TULEVAISUUDEN TUTKIMUSKESKUS

TURUN KAUPPAKORKEAKOULU

TUTU–JULKAISUJA

TUTU PUBLICATIONS

1/2000

Jyrki Luukkanen, Jari Kaivo-oja, Jarmo Vehmas & Juhani Tirkkonen

CLIMATE CHANGE POLICY OPTIONS FOR THE EUROPEAN UNION: ANALYSES OF EMISSION TRENDS AND CO_2 EFFICIENCY

FINLAND FUTURES RESEARCH CENTRE

TURKU SCHOOL OF ECONOMICS AND BUSINESS ADMINISTRATION

Jyrki Luukkanen
Dr. tech. Senior researcher, University of Tampere
Jyrki Luukkanen, University of Tampere, Department of Regional Studies and Environmental Policy, FIN-33014 University of Tampere, Finland
Tel: +358 3 2157 036
Fax +358 3 2157 311
E-mail: jyrki.luukkanen@uta.fi

Jari Kaivo-oja
Lic. Adm., M.Sc. Researcher, Finland Futures Research Centre

Jarmo Vehmas
Lic. Adm. Researcher, University of Tampere

Juhani Tirkkonen
Lic. Adm. Researcher, University of Tampere

ISBN	951-738-994-9
UDK	504.05
	504.3
	339.923EU
	614.7

FINLAND FUTURES RESEARCH CENTRE
Turku School of Economics and Business Administration
P.O. Box 110
FIN-20521 Turku
Finland

Telephone	+358 2 3383 530
Fax	+358 2 2330 755
Internet	www.tukkk.fi/tutu

TABLE OF CONTENTS

1. INTRODUCTION

The Kyoto Protocol to the UN Framework Convention on Climate change includes quantified greenhouse gas (GHG) emission limitation or reduction Commitments to 39 Parties to the Framework Convention. These commitments, listed in Annex B of the Kyoto Protocol, are differentiated targets in percentage of base year or period of emissions for each Party. Six GHGs are concerned in the Kyoto Protocol: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluoropcarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

According to the Kyoto Protocol, EU member states have to reduce GHG emissions together by eight per cent from the 1990 level during the first commitment period 2008-2012. The commitment was shared between 15 member states at the "burden sharing" in June 1998 (Table 1).

Table 1. Burden sharing of the Kyoto commitment between EU member states.

EU member state	**Quantified GHG emission target (percentage of 1990 level)**
Austria	87
Belgium	92.5
Denmark	79
Finland	100
France	100
Germany	79
Greece	125
Ireland	113
Italy	93.5
Luxembourg	72
Netherlands	94
Portugal	127
Spain	115
Sweden	104
United Kingdom	87.5
EU 15	92

The commitments of the Kyoto Protocol listed in table 1 can be met by domestic actions and so-called Kyoto Mechanisms. The detailed guidelines for emissions trading (ET), joint implementation (JI) and clean development mechanism (CDM) influence the carbon gap (difference between the emission trend and the Kyoto commitment) in practice and also to the Parties' ability to fulfil their national commitment. Moreover, emission reductions by JI and CDM must be additional to any that would otherwise occur, and emission reductions achieved by ET and JI shall be supplemental to those reductions achieved by domestic actions. The definitions of the terms "additional" and "supplemental" have an impact to the climate policy options available.

Furthermore, the sink issue, i.e. the definition of "net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period" has an influence to the carbon gap.

And finally, developments in the overall methodology used in all GHG inventories will obviously contribute to the carbon gap in practice. For example, in Finland the total GHG emission figure has been changed from the 65.0 Mt presented in the Second National Communication (1997) to 72.9 Mt in 1998. CO_2 emission changed from 53.8 Mt to 59.1 Mt. An administrative working group was set up in 1998 by Ministry of the Environment to develop the methodology for national GHG inventories. In this context, also methodology to make adjustments due to annual changes in temperature and electricity exchange has been considered.

The purpose of this article is to evaluate the current challenge of climate policy in the European Union and its member states. We will present three different analyses. Firstly, we show a trend analysis of future CO_2 emission developments (CO_2 is considered as the most important GHG) based on two different data sets of historical emissions in 1990-97 and 1987-97, the first one submitted by parties to the UNFCCC Secretariat and the second one collected by International Energy Agency. This analysis will bring out estimates of "carbon gaps", i.e. the difference between the Kyoto commitment and the estimated emission trend.

Secondly, we have made a comparative study of different carbon gaps, those presented by the authors and other estimates provided by European Environment Agency, two estimates provided by UNEP Global Resource Information Database (GRID) and two estimates provided by a consultant, Reinstein & International Associates. This analysis will provide information for relevant policy options from the EU perspective on the possibilities of different Member States to achieve their emissions targets.

Thirdly, we have made a decomposition analysis of CO_2 emission developments in the EU member countries in 1987-1997. This analysis will show how three decomposed effects, namely the intensity effect, activity effect and structural effect, have contributed to historical CO_2 emissions in each EU member state. It will also give information to the background of different carbon gaps shown earlier in this article and the type of needed actions to close the gaps. It must be, however, admitted that cooperation and action to limit climate change is complex because serious responses could reach deep into countries' economic and political interest.

Carbon dioxide, the main contribution to projected climate change, comes predominantly from the use of fossil fuels and deforestation (Grubb et al 1999, 27). In the article we have used CO_2 as the main indicator for the emission development. The estimations of the emissions of other GHG gases defined by Kyoto Protocol are much more uncertain and that is why we have based our analyses only on CO_2 emissions.

2. CO_2 EMISSIONS TRENDS

The calculation of the estimates for national greenhouse gas emission balance is complicated and can be carried out in many ways resulting in different figures. Some calculations are based only on CO_2 emissions resulting from fossil fuel combustion. These estimates are usually the most accurate ones. Estimates of other CO_2 emissions (such as fugitive emissions, agricultural soil emissions, etc.) are much more vague. The estimates of CH_4, N_2O emissions are even more inaccurate depending e.g. on the calculation methods. The base year for the rest of Kyoto six gas basket gases HFCs, PFCs and SF_6 can be 1990 or 1995. The share of these gases in the GHG balance is quite small for EