated to CHP
Latvia	x	x				Feed in tariff for units below 4 MW, using local fuels
The Netherlands			x			Operational support
Poland	x					Purchasing obligation for CHP electricity and for renewables (both electricity and heat)
Sweden			x	x		Support to CHP based on NG and biomass
Slovak Republic	x					Purchasing obligation for CHP electricity and renewables
The United Kingdom				x	x	Government CHP target: 10 GW by 2010

Source: Euroheat and Power (2005)

The supporting schemes in the individual Member States are designed very differently. There are Member States with special laws on the CHP sector (Austria, Germany). Usually the Member States passed several laws in the energy sector. However, in Poland

and Slovakia only one law covers all energy issues. In the following, some characteristics of the schemes in individual Member States are outlined (Euroheat and Power 2005).

In Austria, the CHP support scheme focuses on CHP electricity production. Support is calculated for each CHP plant based on the difference between CHP costs and revenues compared to condensing electricity. The plant must meet efficiency criteria in order to be eligible to be supported. However, the support schemes do not consider the heat produced in CHP plants. In Hungary, benefits for heat from CHP will be considered in the price setting mechanism. In Latvia, the CHP plants entitled to the surplus electricity price must register fuel efficiency higher than 80%. Additionally, to receive the electricity surplus the plant must supply at least 75% of thermal energy produced to a district heating (DH) system. In the Netherlands, the CHP heat support is based on saved CO_2 emissions and certificates are issued for electricity generated in CHP-units. Subsidies for CHP generated electricity are then paid to electricity producers (CHP-owners) based on these certificates. In Poland the CHP support scheme consider both electricity and heat production. It also foresees purchasing obligation for CHP electricity and a bonus for high efficiency units as well as priority for the heat produced.

The United Kingdom commits to a national quantified target of achieving at least 10 GW of good quality CHP by 2010.

5.3.3.1 Purchasing obligation

Purchasing obligation is a common instrument to support CHP in the EU. In several Member States (Austria, the Czech Republic, Germany, Denmark, France, Hungary, Italy, Latvia, Poland and the Slovak Republic) they have been introduced in the past. In Denmark, for example, a special feed-in regulation gives priority and ensures fixed prices for the back-pressure CHP in district heating and industry and for all forms of renewable energies and spreads the costs evenly among electricity consumers. The feed-in scheme for electricity from CHP is based on renewable fuels, which has also ensured the expansion of the use of such fuels (Euroheat and Power 2005).

In France, a regulatory framework set up in the 1990s supported the development of CHP. The French Government imposed a buying obligation for electricity from CHP plants. The selling contract was for 12 years, the price was based on “avoided costs” of a gas combined cycle and applied to CHP plants with the installed capacity between 215 kWe and 100 MWe. Global efficiency of the installation had to be over 65% and the heat over electricity ratio had to reach a minimum of 50%. Since 2000, due to the phase out of the supporting scheme, very little CHP has been installed. A new support mechanism (contracts for 12 years for plants under 12 MWe) was introduced in 2000. However, its progress is occurring very slowly (Cogen 2005).

In the Czech Republic, the CHP electricity purchasing obligation for a stated price including a bonus for decentralisation and evaluation of the possibility- economic and technical availability – to install units for capacities over 5 MWth heat and 10 MWe electricity together with the requests derived from the Directive on the performance of buildings ensure the legal framework for CHP electricity purchase (Euroheat and Power 2005).

In Poland, cogenerated electricity benefits from a purchase obligation, provided it is generated in a 70% efficient process. Electricity distributors are required to sell a minimum share of cogenerated electricity to their end customers. This share of total electricity is set at 12.4% for 2005 and will increase to 16% in 2010. The electricity and heat tariffs have to be approved by the Energy Regulatory Authority (Cogen 2005).

5.3.3.2 Tariff support

Tariff support is another commonly used instrument for CHP support. It functions in Member States as Austria, the Czech Republic, Denmark, Estonia, France, Germany, Hungary, Latvia and Slovenia. Some more details of selected schemes are presented below.

In Austria, the feed-in tariff is not linked to cogeneration process as such, but only to CHP electricity. Therefore the CHP operators concentrate on electricity production whereas high potential for heat are lost. Starting from 2005, the subsidies are calculated for each CHP plant, which must meet efficiency criteria to achieve a subsidy (in 2004 4 €/MWh). Industrial auto-production and private CHP (hotels, residential buildings, etc.) do not receive the subsidy (Euroheat and Power 2005).

In Latvia, a feed-in tariff for plants below 4 MWe was introduced. To benefit from this feed-in tariff, CHP units have to reach an efficiency of 80% and to sell 75% of their thermal energy production to the district heating systems. Additionally there are premiums for CHP plants using renewables. Plants of more than 4 MWe receive special tariffs, too.

In Slovenia, feed-in tariffs are guaranteed for 10 years but decrease by 5% after 5 years and by 10% after 10 years. While a biogas CHP plant will receive 20.8 EURc/kWh, electricity from a district heating system rated above 1 MWe will receive 7.8 EURc/kWh, but the price for cogenerated electricity from an industrial plant rated above 1 MWe is 5.4 EURc/kWh. Currently, the CHP industry is actively engaging with the government to set up a support scheme for medium and large CHP plants, too (COGEN 2005).

5.3.3.3 Taxes and fiscal initiatives

Value Added Tax (VAT), energy taxes, excise taxes, carbon levy tax belong to the fiscal instruments that can be used to support the development of CHP sector. These support mechanisms exist especially in EU-15 Member States (Denmark, Finland, Germany, the Netherlands and Sweden). As this type of instrument implies the existence of relatively high GDP per capita, the new Member States are only starting the process of introducing this type of measure. In the new Member States, instruments such as purchasing obligation and tariff support dominate to date. The United Kingdom, the Czech

Republic, Estonia, Latvia and Lithuania use favourable VAT rates for district heating companies (Euroheat and Power 2005). Table 5.18 provides an overview of energy taxes related to the support of CHP in the EU Member States.

Table 5.18 Energy taxes concerning the support for CHP in the EU Member States

Member States	VAT level	Type of taxes
Austria	20%	Energy taxes are applied and used for CHP/DH support measures
Czech Republic	5% for DH will be kept until 2007, 22% for other energy sectors	Taxes on fuels used for heating will be introduced from 2007
Germany	16%	Fuel taxes and electricity taxes; exemption or reduction of taxes on certain fuels are used for CHP units
Denmark	25%	
Estonia	5% for DH, 18% for other energy sectors	Reduction on shale oil used for DH, exemption and afterwards taxation until 2013
Finland	22%	Energy taxes are used to promote DH
Hungary	15% for DH and natural gas, 25% for electricity	Energy and environmental taxes started to be introduced but it can be claimed back for CHP and DH, transitional period up to 2010 for taxation on electricity, natural gas and coal for DH
Italy	DH: 10% for residential and 20% for other customers	
Lithuania	DH: 5% for households (18% and 13% compensation), 18% for other energy sectors	Exemption for coal, coke lignite and natural gas until 2010
Latvia	Under decision	Excise tax on heavy fuel oil for DH but with transitional period up to 2010
The Netherlands	19%	Fuel taxes, environmental taxes, excise duties
Poland		Excise tax on oil and liquified gas for DH, transitional period for coal used for DH until 2010 and until 2014 for natural gas under certain conditions
Sweden	25%	Excise duties on fuels, energy taxes are applied and carbon taxes are applied and used for the promotion of CHP/DH
Slovak Republic	19%	Transitional period until 2010 for electricity and natural gas taxation

Source: Euroheat and Power (2005)

5.3.3.4 Green certificates

Green certificate schemes for CHP were introduced in Belgium (all three regions), Italy and Sweden. The Swedish scheme was introduced in May 2003 for electricity from renewable energy sources and biomass CHP. The green certificate scheme in the Walloon region (Belgium) is considered to be the most efficient one. The Walloon green certificate scheme ranks as one of the best support mechanisms for CHP in Europe. It is based on avoided CO_2 emissions, with one certificate being issued for 456 kg of CO_2 avoided. Certificates have been trading at EUR 92 for over a year and certificates are awarded for all electricity produced, including electricity that is consumed onsite: as a result, most of cogenerated electricity in Walloon is self-consumed. Because Walloon does not have a very large natural gas distribution network, biomass-CHP is developing fast, especially since CHP electricity from biomass is favoured under the green certificate scheme as it can receive up to two green certificates per MWh generated (COGEN 2005).

5.3.3.5 CHP in the EU emission trading scheme

The most common method chosen by the Member States was establishing a special new entrant reserve for CHP installations. CHP bonus was established in five Member States (Austria, Poland, the Czech Republic, Germany and Slovenia). Other Member States elaborated some special formulae for allocation of allowances to CHP installations. Only four Member States (Cyprus, Malta, Portugal and Estonia) did not develop special methods for allocation to CHP installations.

In the National Allocation Plans for the first trading period 2005-2007, the special treatment of CHP installations usually covers existing installations or new entrants and means granting a bonus or applying some special formulae of allocation for the first trading period. Some Member States (Germany, Greece, Ireland, Spain and the Walloon Region in Belgium) decided to apply special rules to both types of installations. The formula of allocation based on benchmark was introduced in many Member States (National Allocation Plans).

5.3.4 Progress achieved by polices and measures

In order to meet the CO_2 emission reduction targets under the Kyoto Protocol, the EU has set a target of doubling the share of cogeneration in total electricity generation from 9% (in 1994) to 18% (by 2010). Meeting this target is expected to lead to CO_2 savings of 127 Mt, which is the equivalent of 4% of total CO_2 emissions. However, it is predicted that this target may be difficult to achieve (COGEN 2001).

Cogeneration has the potential to supply 22% of generated electricity in the EU by 2020. It is foreseen that cogeneration capacity will have almost trebled from 70 GWe to 190 GWe by the year 2020. This growth will be shared between industrial (to 2010) and domestic micro cogeneration (after 2010). Cogeneration in Central and Eastern Europe has the potential to increase by 50% by 2010 (22 GWe to 38 GWe) (COGEN 2001). In the following (Table 5.19), the past development and the potential and prospects of the

CHP sector for 2010 in the individual EU Member States are outlined. What investments were undertaken and which economic and political influencing factors are prevailing will, for example, be illustrated. The progress and prospects as a whole are evaluated qualitatively.

Table 5.19 Progress and potentials in CHP Development

Member States		Progress	Potential/Prospect
Austria	+	Austria made progress in energy efficiency by CHP mainly thanks to the Green Electricity Act and the feed-in tariffs, however, industrial CHP auto-production had problems because of the low electricity prices as a result of market liberalisation. Without any subsidy, some of the CHP plants have had to shut down. Many of the Austrian CHP systems operate at relatively high costs. Faced with the decrease of feed-in tariffs at the end of 2004, Austria needs to debate the possibilities for other forms of support (COGEN 2005).	A growth rate of 2% per year until 2012 is expected in regard to district heating (COGEN 2005). The government intends to encourage the growth of biomass' share in CHP. The governmental support of CHP should include a gradual decrease in support levels and use a benchmarking system involving minimum efficiency standards as one way of maximising CHP contributions to meet environmental goals in a cost effective way (COGEN 2005)
Belgium	+	The shares of CHP are in line with the European Directive 2004/8/EG to promote co-generation and with targets set and obligations imposed by the Flemish and Walloon governments (requirements on minimum primary energy savings through cogeneration). As with renewable energy the instrument in the Flemish and the Walloon region to promote CHP is issuing CHP certificates for CHP produced electricity. Also here it is assumed that this CHP certificate policy is effective enough (Report under the GHG Monitoring Decision (290/2004/EC) of Belgium 2005).	Overall the prospects for developing new CHP in Belgium are very good. Strong political support and public acceptance; a comprehensive support package; and good economic prospects thanks to the certificates scheme help explain the surge in the number of projects under consideration in each region (COGEN 2005)
Cyprus	-	There are very few known CHP units in operation (COGEN 2005)	A couple of biomass- fired CHP are still in the preparation phase, other new projects are under study, both in industry and the commercial sector and are expected to come online from the end of 2005 onwards (COGEN 2005)
Czech Republic	+	In recent years, a number of district heating plants have been upgraded with more efficient technologies. Some large boiler plants have been replaced, although no new turbines have been installed in the last three years. The Czech government was supportive of cogeneration. The payment guaranteed for electricity from CHP phase out in the end of 2005, after this date, the government has to introduce new support mechanisms (COGEN 2005)	Considerable efficiency improvements are possible in spite of good progress. In particular, coal-fired units will be displaced gradually by efficient gas-fired ones. Total technical potential for new capacity in 2010 is estimated to be 2,000 MWe. This corresponds to a 30% increase of currently installed capacity. However, there is the risk that, due to a number of important economic barriers, the economically feasible CHP potential is not nearly as promising as the technical possibilities. Even under the assumption that the profitability of CHP plants was enhanced through higher feed-in-tariffs it is estimated that the additional CHP capacity likely to be realised would be around 650 MWe, i.e. only one third of the technical potential (COGEN 2005)

Member States		Progress	Potential/Prospect
Germany	+ -	After the German reunification, the Government invested massively to upgrade district heating systems in the Eastern Länder with gas turbines and/or combined cycle CHP installations. In the Western part of the country, a gradual switch from coal to natural gas and heating oil was observed at the same time. The liberalisation of the German energy market brought about hectic and disruptive changes with very negative consequences for CHP. Over the last few years, CHP has been under severe pressure from existing overcapacities, dramatic drops in electricity prices and rocketing gas prices. As a result, considerable cogeneration capacities from industry and municipal authorities were closed down. in April 2002, the German CHP Law came into force. Although the industrial and medium-sized CHP segments have not been very dynamic, recent trends point to the rapid development of biomass-fired units and rapid increase in the numbers of micro-CHP units being installed (COGEN 2005).	The German CHP Law is not expected to bring as much CO_2 reduction as planned (COGEN 2005).
Denmark	+	Denmark has traditionally used a planned approach to the provision of energy services such as heat, electricity and gas, resorting to specific legislation and voluntary agreements between government and the energy sector. As a result, the country has one of the highest shares of district heating and CHP in Europe. Besides the key role played by the planned approach, CHP has developed in Denmark thanks to a willingness of utilities to integrate decentralised generation and through a special remuneration system (COGEN 2005). In 2002, 53% of domestic electricity supply originated from electricity produced together with heat. The proportion in 1990 was 30%, while it was only 20% in 1980. In 2002, almost 83% of district heating was produced together with electricity. In 1990, the share was 60% compared to less than 40% in 1980 (COGEN 2005 Denmark).	Denmark leads the EU in terms of the share of CHP generated electricity. With a little over 50% of its electricity production coming from CHP, CHP is a mature technology and most of the technical potential has already been tapped. It is highly unlikely that CHP's market share in electricity production will climb much higher. The CHP Directive is not expected to bring profound changes to the situation for CHP in Denmark. CHP units in Denmark typically run with very high efficiencies, and therefore are expected to easily meet the threshold to qualify as 'high efficiency' CHP. Additionally, Danish legislation is already very CHP-friendly and therefore not expected to be modified to any large extent by the implementation of the Directive. There are still opportunities in the heating sector for upgrades from conventional boilers to CHP units while central power stations will be taken out around 2010. Replacing these by smaller gas-fired CHP plants would give Denmark the opportunity to switch to a decentralised electricity generation system while cutting down on CO_2 emissions. Many small-scale CHP plants will also have be replaced as from around 2012 (COGEN 2005 Denmark).
Estonia	-	Since 1997 several CHP units have been built by industrial and commercial companies. The analysis of the Estonian legislation in regards to CHP indicates that the general targets are poorly supported by legislation and regulations, with only electricity from biomass receiving substantial support (COGEN 2005)	In 2005 the Estonian Government presented a new National Energy Sector Development Plan. Under the plan, electricity generated at CHP stations is expected to reach 20% of total domestic consumption by 2020, the detailed strategies are under preparation (COGEN 2005).

Member States		Progress	Potential/Prospect
Spain	+ -	During most of the 1990s, cogeneration experienced rapid growth in Spain. The target to increase the installed cogeneration capacity to 2,222 MWe by 2000, set in the 1991 Plan for Energy Savings and Energy Efficiency PAEE, was already achieved in the mid 1990s. The share of cogenerated electricity grew from 3.3% in 1991 to approximately 12% in 2001 – a remarkable success. The year 1999, however, marked a turning point due to soaring gas prices and falling electricity prices. Since 1999, the number of new cogeneration projects has experienced a downturn. The electricity output of existing installations dropped in 2001, for the first time in 10 years (COGEN 2003c)	End of 2002 figures used in the context of the forthcoming national energy efficiency action plan suggest that, technologically, 2,650 MWe additional cogeneration capacity could be added on top of an existing capacity of 5,025 MWe, bringing the total installed capacity to 7,625 MWe. It is assumed that more than 90% of this potential is to be realised in the industrial sector. However, the almost complete absence of national regulation on grid connection for decentralised generators means that potential investors in cogeneration project are subject to arbitrary and sometimes deliberately awkward connection requirements (COGEN 2005).
Finland	+	In Finland the successful development of CHP has been the result of the fact that it was profitable to invest in cogeneration without government support. To such a situation contributed the absence of barriers and – in contrast to many other Member States – good and competitive biomass supply-chain, high demand for heat and high acceptance towards long payback times. Although the Government does not directly support CHP, it has invested a lot in R&D for energy technologies, especially for wood and biomass which already accounts for over 20% of power generation (COGEN 2005)	
France	-	With an estimated share of about 3.5 % of national electricity production (18-19 TWh), CHP remains marginal in France. The huge share of nuclear and EDF's monopolistic position has hindered the development of CHP in the country. Despite these unfavourable structural conditions, certain progress has been made, particularly in the period of 1997-1999. However, there has been a long period of stagnation since, with little additional capacity. Especially harmful to the CHP industry has been the period of uncertainty from 1999 onward in regards to the regime of CHP electricity export prices. The uncertainties over the economics of CHP have discouraged investment in the sector and have brought the nascent industry to a sudden halt. In 1991, CHP plants in France had a total installed capacity of 45 MWe. This number jumped to 601 MWe by the end of 1995, before reaching 4403 MWe in 2000, an increase of about 3802 MWe in 5 years. However, from the beginning of 2001 to early 2004, only an additional 507MWe has been installed. 2003 was an especially disappointing year with only 71 MWe of new CHP (COGEN 2004a)	The French government has been working on designing a white certificate scheme which will also apply to CHP, although it does not apply to plants already falling under the EU ETS. The system is complex and still has to come into operation. For the initial 3-year period (2006-2008), the national goal for energy savings through this scheme is modest: a mere 2.45 TWh annually, although savings (and consequently white certificates) are assessed over the life of the energy saving action. The white certificates for the replacement of an old inefficient power plant by a modern CHP unit would be given in one instalment and would account for the total energy savings realised by the plant throughout its life, using a 6% actualisation rate. Each certificate will have a maximum value of 2 EURc/kWh (COGEN 2005).

Member States		Progress	Potential/Prospect
Greece	-	The Second Greek National Climate Change Programme establishes as one of it key measures in the energy sector the promotion of CHP technology in the industrial and tertiary sectors; however it does not establish a specific target for CHP (COGEN 2003a). CHP in Greece has developed slowly due to the warm climate and low industrial base, recent introduction of natural gas and consequently lack of appropriate tariffs mainly for the tertiary sector, the bureaucratic procedures and existence of a monopolistic electricity utility which was not fully supportive of CHP, although in recent years this has changed somewhat (COGEN 2005).	The government has estimated that the total additional potential for CHP is 400 -700 MWe in the industrial sector and 100-300 MWe in the services sector under current policies to support CHP (COGEN 2005)
Hungary	+	CHP plants in Hungary can be categorised in old CHP plants built in the 1960s and new combined cycle CHP units built after 1994 and gas engine units built after 1999 for the most part (COGEN 2005).	Cogeneration in Hungary has a large potential. The Hungarian Power Company expects cogenerated electricity to represent between 9 and 9.5 TWh of electricity in 2010, a 20-22% share of total Hungarian electricity generation and imports, up from a little over 7.6 TWh in 2003. The growth is expected to come both from brand new installations and from the expansion and modernisation of existing plants. The market opportunities seem to have shifted from district heating refurbishment and upgrading to opportunities in the industrial and service sectors (COGEN 2005)
Ireland	-	Market conditions from 1999 on brought the development of CHP in Ireland to a standstill. In 2000 the Irish Government published “National Climate Change Strategy”, where the aim of avoiding of 0.25 Mt of CO_2 by the means of the use of CHP by the year 2010 was established. However, the average growth in CHP during the last years was too low to meet target set up which approximately require 25 MWe new CHP capacity per year. So far, the Irish government relied on its Alternative Energy Requirement tendering scheme to increase the share of CHP, however only few projects have been commissioned under this scheme, in part due to very low bid price ceiling levels (EURc3/kWh) (COGEN 2005).	
Italy	+	In Italy it is estimated that that the savings of CO_2 emissions were 1.185 kt in 2003 and were higher than in 2002 (1.097 kt) (Euroheat and Power 2005). A favourable regulatory framework in the nineties provided a boost for the development of new cogeneration plants (COGEN 2005)	The potential for further development of cogeneration in Italy is very high and this applies mainly to the service and district heating sectors. However, for CHP to develop strongly, the sector needs a favourable framework. Cogeneration currently faces serious barriers such as complex and expensive rules to sell electricity to eligible customers, bureaucracy in authorisations, uncertain legal framework due to slow liberalization process and repeated changes in the government’s energy policy and uncertainty in obtaining incentives (COGEN 2005).

Member States		Progress	Potential/Prospect
Lithuania	+ -	Five large CHP plants dominate the CHP landscape. These plants are old and require refurbishment. Multi-million modernisation and renovation schemes have begun or are in the planning for several plants. Small-scale CHP was first introduced in Lithuania in 1999 and as of end 2003, there were 15 such plants under operation in the country, many of which operate in industry. The majority of these units use the power and heat on-site and do not export to the grid (COGEN 2005).	The shut-down of the Ignalina nuclear facility (expected at end of 2009) will increase the urgency of stepping up efficiency and adding more capacity. Several large new CHP plants are to be built in the 2007-2012 timeframe, totalling an estimated 170 to 220 MWe. Several small plants are to be commissioned in 2006-2008, several of which are renewable-fuelled. New investments in biomass-fired CHP and "efficient cogeneration units" are to be expected since the secondary act to the Law on Heat (the Procedure for Purchase of Heat from Independent Producers to Heat Supply Systems – July 2003) sets a merit order of heat to be purchased by DH systems which favours these two technologies. Overall, the future electricity market potential of CHP may be as big as 35% of total national generation by 2020 (minimum objective from the National Energy Strategy). This corresponds to 400 MWe of additional CHP capacity.(COGEN 2005)
Luxembourg	+	In 2002 4 MWe of new CHP capacity was being built, with ad additional 3 MWe at planning stage. The government is overall supportive of CHP. Support measures for CHP are mainly aimed at biomass- and biogas-fired units while individuals can receive subsidies covering 25% of total investment costs under certain conditions (COGEN 2005).	
Latvia	+ -	The installed stock is old, and recent investments have concentrated on efficiency improvements while some plants are being reconstructed, the old systems being replaced with modern, advanced technology gas/steam cycle cogeneration installations. Most of the new small-scale CHP has been installed since 2001 and is natural gas-fired, thanks to the feed-in tariffs. Latvia has a good technical potential for CHP but application and interconnection fees are a hurdle for small projects, while profitability is low and transmission charges are high. Despite these barriers, several CHP projects are going ahead in Latvia, most of them in district heating systems. A decisive factor in Latvian energy policy is the dependence on imports of energy from Russia, creating strong political support for energy saving techniques. Though the realisation of goals is hampered by shortage of funds for investments in the energy sector (COGEN 2005)	The technical potential is rather high, with a study by the Latvian DH association estimating that around 500 MWe of new installed CHP capacity in district heating systems is achievable. Apart for small-scale CHP, the conditions for CHP producers have been difficult over the last few years, in particular due to low hydro electricity prices and cheap imports. This is set to change however as from 2005 onward imports are expected to be lower than in past years (COGEN 2005).

Member States		Progress	Potential/Prospect
The Nether-lands	+	In 2000, 4.2 Mt CO_2 eq./year was avoided by combined heat and power (Report under the GHG Monitoring Decision (290/2004/EC) of the Netherlands 2005). The Dutch national policy was traditionally favourable for cogeneration and has resulted in a high percentage of electricity generated by CHP. However, over the last years this has changed due to less state intervention and a more free market approach. Nevertheless, CHP has been given an important role in response to the climate change issue (COGEN 2005).	It is expected that in 2005 an additional 1.0 Mt, in 2010 1.9, in 2015 1.6 and in 2020 1.3 Mt CO_2 eq are avoided by CHP (Report under the GHG Monitoring Decision (290/2004/EC) of the Netherlands 2005). Despite the fact that there is growth potential for more cogeneration capacity, current market forecasts for CHP in the Netherlands are not very good. In the future, investments in CHP will be increasingly determined by the prices on the electricity market. This trend can be seen already at the existing CHP installations. More and more CHP installations are expected to be shut during off-peak hours as the off-peak prices remain so low that they do not in most cases cover the marginal cost price of electricity from CHP. In the long run the situation is unclear and much depends on the success of Government's MEP certificate and grant scheme. It appears that the Government is currently reappraising the support mechanisms for CHP and it is possible that support will shift from existing plants to new CHP installations. Furthermore, future investment will mainly be replacements investments. Indeed, the government is concerned about the development of peak capacity in the medium and long term, whereas it sees current capacity as adequate. As in other markets, a major role for micro-CHP is not expected before 2010 (COGEN 2005).
Poland	+ -	In 1998, the district heating sector in Poland comprised almost 400 individual networks accounting for about 40% of total primary energy demand. As a result of the large share of DH, 70% of Poland's urban population received space-heat and 50% received hot water from district heating systems. It is estimated that distribution energy losses in some systems amount to 45%. There is therefore considerable latent demand for the replacement and refurbishment of heat distribution networks, a demand that will only be realised when heating companies are permitted to charge prices that reflect true economic costs. A Polish specificity is the right of Third Party Access (TPA) to DH networks, which is embedded in the Energy law. With the exception of the city of Lodz, CHP plant owners do not own the pipeline network and while district heating systems in Poland are in poor condition, no funding is available for the necessary refurbishment. Although this situation is unsatisfactory, it is unclear if it is likely to change in the close future. Under the terms of the Polish Energy Law, cogenerated electricity benefits from a purchase obligation, provided it is generated in a 70% efficient process. Electricity distributors are required to sell a minimum share of cogenerated electricity to their end customers. This share of total electricity is set at 12.4% for 2005 and will increase to 16% in 2010. The electricity and heat tariffs have to be approved by the Energy regulatory authority (COGEN 2005).	The potential for modernisation and/or replacement of old boilers and turbines is very high, with nearly 50% of installed boiler and 35% of turbine capacity over 40 years old. The Polish CHP Association estimates that approximately 40% of Poland's electricity production could be generated by CHP and considers the new regulatory context to be favourable in this respect. It sets the conditions for full access of small, independent cogenerators to power markets. In addition, the increasing availability of natural gas is expected to support the growth of CHP, notably through gas turbine systems, in the near future (COGEN 2005).

Member States		Progress	Potential/Prospect
Portugal	+	Since 1997, 303 MW e of gas-fired CHP capacity has been installed. District heating is not seen as having a high potential with only one plant in operation at the site of the EXPO 98. Cogenerators in Portugal have been blessed by a very fair and positive legal framework for decentralised generation technologies based on avoided costs (COGEN 2005).	For the country to reach the targets set by the Government in its National Plan for Climate Change (2004), an additional 800 MWe of installed CHP capacity would be needed by 2010, thereby increasing the share of cogenerated electricity to around 18%. It is unlikely that so much new capacity will come on line in the relatively short time left to 2010. Even a lower target of 1,800 MWe of installed CHP capacity by 2010 looks unlikely to be met (COGEN 2005).
Sweden	+	One goal of the energy policy has been to replace heating with oil and electricity by district heating. Cogenerated electricity from district heating systems rose significantly due to state support. CHP is still progressing, further plants are planned (COGEN 2005).	The Swedish Government's opposition to the development of coal-fired, but also to gas-fired power plants combined with its decision to go ahead with the phase-out of nuclear plants means prospects for growth in CHP are good (COGEN 2005)
Slovenia	+ -	The Government's energy law, adopted in 1999 and amended in 2004, lays down the framework for the purchase of cogenerated electricity (COGEN 2005)	In preparing its national allocation plan for the EU ETS, the Government identified 30 MWe of potential in industry by 2008 and circa 10 MWe in 2 DH systems. On the longer term, the 2003 National energy programme identified substantial economic potential to 2015 (COGEN 2005)
Slovak Republic	-	Historically, CHP production came predominantly from industrial facilities but development of housing infrastructure has created conditions for centralized heat supply. The result of this centralised development is that the overwhelming majority of installed capacity is in the public supply sector while market growth areas are predominantly in the commercial and district heating sectors. Small-scale cogeneration units began to be used in the early 90s. As of early 2004, 121 gas-engine cogeneration units (under 5 MWe) were in operation in Slovakia, with a total installed capacity of 16.3 MWe. Since then, the expansion of CHP in Slovakia has been severely hampered by generation overcapacity in the electricity sector and the high level of price regulation. The government has no cogeneration target and has been concentrating on integrating the European acquis and buying social peace rather than answering the CHP and electricity industries' concerns. There are currently many uncertainties in energy market development in Slovakia, as the Government is in the process of privatising the national power plants, with ENEL set to buy a majority stake (COGEN 2005).	Electricity balance is likely to change when two nuclear reactors will be decommissioned in 2006-2008. In evaluating the future development of the CHP capacity in Slovakia, apparently the priority will be given to refurbishment of old industrial CHP plants, with large scale GT and CCGT CHP plants replacing the existing steam turbine CHP plants currently producing cheap power at marginal costs but facing increasing operating costs and low efficiencies. As for small scale gas-fired ICE CHP plants, these will only be economically viable as island solutions, without export of electricity – again because of the low purchasing price (COGEN 2005).

Member States		Progress	Potential/Prospect
United Kingdom	+ -	The UK is broadly halfway towards this target with just under 4.9 GW of installed capacity by the end of 2003 (Report under the GHG Monitoring Decision (290/2004/EC) of United Kingdom 2005). Lower electricity prices, unhelpful regulation and rising natural gas prices have meant the market stalled in 2000, 2001 and 2002. Since early 2004, however, the prospects for CHP in the UK have improved. Although a number of towns and urban districts have developed community heating networks, the uptake has been rather slow and financing the projects – just as lack of awareness- is still an issue, despite the limited availability of public funds for such projects. CHP in the service sector, and especially hotels and leisure centres, have been developing at a steady pace in the last few years. Organisations such as the CHP Club have been very active in promoting the technology in this particular market segment (COGEN 2005).	Cogenerators in the UK have been openly sceptical of these lofty targets since many have struggled with the liberalisation of the electricity market. Paradoxically, the UK's CHP sector strength is that it does not rely on substantial governmental support mechanisms, as can be the case in other countries. In turn, this also means that if the Government were to move from the current wide array of disparate and weak support programmes to a more comprehensive and affirmative policy, the effects on new investments in CHP would be strongly felt. Looking at community heating, the Energy Saving Trust has calculated a cost-effective potential for community heating in the UK of over 4,000 MWe by 2010. The most interesting feature of the UK CHP scene is the enthusiasm for micro-CHP. Many studies carried out in the UK point to the enormous potential for micro-CHP in the country.(COGEN 2005)
Malta	-	There is no cogeneration installed in Malta, although governmental authorities have determined that there are opportunities for the development of CHP. Besides limited potential for projects, there are a number of barriers to CHP development in Malta. There are no feed-in laws; no incentives; no energy service providers; a lack of local expertise; and, most notably, no guaranteed price for electricity and no natural gas (COGEN 2005).	

Source: *COGEN (2005), Euroheat and Power (2005), COGEN (2004 a, b); COGEN (2003 a, b, c); Reports under the GHG Monitoring Decision (290/2004/EC); own evaluation*

5.3.5 Conclusions

The progress in the EU Member States in regard to steam and electricity production in CHP is rather difficult to assess as comprehensive actual data is not available. EU policy, the Directive 2004/8/EC, aims at providing a framework for the promotion of CHP but does not specify targets for the individual Member States. Furthermore, the Directive only entered into force in 2004, it has to be transposed into national laws in 2006. Against this background of weak data basis and missing progress reports, a quantitative analysis of the progress by policies and measures is hardly possible.

However, on a qualitative basis, several lessons can be learnt: the penetration of the energy market by CHP varies strongly among the Member States. The penetration rate of CHP does not diverge strongly between EU-15 and the new Member States: rather, there are large differences within the two country groups. Beside the lack of special laws on regulating CHP, possible obstacles to the development of CHP are long bureaucratic procedures, unfavourable market structures for decentralised energy supply (i.e. monopolistic supply structures in the energy sector), generation overcapacity, high gas prices and low energy prices. The liberalisation of the EU energy market has both positive and negative effects: positive effects might derive from the abolition of monopolistic structures; decreasing energy prices, however, might reduce incentives for investment in CHP. In general, economic instruments are the most commonly used measures to support CHP, followed by regulatory instruments.

Based on the information provided in Table 5.19, positive developments in the CHP sector could be registered in Austria, Belgium, the Czech Republic, Denmark, Finland, Hungary, Luxembourg, the Netherlands, Portugal, Italy and Sweden. The success of the CHP development can be traced back to diverse political factors. In general the governments of the Member States mentioned are overall supportive of CHP. However, in Finland, the government invested only in R&D, characteristic for that Member State is that the positive trend in CHP could be achieved without governmental support. The type of policies and measures undertaken in the individual Member States is not uniform. Belgium i.e. has a very efficient certificate scheme; Austria made use of feed-in tariffs. In Denmark, however, a planned approach in combination with the willingness of utilities to integrate decentralised generation was the key for success.

In some of these Member States, however, there is a need for adjusting the political framework in the future in order to be able to continue further realisation of CHP potentials. That means that in Austria, the gradual decrease in support levels and higher efficiencies are requested. In the Netherlands, investments in CHP will be increasingly determined by prices on the electricity market – without further policies and measures the share in CHP is expected to decrease. Portugal set national targets for 2010 but will probably fail to meet them. In the Czech Republic and Italy, technical potentials for CHP are estimated to be far larger than the potentials which are expected to be realised under the actual political framework. In Denmark, only a small potential for further improvements remains, the shares in CHP electricity and steam production are high, the CHP market is the most mature in the EU.

Furthermore, good prospects and potentials can be registered in Belgium and in Sweden (in the latter inter alia due to the phase out of nuclear energy). Also Hungary has a large potential for further development of CHP.

Positive developments in the CHP sector in the nineties but drawbacks in recent years can be reported from Germany, Spain and the United Kingdom. In Lithuania and Latvia, major investment in CHP started only in recent years. Problems with CHP development are encountered by France, for example, where nuclear power has a large share in electricity production. But also in Estonia, the Slovak Republic, Germany and Ireland the extension of the CHP sector was hindered due to insufficient legislative support. In Ireland and Germany, the national targets will probably be failed. In the Slovak Republic – in contrast –a national target was not set. In this Member State, the expansion was severely hampered by generation overcapacity in the electricity sector and the high level of price regulation. In Cyprus and Malta there are only a few/none CHP applications. Potentials in these Member States are rather small, but some do exist.

Of those Member States which did not face a thoroughly positive development in the past, remarkable potentials are registered in Slovenia, Latvia, Poland, Lithuania, the

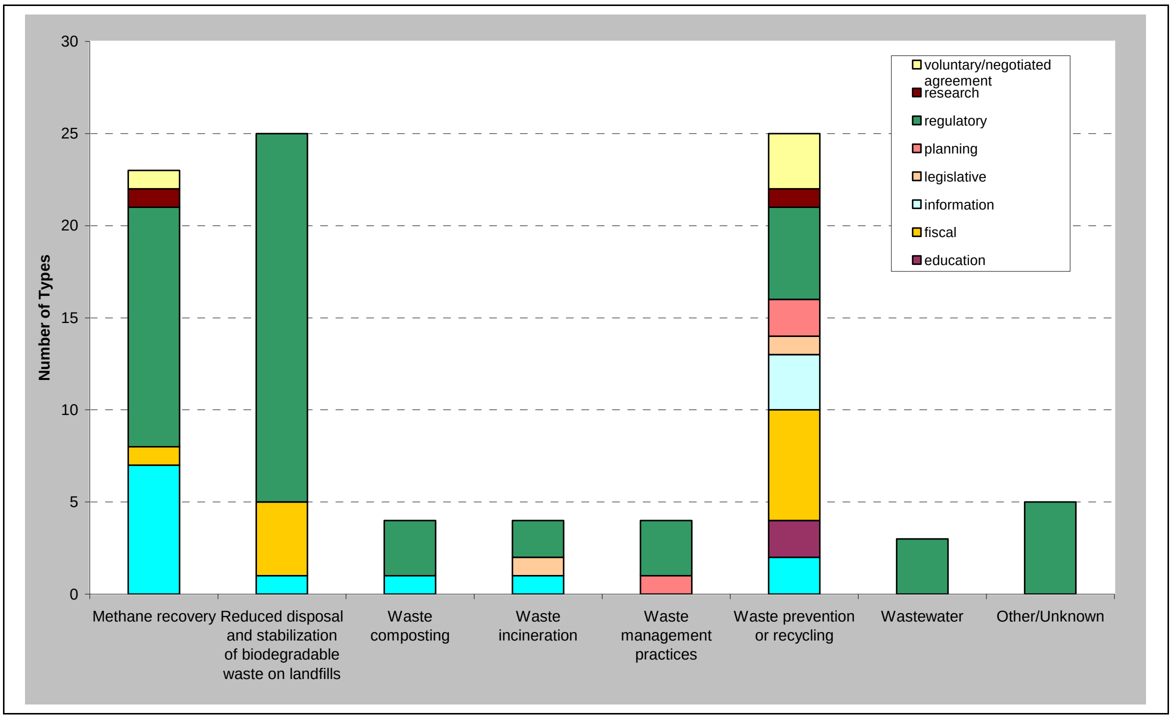
United Kingdom. The UK's strength is that it does not rely on substantial governmental support mechanisms; thus by applying a more comprehensive and affirmative policy, large potentials can be realised. In Latvia the technical potential is rather high.

In conclusion, against the background, because the use of combined heat and power presents a substantial potential for increased energy efficiency and reduced environmental impacts and is considered to be a priority area for many Member States, the overall access to data and country-specific analysis of policies and measures can be assessed as poor.

5.4 Waste management

Greenhouse gases in the waste sector originate from managed and unmanaged waste disposal on land, domestic and commercial wastewater und sludge handling, waste incineration and other waste treatment. However, solid waste disposal on land contributes most to the greenhouse gas emissions of this sector, in EU-15 this source category contributed 73% of the total sectoral emissions in 2003. Considering as well the new Member States, the contribution of solid waste disposal will be even larger, landfilling of municipal waste is a common practice in many of the new Member States. In the following case study, the focus is laid on the waste management practices with special regard to landfilling of municipal waste; wastewater treatment and waste incineration are not analysed in detail. As can be seen in Figure 5.6, most of the policies and measures taken by the EU Member States are related to waste prevention and recycling, landfilling and methane recovery.

Figure 5.6 Number of policies and measures in the waste sector reported in the third National Communications



Source: EU Member States

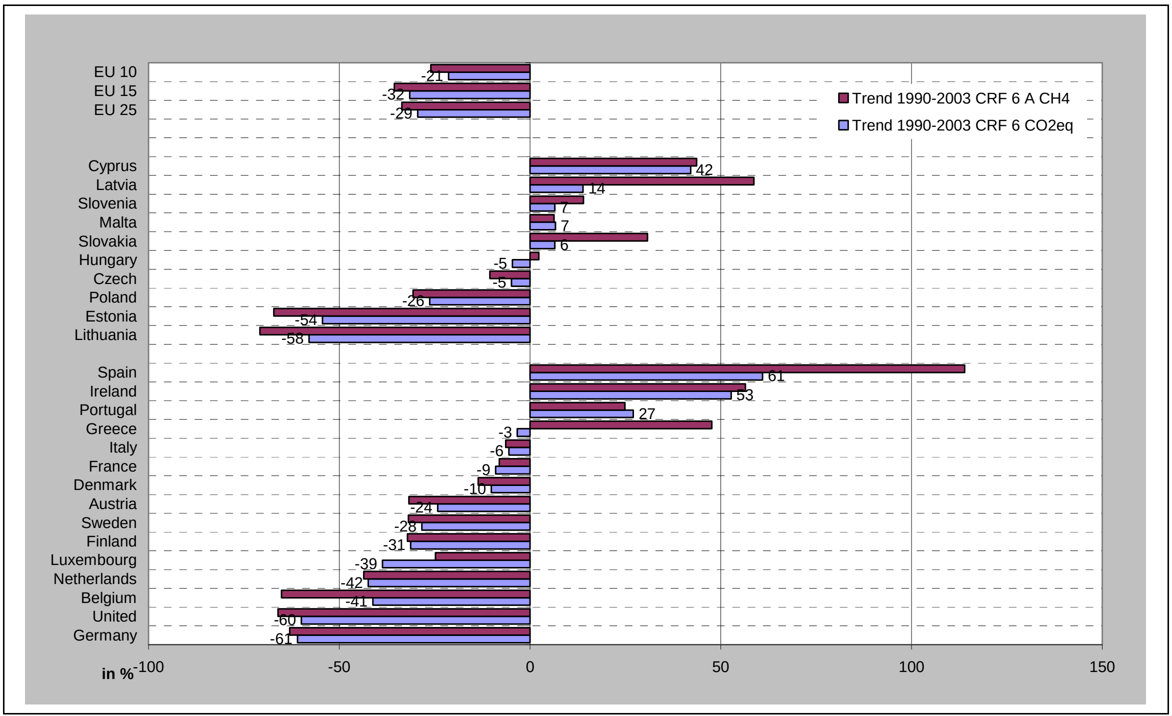
5.4.1 Trends and projections

The emission trends and the projections in the waste sector are a success story for climate change. Both the emission trends and the projections in the waste sector, going more or less hand in hand with the emission trends from solid waste disposal sites (SWDS), show that considerable emission reduction potentials have already been realized and further progress is expected in all EU Member States.

5.4.1.1 Emission trends in the waste sector (1990-2003)

The EU-25 emissions from the waste sector decreased from 178 to 125 Tg CO_2 eq. between 1990 and 2003, which amounts to a reduction of 29%. The significant reduction of emissions from SWDS is the main reason for this favourable trend; see Figure 5.7 in which the waste and solid waste disposal trends of the individual Member States are illustrated.

Figure 5.7 Changes in GHG emissions from the waste sector (CRF 6) and from solid waste disposal (CRF 6 A) between 1990 and 2003



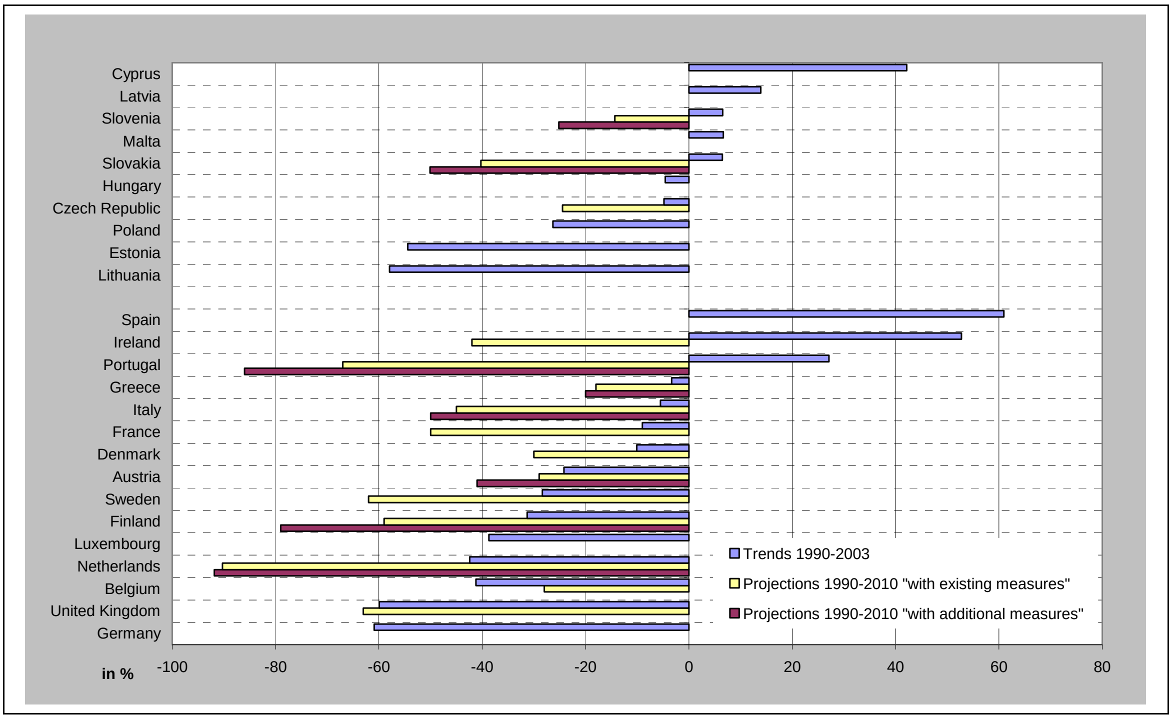
Source: UNFCCC (2005)

While in many EU-15 Member States and in some new Member States both the waste emissions and the emissions from solid waste disposal decreased between 1990 and 2003, an increase was reported in Spain, Ireland, Portugal, Cyprus, Latvia, Slovenia, Malta, Slovakia and Greece. However, considering the EU-averages, EU-15 and EU-10, significant emission reductions could be achieved in both.

5.4.1.2 Emission projections in the waste sector (2003-2010)

Figure 5.8 reveals that all Member States which report emission projections (also those with large increases between 1990 and 2003) expect emission decreases well below the 1990 levels by 2010 (Greece projecting the lowest fall). The largest reductions are projected for Portugal, Finland and the United Kingdom with more than 55% in the “with existing measure projections”, and for Finland and Portugal (more than 75% in the “with additional measures scenario”). Unfortunately Spain, with the second highest increase between 1990 and 2002, Luxembourg and Germany did not report emission projections for waste management.

Figure 5.8 Trends and projections of GHG emissions (in CO_2 eq) from the waste sector (CRF 6) in the EU Member States



Source: UNFCCC 2005; EEA (2004)

Information provided on methods and parameters for projections of waste emissions is usually scarce and often only the projected emissions are provided. Therefore it is difficult to evaluate the quality of the projection. However it should be mentioned that in many third National Communications by the Member States, projections were based on the IPCC Tier 1 method that considerably underestimates emissions in the future because emissions from previously disposed wastes are no longer included in the estimates. It would be straightforward to use the Tier 2 first order decay model for projections as it can be easily extrapolated in the future. Member States should follow the same approaches for inventories and projections in order to get consistent results.

The detailed trends and projections of the individual Member States are provided in the annex.

5.4.2 Waste management policy in the EU

Waste management policy in the EU enshrines the principles of sustainable development. The hierarchy of waste management options places the greatest preference on waste prevention. Where waste cannot be prevented, the order of preference decreases in order re-use, recycling, recovery of energy and finally (as the least preferred option) the disposal in landfills of stabilised wastes from which no further value can be recovered.

The general principles related to the treatment of biodegradable municipal wastes, in order of preference by the EU, are (EC 2001):

- Prevent and reduce BMW production and its contaminations by pollutants
- Reuse of BMW (e.g. cardboard)
- Recycle separately-collected BMW into original material (e.g. paper and cardboard) whenever environmentally justified;
- Composting or anaerobic digestion of separately-collected BMW that is not recycled into original materials, with the compost so produced as able to be used in agriculture or for another environmentally beneficial purpose;
- Mechanical and biological treatment (MBT) of non-source separated BMW as a pre-treatment for landfill disposal and finally;
- Use of BMW for energy recovery

For the emissions from the disposal of BMW on land three EU directives are of relevance as common and coordinated policies:

- Directive 75/442/EC on Waste (Waste Framework Directive)
- Directive 1999/31/EC on the Landfill of Waste
- Directive 94/62/EC on Packaging and Packaging Waste

The early implementation of the EU landfill directive (Directive 1999/31/EC) in some Member States was largely responsible for the decline of greenhouse gas emissions from landfills and it is projected to contribute strongly to further emission reductions until 2010 – especially in the new Member States.

Landfill Directive (Directive 1999/31/EC)

The objective of Directive 1999/31/EC on the landfill of waste is to prevent or reduce as far as possible the negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, and on the global environment, including the greenhouse effect, as well as any resulting risk to human health, from landfilling of waste during the whole life-cycle of the landfill.

Pursuant to Article 5(1) of the Directive, Member States must set up a national strategy for the implementation of the reduction of biodegradable waste going to landfills not later than 16 July 2003. The Landfill Directive sets guidelines for the monitoring and control of landfills in the Member States. The Directive sets, as a policy target, the phased reduction of biodegradable municipal waste going to landfill. Member States are restricted to landfill and amount of BMW that is a percentage of the total amount of BMW **generated** in 1995 in the country. The targets are:

By 2006, 75% by weight of the BMW generated in 1995

By 2009, 50% by weight of the BMW generated in 1995

By 2016, 35% by weight of the BMW generated in 1995

Member States **landfilling** more than 80% of their municipal waste produced in 1995 (Spain, Italy, Ireland, UK, Greece as well as well as all 10 New Member States) have been allowed to postpone the achievement of these targets for a maximum of four years.

The Commission is monitoring the implementation of the Landfill Directive and the progress of Member States towards achieving the reduction targets set by the Directive. By January 2004 the Commission had received the national strategies of twelve of fifteen EU Member States (EU-15). The new Member States had to submit their national strategies after accession; they are not yet available to the public.

An overview of the national strategies are provided in Table 5.20 based on EC (2005b). Further details of the national strategies can be found in the EC (2005a).

Table 5.20 National strategies for the reduction of biodegradable waste going to landfills

	Percentage of biodegradable MSW that is landfilled*	Biodegradable MSW accepted by landfills	Separate collection of biodegradable MSW	Separate collection/recovery of packaging waste	Waste incineration	Home composting/composting	MBT/pretreatement of biodegradable MSW	Regional planning/strategies	Energy recovery	Economic measures to increase price of landfilling
Austria	< 35%	waste pretreated by incineration (TOC < 5%) or by MBT	x	x						
Belgium (Flemish region)	< 35% (national)	banning planned of unsorted household waste, waste collected for recovery and combustible fraction (TOC > 6%)								
Belgium (Walloon region)			+ (voluntary)	+ (targets)		+	+		+	
Denmark	< 35%	waste suitable for incineration not accepted								
France	35% - 75%	Since 2002 only 'final waste' (waste that cannot be treated anymore under present tech. & econ. conditions)	+	+ (targets)	+					
Germany	35% - 75%	By 1 June 2005 MSW pretreated by incineration (TOC < 3%) or by MBT (TOC of 18%)	x	x (high recovery)						
Italy	> 75%	landfill ban for high and medium risk animal by-products and organic healthcare waste	+ (southern regions)		+					economic measures (incl. an ecotax)
Greece	> 75%	pre-treatment necessary		x			+	+		
Luxembourg	< 35%		x						x	
Netherlands	< 35%	ban of landfilling of separately collected biodegradable waste	+ (targets)		x	+	+			
Portugal	> 75%	introduction of phased landfill restriction are under consideration	+ (targets)	+ (targets)	+	+	+			landfill fees are under consideration
Sweden	< 35%	ban of landfilling of combustible waste and organic waste			x		+			
United Kingdom	> 75%			+ (targets)				+		tradable allowances for the landfilling of biodegr. MSW
Spain	> 75%	By January 2004 Ireland and Spain have not submitted their national strategies, Finland's strategy was submitted to late to include in the Report COM(2005) 105 final								
Ireland	> 75%									
Finland	> 75%									

* 2005 or the last year for which information was available; MBT: mechanical biological treatment; x: implemented/high share; +: planned

Source: EC (2005b), the national strategies are analysed more in detail in the context of other national policies and measures in the waste sector (section 5.4.5)

While the Landfill Directive influences strongly the GHG emission level in the waste sector, the Directive 94/62/EC on Packaging and Packaging Waste has - comparatively - a minor impact. Support of waste recycling and recovery by the Directive results in the effect that waste is diverted from landfills and as a consequence less methane emissions are generated by i.e. paper package waste.

Directive 94/62/EC on Packaging and Packaging Waste

This Directive aims to harmonise national measures in order to prevent or reduce the impact of packaging and packaging waste on the environment and to ensure the functioning of the Internal Market. It contains provisions on the prevention of packaging waste, on the re-use of packaging and on the recovery and recycling of packaging waste. The Directive came into force on 31 December 1994; the date for implementation by Member States into national legislation came into force on 31 December 1996.

Article 6 of the Directive establishes targets to be achieved by 30 June 2001 for the recovery and recycling of packaging. The targets were:

- 50%-65% recovery and incineration at waste incineration plants with energy recovery and
- 25%-45% recycling with a minimum of 15% by weight for each material

By 31 December 2008 advanced targets were agreed:

- Recovery target: Min 60%
- Recycling target: 55%-80% with diverse minima for each material.

The authors of the study on the Implementation of Directive 94/62/EC (Ecoloas 2005) come, however, to the conclusion that most of the packaging recovery and recycling in the EU-15 is not directly related to the effects of the Directive. Most of the packaging recycling would also have taken place in the absence of the Directive, either because it is economically profitable or because of pre-existing national legislation or other initiatives.

5.4.3 Key parameters influencing emissions from solid waste disposal sites

As a basis for assessment, in the following the key parameters influencing emissions from SWDS are outlined.

Landfill gas, consisting of approximately 50% CH_4 and 50% CO_2 by volume, is formed inside SWDS by the bacterial decomposition of organic matter. For biodegradable waste, the carbon content was originally taken up as CO_2 from the atmosphere and it thus stored in the material. Depending on the waste management practice used for the materials, the carbon can be released either as CO_2 or as CH_4. If released as CH_4, and due to the different global warming potentials of CO_2 and CH_4, there is a net contribution to the greenhouse effect. Therefore methane is the compound of most interest in the gas emissions from landfills.

The most significant factors affecting CH_4 generation in landfills are, following IPCC (1996) and EC (2001):

- *Physical factors:* Moisture content is an important physical factor influencing landfill gas production. Furthermore temperature, pH, and nutrient availability affect the growth rate of the bacteria. These factors are influencing the potential to actual landfill gas generation rates.
- *Waste disposal practices:* Waste disposal practices influencing the CH_4 generation concern the control of the placement of waste and the management of the landfill site. Disposal can be managed either to encourage development and maintenance of anaerobic activity by installation of percolate irrigation to increase moisture and gas collection, or to encourage the opposite by removal of biodegradable waste and avoidance of water intrusion. Furthermore the methane generation depends on the amount of methane which is oxidised in the upper layers of the waste mass and in cover material, where oxygen is present. Non-managed SWDS tend to emit less methane than managed as a larger fraction of waste may decompose aerobically in the top layers.
- *Waste composition:* The composition of waste is one of the main factors influencing both the amount and the extent of CH_4 production within solid waste disposal sites. Municipal waste typically contains significant quantities of degradable organic matter. The organic carbon which is dissimilated is potentially converted into landfill gas. Different countries and regions are known to have MSW with widely differing compositions.

The actual emissions of methane into the atmosphere are additionally influenced by:

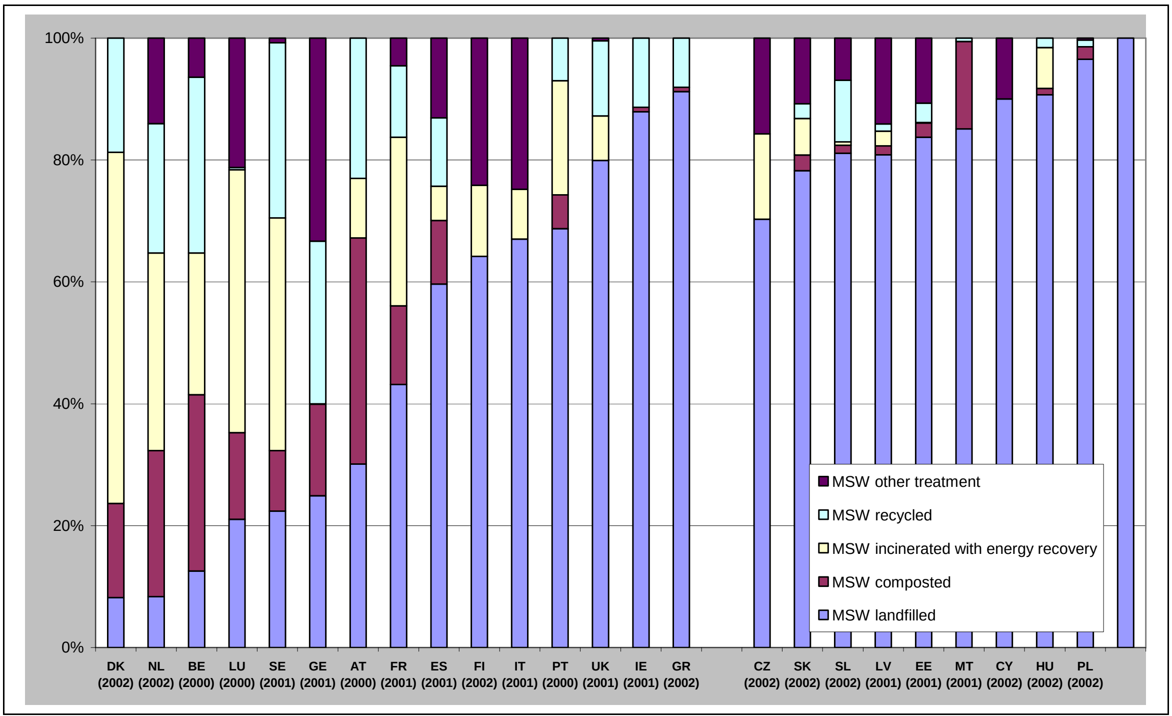
- *Methane recovery:* The gas recovered is burned in a flare or energy recovery device. Landfill gas recovery has become more frequent as a measure to reduce CH_4 emissions from SWDS and to save energy, but it is limited to the time period (20-30 years) when the methane concentration in the gas is high and gas recovery feasible. Leaks in the collection system may reduce the effectiveness of the recovery.

5.4.4 Comparison of key parameters in the Member States

Before analysing the policies and measures in the Member States, the EU Member States' key parameters influencing the emission level will be compared in order to evaluate reduction potentials which were already realized in the past or which can still be addressed by the policies and measures planned, adopted and implemented. On this basis, methods to evaluate the Member States' projections in the waste sector respectively the reduction effects of the national policies and measures are developed.

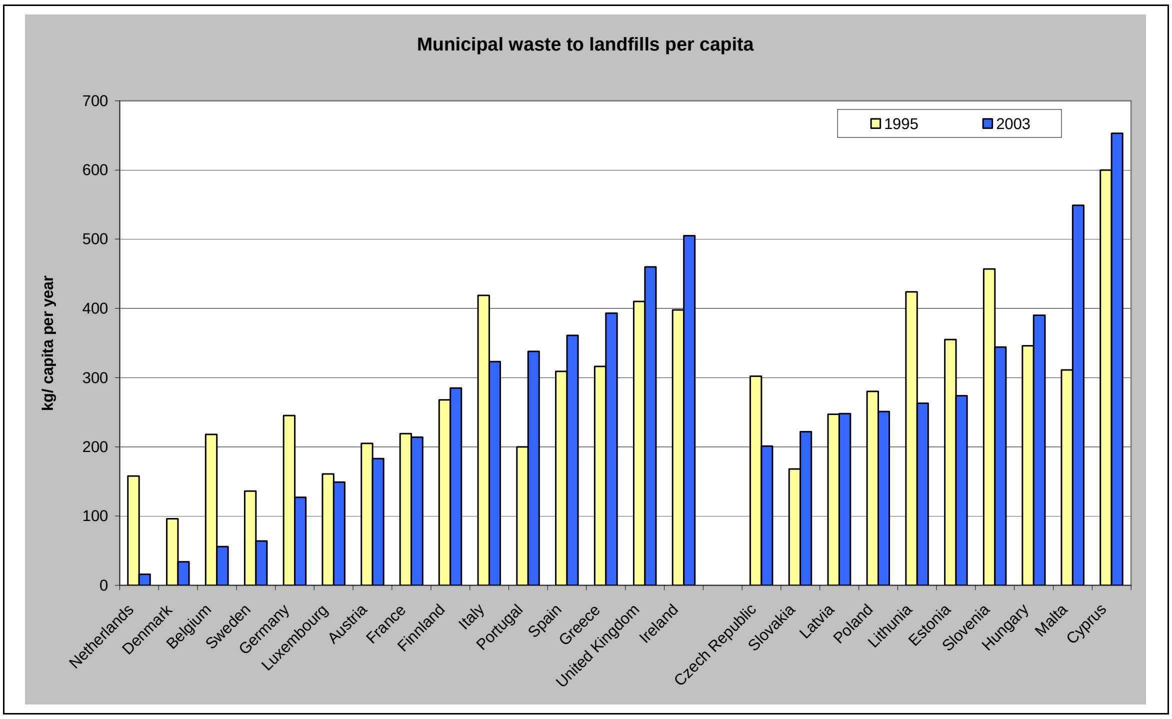
The different waste management practices in the individual Member States reveal a first insight in possible reduction potentials. Figure 5.9 provides an overview of the waste management practices in all European Member States. It is evident that in the new Member States the share of MSW landfilled is on average larger by far than in the EU-15. This can be traced back to the fact that solid waste disposal on landfills is a low cost disposal practice with moderate technical requirement compared, for example, to waste incineration – the latter being a common practice in several EU-15 Member States. Furthermore the early implementation of the EU Landfill Directive reduced the EU-15 average significantly. In general, the CH_4 reduction potential tends to be larger in those Member States which have a high share of landfilling – at least if the waste landfilled has a high share of biodegradable waste.

Figure 5.9 Municipal waste management practices in the European Union



Source: Eurostat 2005 (last data available)

Figure 5.10 Municipal waste to landfills per capita



Source: Eurostat (2005)

Figure 5.10 gives additional insights in the trend regarding the disposal of MSW on landfills. It can be seen that in nine of the EU-15 Member States (the Netherlands, Denmark, Belgium, Sweden, Germany, Luxembourg, Austria, France, Italy) the amount of MSW disposed on landfills per capita showed a favourable trend between 1995 and 2003, while in six of the EU-15 Member States the amount was increasing (Finland, Portugal, Spain, Greece, the United Kingdom, Ireland). It is striking that those EU-15 Member States which have a per-capita disposal rate which lies over the EU-15 average in 2003 are the Member States in which the disposal rate per capita was growing between 1995 and 2003; thus potentials to reduce emissions are assumed to be largest in these Member States.

In the new Member States a similar tendency is perceivable but not as pronounced as in EU-15. The per-capita disposal rates in many of the new Member States are similar to the European average[26], only the rates in the small Member States Malta and Cyprus are larger than the highest rate in EU-15.

Potentials to reduce the disposal rate by a shift towards other waste management practices can be assumed in the new Member States as well as in the EU-15 Member States with increasing and high disposal rates (Finland, Portugal, Spain, Greece, the United

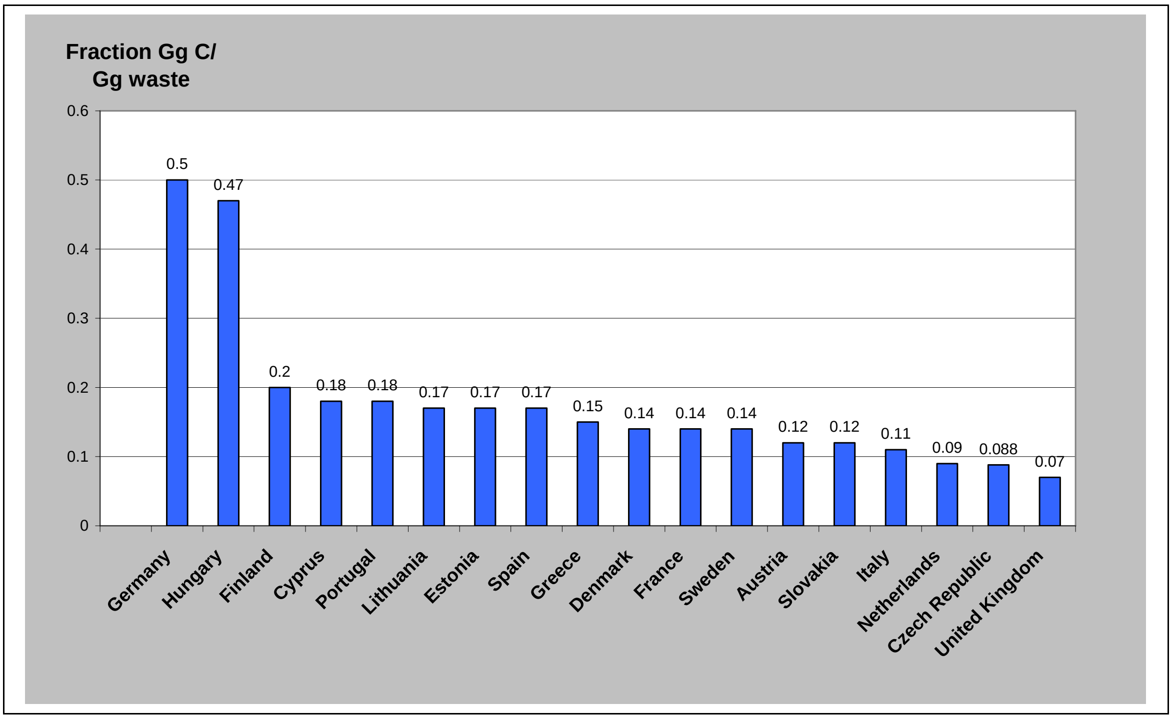
[26] This conclusion relates to the average on the EU-15 Member States not taking into account the amount of waste of the individual Member States.

Kingdom, Ireland). However, the potential to reduce methane emissions from SWDS is only coupled with the potential to reduce the disposal rate if biodegradable waste is concerned. The MSW disposal rate might be high, but if the dissolved organic carbon of that waste is low, the high MSW disposal rate does not result necessarily in a high emission level.

Thus, in the next step, the DOC values of the individual Member States are illustrated (Figure 5.11). The average DOC values of MSW vary significantly between 0.07 Gg C/Gg waste and 0.5 Gg C/Gg waste, with Germany and Hungary somehow as outlier. The DOC values in EU-15 and the new Member States are comparable; there is no clear trend that EU-15 average is higher or lower than the EU-10 average.

The DOC value of the MSW landfilled is influenced if other waste management practices are intensified for a certain fraction of MSW. For example if the recycling rate of glass, metal and other inert waste is improved, the DOC of MSW tends to increase. However, if biodegradable waste is collected separately and disposed of or pre-treated by other waste management practices i.e. composting or biologic mechanical treatment, the DOC of the MSW disposed on landfills tends to decrease.

Figure 5.11 Average DOC in municipal waste



Source: UNFCCC (2005)

Based on the analysis of the per-capita amount of waste landfilled and of the DOC, a rough assessment of the emission reduction potential by separate collection/treatment and disposal has been undertaken (Figure 5.11). The EU Member States are grouped into four categories regarding their per-capita amount of waste landfilled and the DOC value (low, medium, high and not indicated). The combination of the two figures is an indicator for the emission reduction potential by other BMW practices.

Table 5.21 Assessment of emission reduction potential by separate collection/treatment/disposal of BMW

Member States	MSW landfilled per capita	DOC	Reduction potential by separate collection/ treatment/ diposal of BMW
Data source	**Eurostat**	**CRF 2005**	**Estimate by Öko-Institut**
Belgium	low	not indicated	low
Czech Republic	medium	low	low-medium
Denmark	low	medium	low-medium
Germany	low	high	low-medium
Estonia	medium	medium	medium
Greece	high	medium	high
Spain	high	medium	high
France	medium	medium	medium
Ireland	high	not indicated	high
Italy	high	low	medium-high
Cyprus	high	medium	high
Latvia	medium	not indicated	medium
Lithuania	medium	medium	medium
Luxembourg	medium	not indicated	medium
Hungary	high	high	high
Netherlands	low	low	low
Austria	medium	low	low-medium
Poland	medium	not indicated	medium
Portugal	high	medium	high
Slovenia	high	not indicated	high
Slovakia	medium	low	low-medium
Finland	medium	medium	medium
Sweden	low	medium	low-medium
United Kingdom	high	low	medium

Source: Eurostat (2005); UNFCCC (2005); own estimates

A multitude of policies and measures reported by the Member States are related to other waste management practices (Table 5.20 and Figure 5.6). Prerequisite to reflecting on changes in waste management practices and including emissions and emission reductions from such practices in the inventory is that country-specific parameters are developed and adjusted over time – also in the projections.

For example, changes in waste management practices definitely have an influence in the middle to long term on the average DOC of waste in landfill. However, the effect of these policies and measures can only be revealed in the emission level reported in the inventory in case the DOC of waste is adjusted and not taken as a constant over time. An assessment of the DOC values indicated in the inventory 2004 for the year 1990-2002 shows that some Member States (Austria, Greece, Hungary, the Netherlands, Portugal, Slovenia, Spain, Sweden and the United Kingdom) adjusted their national DOC in this period, others did not (Denmark, Finland, France, Germany, Ireland and Italy).

Table 5.22 DOC of Municipal Waste

	1990	1995	2000	2003
Member States with varying DOC value over time				
Austria	0.200	0.150	0.120	0.120
Greece	0.148	0.150	0.152	0.153
Hungary	0.550	0.540	0.562	0.481
Netherlands	0.131	0.125	0.110	0.091
Portugal	0.186	0.187	0.183	0.183
Slovenia	0.470	0.470	0.470	0.450
Spain	0.177	0.172	0.173	0.173
Sweden	0.140	0.140	0.130	0.140
United Kingdom	0.060	0.061	0.070	0.065
Member States with constant DOC values in time series				
Denmark	0.500	0.500	0.500	0.500
Finland	0.197	0.197	0.197	0.197
France	0.143	0.143	0.143	0.140
Germany	0.500	0.500	0.500	0.500
Ireland	1.000	1.000	1.000	1.000
Italy	0.115	0.115	0.115	0.115

Source: UNFCCC (2005)

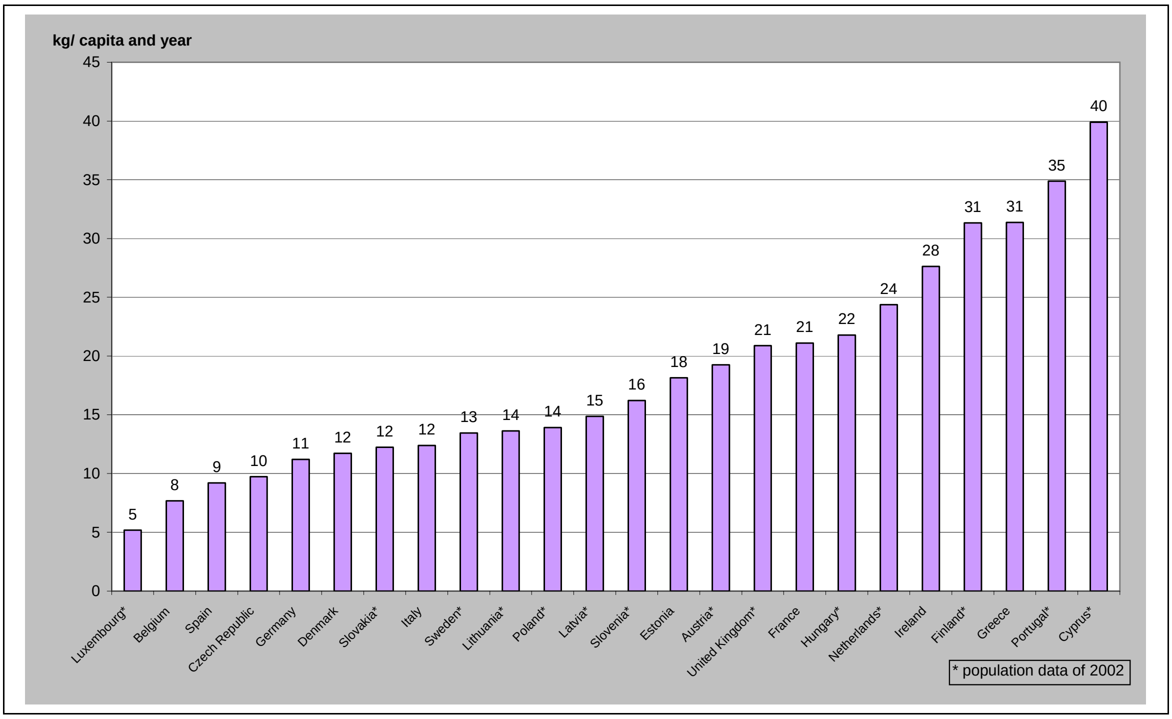
Besides lower quantities of organic carbon deposited into landfills, the major determining factor for the decrease in net CH_4 emissions are increasing methane recovery rates from landfills. The recovered CH_4 is the amount of CH_4 that is captured for flaring or energy use and is a country-specific value which has significant influence on the emission level. 23 policies or measures related to this category are indicated in the third National Communication measure. Methane recovery can be addressed as effective measure as long as sufficient methane is generated on landfills. The technical and economic feasibility of this measure is called into question if the methane generation is strongly decreasing respectively falls under a certain limit. Against the background that the EU Member States reduce or even ban the biodegradable organic waste from landfills according to the Landfill Directive, methane recovery represents only a short- to middle term reduction option, but is very effective during this period.

In general, the emission reduction potentials by methane recovery depend on several factors:

- MSW disposed on landfills (Figure 5.12);
- Methane generation by SWDS (depending on physical factors, waste disposal practices and waste composition)
- Share of methane recovery (Number of landfills that are able to recover)
- Collection efficiency for landfill gas (collected landfill gas/gas generation)

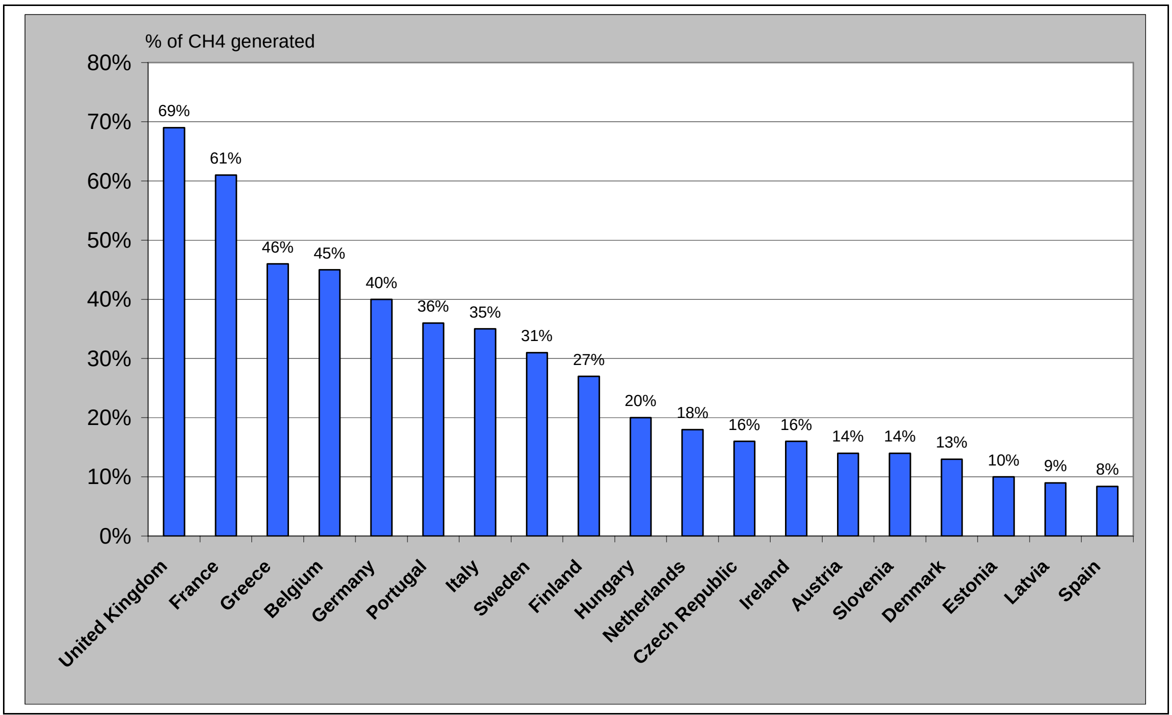
Figure 5.12 and Figure 5.13 provide an overview of the methane generation by MSW on landfills per capita and share of methane recovery in the individual Member States.

Figure 5.12 CH_4 generation by MSW on landfills in kg per capita in 2003



Source: Methane emissions and recovery: UNFCCC (2005), Population data: Eurostat (2004b)

Figure 5.13 Share of CH_4 recovered at CH_4 generation on landfills in 2003



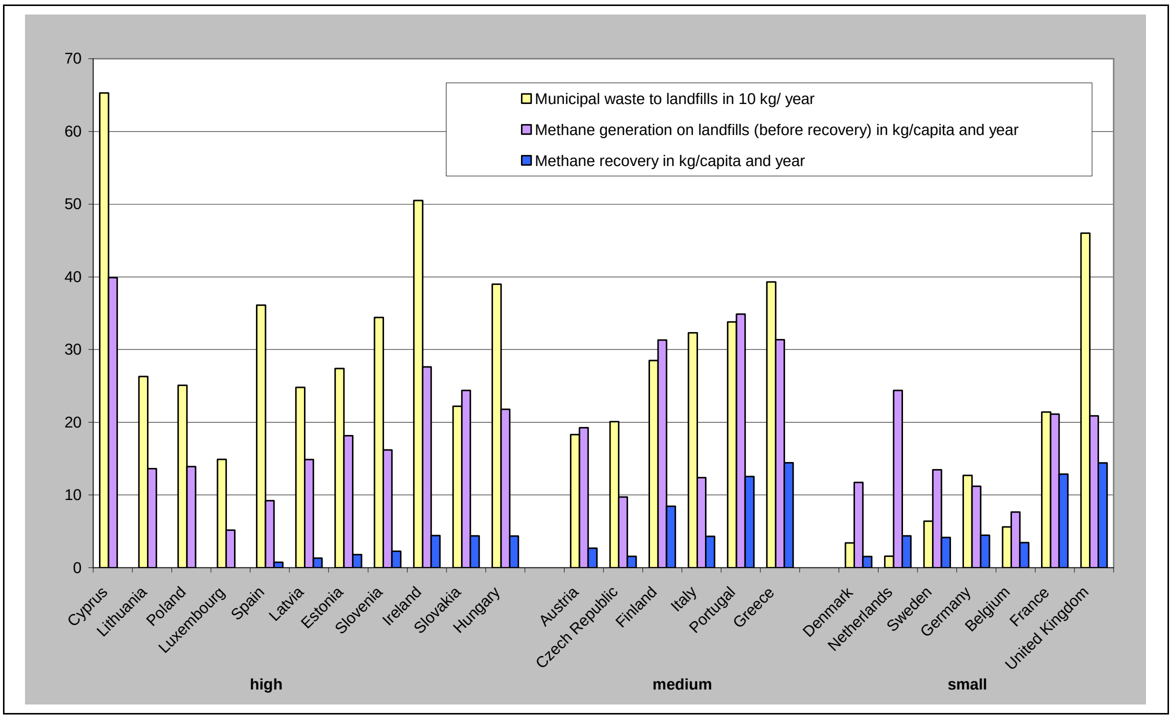
Source: UNFCCC (2005)

The per-capita CH_4 emissions from landfills vary significantly among the Member States. The per-capita CH_4 emission from landfills vary by a factor of around 8, between 5 kg CH_4/capita and year in Luxembourg and 40 kg CH_4/capita and year in Cyprus due to the diverse waste compositions and methane generation potentials.

The share of CH_4 recovered which was reported by Member States in their inventory submission 2005 show a similar range, the share in Spain amounts to 8 % and in the United Kingdom to 69 % while six Member States did not indicate their share. It is not transparent in which Member States no CH_4 recovery is applied and in which the share was not identified and reported. Landfills in the new Member States generally have lower shares of CH_4 recovery or no recovery at all.

In Figure 5.14, the above mentioned factors, the MSW disposed on landfills, the methane generation from SWDS and the methane recovery are illustrated in parallel.

Figure 5.14 Assessment of reduction potential by methane recovery



Source: UNFCCC (2005); Eurostat (2005), own estimates

On the basis of Figure 5.14 an estimate of the emission reduction potentials by methane recovery was undertaken. The Member States are classified in those having an emission reduction potential by methane recovery which is:

- *small*: Member States with a low per-capita rate of waste landfilled, a low methane generation from SWDS and/or a high share of energy recovery: Reduction potentials by methane recovery were already realised in the past and can only be addressed by policies and measures in future in a limited way (UK, France, Belgium, Germany) or the per-capita amount of waste landfilled is very low and some methane recovery has been applied (Denmark, the Netherlands, Sweden).
- *large*: Member States with a high per-capita rate of waste landfilled, a high methane generation rate from landfills and/or a low recovery rate. Some Member States did not indicate their methane recovery rate (Cyprus, Lithuania, Poland and Luxembourg) – they can be assumed to be either zero or rather low. Spain, Latvia, Estonia, Slovenia, Ireland, Slovakia and Hungary already practice methane recovery but as large amounts of waste are landfilled, there is a large potential to be addressed by policies and measures in the future.
- *medium*: Member States with a medium per-capita rate of waste landfilled, methane generation potential and share of energy recovery.

5.4.5 Assessment of policies and measures by Member States

In general, Member States' waste policies aim to reduce the disposal of organic carbon on landfills as it is required by the Landfill Directive. Therefore most of the policies and measures taken by the Member States are directly related to a reduced disposal of biodegradable waste on landfills but also to a stabilisation of existing SWDS and to methane recovery on landfills. Other policies and measures, those related to waste management practices, waste composting, waste prevention and recycling and waste incineration are also – more indirectly – contributing to a reduction of methane from solid waste disposal sites.

The policies and measures taken respectively reported by the Member States in the third National Communications and the Monitoring Mechanism Reports[27] were assessed in detail. One should keep in mind for the evaluation of the policies and measures that the completeness, level of detail and quality of the reporting vary significantly from Member State to Member State. In only a few cases quantitative reduction effects are allocated to the measures reported. Furthermore there is hardly any information on the effectiveness of already implemented measures respectively explanations are missing how the measures will be monitored in future.

Starting with the broad categorisation of the policies and measures according to the category and type, an analysis of the diverse waste management options is undertaken, their environmental impact and the dissemination of the options will be outlined. The assessment will be finalised by some conclusions on the policies and measures taken.

5.4.5.1 Categorisation of policies and measures

Table 5.23 reveals a first insight into which Member States reported policies and measures in regard to which waste management option. From six Member States (Cyprus, Malta, Hungary, Lithuania, Ireland and Luxembourg) no information was available. Too much importance should not be ascribed to the number of measures taken; they cannot be taken as a reliable indicator of how effective, extensive or progressive the measure is. Furthermore some policies and measures were in a planning status when the third National Communications were published and were not implemented afterwards i.e. due to a change in government or waste policy.

[27] Monitoring Mechanism Reports which were available at 15th of June 2005.

Table 5.23 Number and category of policies and measures in the waste sector reported in EU-25

Member State	Total	methane recovery	reduced disposal and stabilization of biodegradable waste on landfills	waste composting	waste incineration	waste management practices	waste prevention or recycling	mechanica-biological treatment	wastewater	other
Austria	**8**		3		1	1	2	1		
Belgium	**8**	2	2		1		3			
Czech Republik	**2**	1					1			
Denmark	**5**	1	1				3			
Estonia	**2**		1							1
Finland	**6**	1	1				4			
France	**10**	2	3	1	2		1			1
Germany	**2**		2							
Greece	**2**	1	1							
Italy	**2**	1	1							
Latvia	**3**	2					1			
Netherlands	**5**	2	3							
Poland	**3**	2		1						
Portugal	**1**					1				
Slovakia	**4**	1							3	
Slovenia	**5**	1			1	1	2			
Spain	**2**	1		1						
Sweden	**6**	2	3			1				
United Kingdom	**1**		1							
Total	**77**	**20**	**22**	**3**	**5**	**4**	**17**	**1**	**3**	**2**

Source: EU Member States; UNFCCC (2005); categorisation by Öko-Institut

It was already mentioned in the analysis of Table 2.1 that most of the policies aim to reduce the disposal of biodegradable waste on landfills, methane recovery and waste prevention and recycling. However, the categories selected are not independent from each other and are not always mutually exclusive. Measures which were classified under "reduced disposal of waste on landfills", for example a ban on biodegradable MSW, necessarily resulting in a shift towards other waste management practices like, for example, waste composting or mechanic-biological treatment of waste. Taking this interaction into account, the high difference in numbers of measures reported should be put into perspective.

In the following, barriers preventing sustainable waste management and a high share of CH_4 recovery are outlined. On this basis it is easier to evaluate what type of policies and measures are adequate to address deficiencies and realize further potentials. In general, the following barriers are possible obstacles for sustainable waste policies:

- Legal framework with clear policy targets is missing or insufficiently pursued.
- Lack of awareness of relative costs and effectiveness of alternative technical options (e.g. MBT, CH_4 recovery).
- Recycling and recovery potentials are not identified or cannot be realized in an economically profitable way.
- Cost structure (e.g. high investment costs) and total cost of waste infrastructure.
- Different policy actors are responsible for energy generation, fertilizer supply and waste management and co-operation is insufficient.

For successful waste policies, these barriers – once they are identified – need to be addressed through appropriate measures. Pre-requisite for a sound waste policy is a legal framework. Furthermore, it is advantageous to formulate principles and targets of waste policies in national waste management plans. Appropriate institutional framework and waste management infrastructure is needed as well. These basic needs can be addressed by a wide range of instrument types. Starting with legislative and regulatory measures for the legal framework, the institutional framework could be established by planning, information and education. The infrastructure, however, might also need to be supported by economic and fiscal instruments. Voluntary agreements can be used to implement waste management projects, like recycling for example, which are economic profitable but in areas where other barriers exist. This type of instrument is usually quite low-cost and flexible in targeting barriers and providing effective information and assistance. On the basis of regulatory measures binding targets and standards can be set, e.g. a ban of landfilling BMW on SWDS. Once an appropriate infrastructure as well as technical awareness exists, market based programs may help to change the cost structure (reduce the high up-front costs) and to finance the total cost of waste infrastructure. National actions can include providing tax credits or low-cost financing on the one hand or taxes to provide a higher incentive for alternative waste options and to generate a tax revenue on the other hand. Table 5.24 provides a broad overview of the policy types applied and reported in regard to the diverse waste management options.

Table 5.24 Types and categories of policies and measures in the waste sector

Category	Total	economic	education	fiscal	information	legislative	planning	regulatory	research	voluntary/ negotiated agreement
Methane recovery	**23**	7		1				13	1	1
Reduced disposal and stabilization of biodegradable waste on landfills	**25**	1		4				20		
Waste composting	**4**	1						3		
Waste incineration	**5**	1				1		3		
Waste management practices	**4**						1	3		
Waste prevention or recycling	**25**	2	2	6	3	1	2	5	1	3
Mechanic-biological treatment	**1**							1		
Wastewater	**3**							3		
Other/Unknown	**2**							2		
Total	**93**	**12**	**2**	**11**	**3**	**2**	**3**	**53**	**2**	**4**

Source: EU Member States; UNFCCC (2005); categorisation by Öko-Institut

The next analytical step consists in looking in detail at the measures taken in the individual waste management categories.

5.4.5.2 Waste management practices

Only four measures are categorised into the general category "waste management practices". The policies indicated in Table 5.25 are general waste policies and plans. These measures are addressing the legal framework and policy targets in the waste sector in these Member States. But it is obvious that many more Member States have similar waste policy frameworks with targets but do not explicitly report them in the third National Communications as measures. Therefore a further evaluation of these measures is not carried out.

Table 5.25 Measures reported by EU Member States in regard to waste management practices

Member State	Description of measure
Austria	Waste Management Act 1990:Framework law regulating waste management – minimisation of environmental impacts
Portugal	Plan of Action for Urban Solid Waste; Strategic Sectoral Plan for Management of Urban Solid Waste; National Plan for prevention of Industrial Waste; Strategic Plan for Hospital Waste; Strategic Plan for Industrial Waste; Strategic Plan for Reduction of Industrial Waste; Application of Landfill Directive: Promote reduction, reutilisation and recacling of the various types of waste, thus promoting direct and indirect GHG emissions reductions
Sweden	Environmental Code requirements vis-a-vis municipal waste plans: more efficient waste
Slovenia	Regulation on Waste Disposal and Waste Management: Emission reduction due to the regulation and closure of dumping areas and better waste handling

Source: EU Member States

5.4.5.3 Waste recycling and prevention

Waste prevention is the most sustainable approach to reducing emissions from the waste sector. Recycling diverts components of waste stream for reusing the materials contained within them. Some materials can be recovered mechanically from bulk- collected MSW, such as metals recovered in incinerator ash and metals and glass recovered from MBT. To obtain a higher quality of material requires segregation from other wastes at source. This is usually essential for paper and plastic recycling. Recycling of the latter two materials can contribute to a reduction in the amount of biodegradable waste on landfills, while metals and glass i.e. do not contribute to methane generation on landfills. Moreover, in general, waste recycling saves usually energy and hence emissions of greenhouse gases and other pollutants. A further positive environmental benefit from this waste management option is that it prolongs reserves of finite resources and thus contributing to the sustainable use of resources (EC 2001).

Table 5.26 reveals an insight into the policies and measures reported by the Member States in the field of waste recycling and prevention. It can easily be seen that a large number of Member State take measures in regard to this management option.

Table 5.26 Measures reported by EU Member States in regard to waste recycling and prevention

Member State	Description of measure	Emission reduction effect (2010) in Mt CO2 eq	
		Mt CO2 eq	% of CO2 eq in 2003
Austria	Promotion of waste recovery: higher share of waste recycling		
	Other programmes to launch waste prevention and recovery: prevention of waste; higher share of energy recovery / recycling		
Belgium	Introduction of specific channels of waste management: Optimised management and recovery of industrial waste		
	Reduction of waste at source: To reduce the quantity and harmfulness of waste at source recovery of waste		
Czech Republik	Draft Act on waste and Draft Act on packaging: Harmonization of the CR legislation with the EU legislation		
Denmark	Waste tax: more recycling, least possible landfilling		
	Weight-based taxes		
	Grant programme for cleaner products: waste reduction, pollutants out of the waste	200	7
Finland	Waste minimisation, the collection and recovery of waste paper and other waste fractions		
	Waste tax		
	Waste minimisation, the utilisation of source-separated waste fractions as material and energy		
	Development of waste taxation		
France	Reinforcing Recycling of Materials or Organic Matter		
Latvia	Waste recycling: To reduce the amount of household waste in landfills		
Slovenia	Waste Disposal Tax: Reduced quantity of waste		
	Separate Waste Collection and Packaging Waste Management: Reduced quantity of waste by source	42	5

Source: EU Member States

Table 5.24 and the description of the measures taken by the Member States (Table 5.26) show that the waste recovery and prevention is supported by a wide range of different policy types, starting from voluntary agreement via research to more binding measures, like taxes. In general the reduction effects from these measures are difficult to assess.

The general conclusion from the implementation of the Directive 94/62/EC on Packaging and Packaging Waste (Ecolas 2005) has been (section 5.4.2), that recycling is often implemented in the absence of legislation, merely to the fact that it is economically profitable. In these cases soft instruments like awareness raising or research support for identifying the reduction potential seem to be sufficient. In cases where recycling is not economically profitable an assisting economic instrument like taxes could extend significantly the share of recovery and recycling.

5.4.5.4 Reduced waste disposal and stabilization of biodegradable organic waste on landfills

Reduced waste disposal on landfills and stabilization of biodegradable organic waste on landfills is one of the most important strategies in the waste sector which is significantly advanced by the EU Directive on Landfills 1999/31/EC. As can easily be seen by analysing Table 5.27, measures are mainly reported in the National Communications by Member States whose potential nowadays can be estimated to be minor. It can be assumed that part of the policies and measures are already showing their effect. Contrariwise, many Member States for which a high reduction potential can be assumed did not report policies and measures.

Table 5.27 Measures reported by EU Member States and assumed reduction potential in regard to reduced waste disposal on SWDS

Member State	Reduction potential by reduced disposal and stabilization of biodegradable waste on landfills	Description of measure	Emission reduction effect (2010) in Mt CO2 eq	
			Mt CO2 eq	% of CO2 eq in 2003
Austria	low-medium	Landfill Regulation 1996: Minimisation of waste landfilling	900	26
		Landfill Charge Act 1989: Reduction of disposal of waste on landfills; earmarking of revenue for clean-up of contaminated land		
		Expansion of waste treatment capacities other than landfilling: Banning disposal on landfills, by 2004/2008; expanding share of other capacities, e.g. energy efficient incineration		
Belgium	low	Moratorium on dumping organic waste (Ban on dumping organic waste): Closure of biologically active landfill sites		
		Ban on dumping biodegradable organic waste:To stop waste going to landfill sites		
Denmark	low-medium	Obligation to send combustibel waste for incineration (in practice a ban on landfilling): less landfilling, energy production, more recacling, CH4 reduction	300	21
Estonia	medium	Requirements to Establishing, Using and Closing of Landfills		
Finland	medium	Government decision on landiflls		
France	medium	Ban on Dumping of Ordinary Waste	12,200	85
		Biological Pre-Treamtment as an inhibitor during the Operating Period		
		Analysis and Control of Biochemical Reactions in Dumps		
Germany	low-medium	Technical Instruction on Waste from Human Settlements (TA Siedlungsabfall) and Ordinance on Envrionmentally Compatible Storage of Waste (Ablagerungsverordnung): To prevent CH4 emissions and use substitutes for fossil fuels		
Greece	high	Landfill Directive: waste management		
		Technical Instruction on Waste Management (TA Abfall), Part 1, and Ordinance on Landfills (Deponieverordnung)	300	6
Italy	medium- high	Legislative decree 36/ 2003: Stabilization of the organic fraction: operating and technical requirements for waste and landfills	640	5
Netherlands	low	Decree on Soil Protection from Landfills		
		Decree on Waste landfills and waste landfills bans		
		Landfilling Tax		
Sweden	low-medium	Ban on landfill of organic waste: More stable landfills and use of waste as a resource		
		Ban on landfill of sorted burnable waste: Improvement in disposal of all burnable waste		
		Waste Tax Act: Reduce the quantity of landfilled waste		
United Kingdom	medium	Waste Strategy and EU landfill Directive	300	3
Cyprus	high			
Latvia	medium			
Lithuania	medium			
Luxembourg	medium			
Hungary	high			
Poland	medium			
Portugal	high			
Slovenia	high			
Slovakia	low-medium			
Ireland	high			
Spain	high			
	Estimate by Öko-Institut	Third National Communications		

Source: EU Member States; estimate by Öko-Institut

The National Strategies pursued for achieving the targets of the EU Directive which were illustrated in Table 5.20 amend and update those of Table 5.27. However the national strategies in the new Member States are not outlined there.

Table 5.27 and Table 5.20 reveal that measures related to this waste management option were estimated in several Member States. Looking in detail at the measures it can be concluded that there are several different approaches to coping with the requirements of the EU Directive. In most of the Member States biodegradable MSW waste is banned from landfills or there is a strong obligation for pre-treatment (Austria, Denmark, France, Germany, Italy, Greece, the Netherlands and Sweden). Estonia reports that they are in the process of defining the requirements for establishing, using and closing for landfills. In contrast, other Member States apply economic instruments: the United Kingdom makes use of tradable allowances for landfilling of biodegradable waste, in the Netherlands the ban is combined with a landfilling tax. Portugal it is under consideration if economic and/or regulatory instruments are introduced.

5.4.5.5 Methane recovery

Methane recovery as an emission reduction option was already described in detail. It plays an important role for the climate policies in the waste sector. In Table 5.28 the analysis results from section 5.4.4 are confronted with the policies and measures effectively reported by the Member States in their third National Communications. As can be seen, even five Member States with a reduction potential which was assessed to be minor report measures related to methane recovery. Looking in detail at the description of these measures, it can be noticed that in Member States with low shares of MSW going to landfills (Sweden, the Netherlands and Denmark) the focus is laid on former dumpsites, even there reduction potentials are assumed.

Only four Member States (Spain, Poland, Slovenia and Slovakia), for which the emission reduction potential by methane recovery is estimated to be high, report measures in this field. In other Member States which have favourable conditions for an increased share of methane recovery, Estonia, Ireland, Cyprus, Lithuania, Luxembourg, Hungary, Austria and Portugal, this waste management option should be considered further as a possible emission reduction option in future.

Table 5.28 Measures reported by EU Member States and assumed reduction potential in regard to methane recovery

Member States	Reduction potential by CH_4 recovery	Description of measure	Emission reduction effect (2010) in Mt CO2 eq	
			Mt CO2 eq	% of CO2 eq in 2003
Belgium	low	Modifications to the VLAREM legislation:Elimination and recovery of discharged gases		
		Remedial treatment of old landfill sites: Recovery of discharged gas		
Czech Republic	medium	Utilization of landfill gas		
Denmark	low	Increased collection of methane from landfill sites	93	8
Germany	low			
Greece	medium	Flaring of landfill gas	98	3
Spain	high	Reduction program, National Plan for urban waste: Capture and use of biogas		
France	low	Recovery of Methane at Dump site		
		Efficiency of Gas Capture Systems in Dumps		
Italy	medium	Energy recovery from municipal waste	330	3
Latvia	high	Biogas generation Project Modernisation of "Getlini"- Riga municipal landfill	18	3
		Project No.2 Waste management in Liepaja (modern waste management system and use of produced biogas for energy generation)		
Netherlands	low	Identification of reduction potential of emissions from former dumpsites		
		Financial support programs for landfill gas collection and utilization		
Austria	medium			
Poland	high	Construction of 400 kW/year biogas energy systems		
		Modernisation of medium-size landfills together with their degasing		
Slovenia	high	Landfill Gas Extraction and Combustion, Energy Exploitation or Use of Landfill Gas	126	22
Slovakia	high	Support of separated waste collection and utilisation of biologically active waste biogas combustion	260-428	19-30
Finland	medium	Landfill gas recovery and utilization		
Sweden	low	Collection of landfill gas		
		Landfill Directive: Compulsory collection of landfill gas		
United Kingdom	low			
Estonia	high			
Ireland	high			
Cyprus	high			
Lithuania	high			
Luxembourg	high			
Hungary	high			
Portugal	medium			
	Estimate by Öko-Institut	3rd National Communications		

Source: EU Member States; estimate by Öko-Institut

5.4.5.6 Waste incineration

The most widely practised alternative to landfilling is mass-burn incineration, where bulk MSW is burnt with little or no pre-treatment. Energy recovered from waste can replace the need for electricity and/or heat from other (fossil) fuels. The net climate change impacts of incineration depend on how much fossil-fuel carbon from conventional energy sources incineration displaces. The main residue from incineration is volume-reduced inorganic ash, which has virtually no capacity to produce methane when disposed of in landfills. With an operational life of 20-30 years, incinerators need a guaranteed supply of waste within specified composition ranges. Waste management planners must therefore take careful account of the impact of recycling activities on the availability and composition of waste destined for incineration under long term contracts. For example, extensive recycling or paper or plastics could result in a residual waste enriched in food and garden wastes that would be too wet to incinerate.

An environmental drawback of this technology option is that emissions arise from harmful airborne pollutants such as NO_x, SO_2, HCl, fine particulates and dioxins. CO_2 emissions arise from fossil-derived waste (e.g. plastics) and N_2O contributing to global warming. However, thanks to progress in incineration technologies, emission reductions could also have been achieved in regard to these emissions. Furthermore, in cases in which large amounts of waste has to be transported over distances in order to operate the waste combustion plant at full capacity, the net climate impact will be less positive. However, this is also true for other waste management practices (landfills, MBA, composting) and can be influenced by efficient waste planning and adequate projection of waste generation rates. Finally, waste incineration is a comparatively expensive waste management option.

Table 5.29 Measures reported by EU Member States in regard to waste incineration

Member State	Description of measure	Emission reduction effect (2010) in Mt CO2 eq	
		Mt CO2 eq	% of CO2 eq in 2003
Austria	Efficient energy recovery from waste: energy recovery from waste incineration (CHP)		
Belgium	Modifications of waste incineration installations:To improve the environmental performance of incinerators		
France	Conversion of Waste to Energy: Energy substitutes (doubling the incineration capacity of OM) Make Heat Recovery from Incinerators a widespread practice	1,300	9
Slovenia	Thermal waste processing: Reduced quantity of waste and exploitation of waste energy		

Source: EU Member States

5.4.5.7 Waste composting

Waste composting is the aerobic degradation of waste to produce compost which can be used as a soil improver. It avoids methane production from degradation of organic waste in landfills as degradation is aerobic. Furthermore it has beneficial effects on greenhouse gas emissions by replacing other products like fertiliser and peat and may also lead to increased storage of carbon in the soil (carbon sequestration). Composting needs careful control of the composting process to avoid bio-aerosols. Efficient source segregation of food and garden wastes destined for centralised composting is an absolute prerequisite if the resultant compost is to be of sufficient quality of marketing (EC 2001).

As can be seen in Figure 5.9 the EU-15 Member States with the lowest share of MSW landfilled make use of waste composting as an alternative waste management option for biodegradable waste. Reduction potentials by composting can be assumed in Member States with high shares on BMW to SWDS which do not practice waste composting yet, for example Finland, Italy, the United Kingdom, Ireland, Greece and the new Member States.

In the third National Communications, however, only three Member States (France, Poland and Spain) reported policies and measures related to composting (Table 5.30).

All three Member States already practice this waste management option, although Poland only to a small degree.

Table 5.30 Measures reported by EU Member States in regard to waste composting

Member State	Description of measure
France	Agronomic Recycling of Organic Waste
Poland	Processing of 2 % of waste annually to produce compost for the purpose of the landfill to coverage and relevant land reclamation: emission reduction from landfills
Spain	Compost program, National Plan for urban waste: Use of organic municipal waste for composting

Source: EU Member States

Moreover, in the national strategies (Table 5.20) the Walloon region in Belgium, the Netherlands and Portugal indicate this waste management practice explicitly as national strategy for the reduction of biodegradable waste going to landfills. However, these Member States have as well already significant shares of MSW composted (Figure 5.9).

The analysis shows that even Member States with a considerable share of waste composted use this option to reduce further their greenhouse gases. Therefore it can be assumed that in most of the Member States, but especially in the Member States mentioned above (Finland, Italy, the United Kingdom, Ireland, Greece and the new Member States), further potentials could be realised.

Analysing the inventory submission 2005, there are only 5 Member States (Austria, Belgium, Finland, Italy and the Netherlands) (UNFCCC 2005) reporting emissions from composting which contradicts the fact that, according to the Eurostat data (Figure 5.9) 19 Member States make use of composting as waste management option. Inter alia this can be traced back to the fact that the Revised 1996 IPCC Guidelines (1996) do not give methodological guidance on estimation of emissions from composting. However, if the policies and measures related to this management option will be taken more often, it is essential that emissions are monitored appropriately: there is a need for detailed guidelines to determine emissions from composting. It is planned to include calculation methodologies related to composting into the 2006 IPCC Guidelines.

5.4.5.8 Mechanical- Biological Treatment

MBT is a pre-treatment option for landfilling. Raw MSW (or residual waste enriched in putrescible wastes after the removal of materials for recycling) is processed by a combination of mechanical and biological steps to reduce the bulk and biological activity of the processed waste, which is then landfilled or used for landfill site cover or restoration. Recyclable or combustible materials may be removed from the waste for recycling or incineration. Pre-treatment of MSW by MBT prior to landfilling significantly reduces methane emissions from the landfilled waste, compared with untreated MSW. However this waste management option still depends on landfill as repository of final waste, so not as sustainable as recycling or composting. MBT is currently mostly confined to Austria and Germany (EC 2001).

Table 5.31 Measures reported by EU Member States in regard to mechanical biological treatment

Member State	Description of measure
Austria	Define technical state of art for mechanical-biological treatment of waste: Better investment security for operators of waste treatment sites with respect to technical standards Expansion of waste treatment capacities other than landfilling: Residual matter from thermal or mechanical-biological treatment will have to be disposed of in mass waste landfills with very limited content of methane gas and other pollutants.

Source: EU Member States

Regarding reporting the situation similar as described in context with waste composting: the IPCC Guidelines (1996) do not propose methodologies to determine emissions from landfills if the waste is mechanical-biologically pre-treated.

5.4.6 Conclusions

In the waste sector, considerable emission reduction potentials have already been realized and further progress is expected in all EU Member States. Although in EU-9 and in EU-15 in average emission reduction could be achieved between 1990 and 2003, there are Member States with increasing emissions in this period (Cyprus, Latvia, Slovenia, Malta, Slovakia, Spain, Ireland and Portugal). Up until 2010, however, also in these Member States a trend reversal is projected.

A large share of emissions in the waste sector derives from the landfilling of waste. The most significant factors affecting CH_4 generation in landfills are physical factors, waste disposal practices, waste composition; the methane emission is additionally dependent on the recovery rate. The early implementation of the EU landfill Directive (Directive 1999/31/EC) in some of the EU-15 Member States was largely responsible for the decline of GHG and is projected to contribute strongly to further emission reductions until 2010 – especially in the new Member States. Emission reduction potentials are assessed to be high in the Member States with a high per-capita rate of waste landfilled, high methane generation rate and/or low recovery rates. This is the case in most of the new Member States, Spain and Ireland. In Member States with a low per-capita rate of waste landfilled, a low methane generation and/or a high share of recovery, the greatest potentials have been already realised (Denmark, the Netherlands, Sweden, the United Kingdom, France, Belgium and Germany).

There are different environmental impacts and potentials to reduce the net climate impact by other waste management options than landfilling. The potentials of the waste management options – and the influencing factors which vary from country to country and have to be assessed individually– are analysed in detail in EC (2001) and will not be highlighted in this context.

The analysis of the policies and measures reported in the third National Communications shows that in most of the cases regulatory instruments are applied to reduce the biodegradable waste from landfills, in some cases economic instruments are preferred. Incentives for methane recovery are predominantly achieved by economic instruments. However the closely related promotion of other waste management practices is advanced by a multitude of types of measures beside the widespread use of regulatory instruments both soft measures like informative, educational approaches and voluntary agreements especially in regard to waste prevention and recycling and invasive instruments but also fiscal instruments and research is applied.

As all Member States have to deal with alternative treatment of biodegradable waste, the most sustainable alternative composting should be focused more intensively in future. However, there is a clear need to develop international guidelines for the determination of the emission related to these management options in order to reflect adequate the progresses in the inventories and to have a sound basis form monitoring.

It can be concluded that by reaching the targets of the Landfill Directive major emission reduction potentials in the waste sector are realised. However, there are more emission reduction potentials – further shifts to more favourable waste management practices as waste prevention and recycling. Furthermore potentials by methane recovery are not directly addressed by the Directive.

Having analysed the policies and measures reported in the third National Communications, it is unclear whether the projected emission reductions and the targets of the Landfill Directive will be achieved especially in those Member States which had increasing waste emissions in the past. Many of these Member States did not report in the third National Communications or did not report in detail their policies and measures undertaken. Furthermore the new Member States did not have to report yet their national strategies to achieve the target by the Landfill Directive. On this basis it is difficult to assess the effectiveness of the policies – a pre-requisite for the successful implementation of the Landfill Directive and the realisation of the national projections.

6 Summary and conclusions

The most recent progress report under the Greenhouse Gas Monitoring Mechanism showed that many EU Member States are at present considerably far off their target to reduce greenhouse gas emissions under the Kyoto Protocol. Against this background it seems to be indispensable that the EU Member States not only put efforts into introducing additional policies and measures but also that the effectiveness of the policies and measures is improved.

Methodological aspects

In this report we analysed the impacts of the Member State's climate policies and measures on their greenhouse gas emission trends and projections. Since the projected developments can often only be understood if the past trends are taken into account, we put particular emphasis on the integrated presentation and simultaneous evaluation of trends and projections. In our first analytical step we applied a set of indicators which allowed us to identify the driving forces for the greenhouse gas emissions, namely the share of CO_2 emissions in total greenhouse gas emissions (CO_2emissions/total greenhouse gas emissions), the carbon intensity (CO_2 emissions/total primary energy supply), the conversion efficiency (total primary energy supply/total final energy consumption), the energy intensity (total final energy consumption/gross domestic product) and, last but not least, the economic development (gross domestic product/capita). Based on this set of indicators we were able to explain the past and the projected development of the greenhouse gas emissions per capita at macro level by applying two different methodological approaches, a relative and absolute decomposition analysis:

- The decomposition of the driving forces in relative terms provides an overview of the causes for the development of the per-capita greenhouse gas emissions. For the analysis the development of these driving forces indicators were normalised to 100 in 1990 and plotted in a single graph for each Member State.
- For the decomposition of the driving forces in absolute terms we applied the LOG mean Divisa index decomposition method developed by Ang (2004). This method enabled us to quantify the annual contribution of each driving force to the greenhouse gas emission trends and projections.

As a basis for in the decomposition analysis a comprehensive database for greenhouse gas emission, energy and socio-demographic data, such as population and gross domestic product was compiled. This database includes time series based on different data sources both for the past trends and for the projected development. As not all the data necessary for the analysis are provided by one data source, the database inevitably had to be compiled from different data sources.

From this database a reference data set for the further analyses was selected and examined with regard to its data quality. This analysis showed, however, that combination of different data sources might undermine the reliability of the database as the data sources selected are not fully compatible and consistent. Consistency problems mainly occurred with regard to the carbon intensity. They became apparent when data of fossil Primary Energy Supply by UNFCCC and Eurostat were compared. The reliability analysis showed that deviations of the two data sources in the reference data were significant, and varied significantly between each Member State. Against this background, the vertical comparison of this indicator between different countries had to be interpreted with cautious. In most of the EU Member States the development of the indicator over time was not directly affected by the inconsistencies, however, the inconsistencies identified in the cases of Belgium, Latvia, Sweden and the United Kingdom had to be taken into account for the interpretation of the development of their carbon intensity. In spite of these problems we had to pursue a pragmatic approach in order to a have a data set which is complete with regard to Member States and years available.

Decomposition analysis

Based on the decomposition methodologies and the reference data set a comprehensive analysis of the development of the driving forces was undertaken for each of the EU Member States. This approach was completed by an international comparison of the driving forces indicators for the EU as a whole.

The analysis highlighted EU trends and projections and how they are influenced by developments in individual Member States. Based on the absolute level of the indicators in the Member States and the relative changes, potentials for further policies and measures were identified. Some essential results are summarized below:

- It was assessed that on average the carbon intensity of all EU Member States considered was improved by 11% during the period between 1990 and 2002. In the years to come it will further improve although at a slower pace (-7%) which can be explained by the deterioration of carbon intensity in the new Member States (+5%). In Ireland and Portugal the carbon intensity will be higher at the end of the recent decade than in 1990. Therefore particularly in these countries it should be investigated whether additional policies and measures can be established to change this trend before the end of the period.
- For the European Union as a whole, the conversion efficiency virtually did not change during the nineties and will not do so until 2010. In most of the Member States the conversion efficiency remained constant or deteriorated but is projected to improve again over the period considered. Particularly the Czech Republic and Estonia should screen their potentials for improvements of the conversion efficiency as it deteriorated substantially during the nineties and is projected to continue deteriorating until 2010.

- On average, the energy intensity in the EU was improved by 16% during the nineties. Until 2010 it will be further improved by an additional 7%. While there is an obvious overall trend to lower energy intensities, the performance of the individual Member States varied substantially. The energy intensity in the new Member States was improved and is projected to improve much more than in the EU-15 Member States as it was, in absolute terms, several times worse than the EU average in 1990.
- There was an overall EU trend towards lower per-capita greenhouse gas emission in the nineties. However, some EU-15 Member States (Portugal, Spain, Austria, Italy and Greece) with high economic growth and per-capita greenhouse gas emissions significantly below the European average showed an increase in the per-capita greenhouse gas emissions in this period. Slovenia is the only new Member State with increasing per-capita emissions between 1990 and 2002.

  Regarding the projected greenhouse gas emissions per inhabitant, the picture is more heterogeneous. There are both new and EU-15 Member States with rising per-capita emissions. The overall trend in the EU-15 Member States still remains negative (-4%). In the New Member States, however, per-capita emissions will grow by 11% between 2002 and 2010. The development in the individual Member States varies substantially. In some countries the per-capita greenhouse gas emissions will grow significantly (Latvia, Poland, Hungary, Luxembourg and Denmark), in others the per-capita emissions continue to decline (Germany, Ireland, the Slovak Republic and the Czech Republic).

For the assessment of the absolute contribution of each driving force to the greenhouse gas emissions trends and projections the Log Mean Divisa Index decomposition was applied. Based on this method we could estimate the annual contribution of these indicators during the periods 1990-1995, 1995-2002 and 2002-2010. The most important results are presented below:

- In the new Member States the improvement of energy intensity contributed most to the emission reduction: Between 1990 and 1995 (1995-2002) the improvements of the energy intensity induced a greenhouse gas emission reduction of -4.5 Mt CO_2 (-4Mt CO_2) annually. In the first half of the nineties, the reduction of total greenhouse gas emissions was delayed by the deteriorating conversion efficiency (+1.25 Mt CO_2/a). In the second half of the nineties, the economic growth was responsible for an increase of emissions by +3.5 Mt CO_2 annually. Somewhat more positive effects on the emission level derived from improvements of the carbon intensity. But for future this driving force is projected to delay the emission reduction. Between 2002 and 2010 the greenhouse gas emissions are projected to grow by +3.5 Mt CO_2 annually, mainly due to economic growth (+4.7 Mt CO_2/a) which cannot be compensated any longer by improvements of the energy intensity (-4 Mt CO_2/a).
- In the EU-15 Member States the energy intensity also contributed rather positively to the reduction of greenhouse gas emissions (1990-1995: -7 Mt CO_2/a, 1995-2002: -3.7 Mt CO_2/a). At the beginning of the nineties and up until 2010, the improve-

ments of the carbon intensity had or will have a significant impact on the reduction of greenhouse gas emissions. Its contribution will be even larger than that of the energy intensity. The conversion efficiency, which shows a favourable trend in the new Member States, turned out to be a limiting factor for the emission reductions in the EU-15 Member States at the end of the nineties. Improvements in the future will, however, support the compensation of the increase due to economic growth.

In-depth analysis of driving forces

Because the analysis on macro level does not always provide a clear picture of the diverse influencing factors, an in-depth analysis of the conversion efficiency, the carbon intensity and the transport sector was undertaken.

The *conversion efficiency* was investigated in detail in regard to overlapping and partly conflicting structural and efficiency effects in order to address properly starting points for policies and measures. It could be assessed that there is an overall trend in the EU towards a higher share of electricity consumption in total final energy consumption which is one of the largest obstacles to improve the conversion efficiency. Achievements in efficiency improvements tend to compensate the negative structural impact on the conversion efficiency: There is an overall EU trend towards higher efficiencies in heat and power generation – inter alia by combined heat and power (CHP) –, both in the past and for the future.

Apart from the general EU trends potentials for more efficiency improvements in electricity generation are identified in Sweden, France, Germany and Greece as these Member States have efficiencies in electricity generation lower than the EU average and they have rather low shares of CHP in electricity generation. Potentials for more ambitious efficiency targets and promotion of CHP in steam generation could be assumed in Latvia, Slovakia, Sweden, France, Greece, Ireland and Cyprus.

It was striking that some Member States which in 2002 already had the highest efficiencies in the EU (electricity generation: Luxembourg, the Netherlands, Ireland, Denmark and the United Kingdom; steam generation: Hungary, Denmark, Italy, the Netherlands and the Czech Republic) still have very ambitious targets, ending up with efficiencies which are even more favourable than the EU-average.

In the EU-15 a further increase of electricity generation in CHP plants is expected, while the substantially higher CHP share in electricity generation in the new Member States will decrease slightly, resulting in a growth in EU-25 but at a slightly slower pace than in the past. However, CHP in total electricity generation has mainly decreased in Member States which already have and will have in 2010 shares above the average values in the EU. The average share of CHP heat increased and is projected to grow further in 2010, although somewhat more strongly in the new Member States than in EU-15.

In general the *carbon intensity* of the TPES can be reduced through an increased contribution of nuclear or renewable energies or through a shift from carbon intensive to less carbon intensive fuels.

During the nineties, most Member States improved their carbon intensities of the TPES, some of them even significantly. In most Member States this improvement was supported through the increased contribution of renewable energies. In most of the Member States who dispose of nuclear power plants this trend was also supported by an increased contribution of nuclear energy to the TPES. However, in Belgium, Finland, the Netherlands and Slovenia the contribution of nuclear energy did not change or decreased slightly. Only Spain and Sweden had to compensate their reduced contribution of nuclear energies through putting more efforts into the other strategies. Most Member States also shifted their fossil energy supply to less carbon intensive fuels. In Denmark, Finland, Ireland, Portugal, Latvia and Poland, however, the carbon intensity of the FPES did not improve but rather deteriorated. Finland, Ireland, Portugal and Poland were also the countries where the carbon intensity deteriorated or was not improved substantially during the nineties.

For the future the picture is somewhat different: The EU as a whole will improve their carbon intensity at the same rate as during the nineties (-0.8%/a). But as the carbon intensity is projected to grow again in the new Member States (+0.8%/a) this rate can only be maintained through stronger improvements in the EU-15 Member States (-1.2%/a). The increased contribution of nuclear energy will only in Finland, France and the Czech Republic improve the carbon intensity of the TPES. In all other countries with nuclear reactors the share of nuclear energy is projected to decline until 2010. To compensate this trend, it is necessary to put additional efforts into the other strategies. Correspondingly it is projected that the contribution of renewables will increase substantially, particularly in the EU-15 Member States while it is decreasing in some of the new Member States. The improvement of the carbon intensity of the fossil primary energy supply will be continued in most of the Member States. However, substantial deteriorations are expected in Denmark, Finland, Luxembourg, Latvia and Poland. In Belgium, Germany, Spain, Lithuania and Slovakia the shift to less carbon intensive fuels will, in contrast, be intensified according to the projections.

All in all, one can conclude that particularly Denmark, Finland, Luxembourg, Poland and Latvia should investigate whether there are remaining potentials to improve their carbon intensity of the fossil primary energy supply through a shift to less carbon intensive fuels. According to the projections, the contribution of renewables to the TPES will decline in Portugal, Estonia, Hungary, Latvia and Slovakia. Therefore these countries should explore further potentials for an increased contribution of renewable energies to their TPES.

The in-depth analysis of the *transport* sector showed that the significant growth in energy demand of this sector counteracted other savings in total final energy. Based on indicators regarding passenger and freight transport as the share of energy demand by transport at total final energy consumption, share of cars and trucks at the modal split, per-capita energy consumption, passenger and freight kilometres and the share of cars and trucks per 1,000 inhabitants, differing trends and projections of the Member States were identified in order to provide a more differentiated picture of the EU trend.

These results show that in energy consumption of road freight and passenger transport, processes of convergences between the new and EU-15 Member States are taking place. Based on the projections, the overall trend towards higher per-capita energy consumption, going hand in hand with increasing freight and passenger kilometres in road transport, cannot be reversed up until 2010. In other words, efficiency gains by technological progress are not sufficient to reverse the growth in energy demand for road mobility. The stabilisation of the road fleets cannot be achieved up until 2010; both the number of cars per 1,000 capita and the number of trucks per 1,000 capita are projected to grow – in the new Member States with a significantly larger growth rate than in EU-15. Shifts in the modal splits, which result in a decreased share of road at total transport, can be noticed in some of the Member States. But they can only be assessed as positive if road transport is substituted by less energy intensive transport modes. However, if the share of aviation is growing instead, the energy and emission balance continues to deteriorate. Altogether, the growing energy demand in the transport sector is obviously one of the largest obstacles for total emission reductions.

Case studies

Finally, an analysis of selected policies and measures applied by the Member States was undertaken. The aim was to focus on widely applied national measures as well as common and coordinated policies on an EU level. In the form of case studies, the promotion of combined heat and power and renewable energies as well as the policies and measures in the waste sector were investigated in detail. By doing so, an informative basis was provided on which the effects of policies and measures can be evaluated with more reliability.

The case study on *renewable energies* showed that all Member States initiated polices and measures in this policy field, not only in order to achieve emission reductions under the Kyoto Protocol but also to fulfil the target of Directive 2001/77/EC. This directive imposes the obligation to increase the share of renewable energy sources in energy production. However, analysis of the progress reports reveals that policies and measures currently in place are insufficient to achieve the overall EU target: it is expected that the share of renewables can be increased only to 18-19% in 2010, herewith missing the target of 22%. One of the reasons for this discrepancy appears to be that a number of Member States have not yet introduced effectual policies which are in line with their targets the have adopted. According to the Progress Report by the Commission (EC 2004), only four Member States are currently on track to meet the target: Denmark, Germany, Spain and Finland. While the United Kingdom, the Netherlands, Ireland, Belgium, France, Sweden and Austria are about on track, the European Commission comes to the conclusion that in Greece and Portugal, considerable efforts are still needed to reach the target.

As far as the types of instruments are concerned, it could be assessed that feed-in tariffs are still the most common one. However, currently some Member States tend to give it up and introduce a quota system which is regarded to be a more economically efficient measure. Simultaneously, fiscal measures, such as tax refund, exemption and investment support (subsidies, loans) exist as a very common tool in many countries, both in EU-15 and in the new Member States.

The progress in policies and measures for the promotion of *combined heat and power (CHP)* production is rather difficult to quantify due to the weak data basis. EU policy, the Directive 2004/8/EC, aims at providing a framework for the promotion of CHP but does not specify targets for the individual Member States. Furthermore the Directive entered into force only in 2004. It has to be transposed into national laws by 2006.

However, on a qualitative basis, several lessons can be learnt: the penetration of the energy market by CHP varies strongly among the Member States. The penetration rate of CHP does not diverge strongly between EU-15 and the new Member States: rather within the two country groups there are large differences. Beside the lack of special laws on regulating CHP, possible obstacles of the development of CHP are long bureaucratic procedures, unfavourable market structures for decentralised energy supply (i.e. monopolistic supply structures in the energy sector), generation overcapacity, high gas prices and low energy prices. The liberalisation of the EU energy market has both positive and negative effects: positive effects might derive from the abolition of monopolistic structures; decreasing energy prices might, however, reduce incentives for investment in CHP. In general, economic instruments are the most commonly used measures to support CHP, followed by regulatory instruments.

Positive developments in the CHP sector could be registered in Austria, Belgium, the Czech Republic, Denmark, Finland, Hungary, Luxembourg, the Netherlands, Portugal, Italy and Sweden. The success of the CHP development can be traced back to diverse political factors. In general the governments of the Member States mentioned above are all in all supportive of CHP. The types of policies and measures applied in the individual Member States are diverging. Belgium has a very efficient certificate scheme. Austria made use of feed-in tariffs. In Denmark, however, a planned approach in combination with the willingness of utilities to integrate decentralised generation was the key for success.

In some of these Member States, however, there is a need for adjusting the political framework in the future in order be to able to continue further realisation of CHP potentials (Austria, the Netherlands, Portugal, the Czech Republic and Denmark). Furthermore good prospects and potentials can be registered in Belgium, in Sweden, in the latter inter alia due to the phase out of nuclear energy. Also Hungary has a large potential for further development of CHP.

Positive developments in the CHP sector in the nineties but drawbacks in the recent years can be reported from Germany, Spain and the United Kingdom. In Lithuania and Latvia, major investment in CHP started only in the recent years. Problems with CHP development are being encountered in, for example, France, where nuclear power has a large share in electricity production. But also in Estonia, the Slovak Republic, Germany and Ireland the extension of the CHP sector was hindered due to insufficient legislative support. In Ireland and Germany, the national targets will probably be failed. In the Slovak Republic – in contrast – a national target was not set. In this Member State the expansion was severely hampered by generation overcapacity in the electricity sector and the high level of price regulation.

Of those Member States which did not face a thoroughly positive development in the past, remarkable potentials are registered in Slovenia, Latvia, Poland, Lithuania, the United Kingdom. The United Kingdom’s strength is that it does not rely on substantial governmental support mechanisms, thus by applying a more comprehensive and affirmative policy, large potentials can be realised. In Latvia the technical potential is rather high.

Even though the use of combined heat and power presents a substantial potential for increased energy efficiency and reduced environmental impacts and even though it is considered to be a priority area for many Member States, the overall access to data and country-specific analysis of policies and measures can be assessed as poor.

The case study in the *waste sector* showed that considerable emission reduction potentials have already been realized – especially regarding emissions from landfilling – and that further progress is expected in all EU Member States. One of the most important driving forces was and will be the EU Landfill Directive (Directive 1999/31/EC) which was implemented at an early stage in some of the EU-15 Member States. It will be largely responsible for the further decline of greenhouse gas emissions especially in the new Member States.

Emission reduction potentials were assessed on the basis of several parameters. They are assumed to be high in the Member States with a high per-capita rate of waste landfilled, high methane generation rate and/or low recovery rates (most of the new Member States, Spain and Ireland).

The analysis of the policies and measures reported in the third National Communications showed that in most of the cases regulatory instruments are applied to reduce the biodegradable waste from landfills, in some cases economic instruments are preferred. Incentives for methane recovery are predominantly achieved by economic instruments.

However the closely related promotion of other waste management practices is advanced by a multitude of types of measures beside the widespread use of regulatory instruments both soft measures like informative, educational approaches and voluntary agreements especially in regard waste prevention and recycling and invasive instruments but also fiscal instruments and research is applied.

It is unclear whether the projected emission reductions and the targets of the Landfill Directive will be achieved especially in those Member States which had increasing waste emissions in the past. Many of these Member States did not report or did not report in detail in the third National Communications their policies and measures undertaken. Furthermore the new Member States did not have to report yet their national strategies to achieve the target by the Landfill Directive. On this basis it was difficult to assess the effectiveness of the policies.

As a sustainable alternative to the treatment of biodegradable waste, composting was identified. However, there is a clear need to develop international guidelines for the determination of the emission related to these management options in order to reflect adequate the progresses in the inventories and to have a sound basis form monitoring.

It can be concluded that by reaching the targets of the Landfill Directive major emission reduction potentials in the waste sector are realised. However, there are more emission reduction potentials: further shifts to more favourable waste management practices such as waste prevention and recycling. Furthermore, potentials of methane recovery are not directly addressed by the Directive.

Final remarks

All in all, the analysis has shown that the climate policies of all EU Member States can be improved at one point or another. The analytical tools applied in this report are basically top-down. However, the results of this approach were flanked by in-depth analyses of selected indicators and bottom-up studies for selected policy areas. With these methodologies starting points for the further investigation of potential policy improvements can be identified for each EU Member State.

But apart form these achievements, the analysis has also revealed that there are still large deficiencies regarding the data necessary for these kind of analysis. Due to data inconsistencies we had to refrain from the international comparison of some indicators, particularly if they were calculated with data from different sources. More efforts should therefore be put into the harmonisation of energy data provided by Eurostat with greenhouse gas emission data submitted under the UNFCCC.

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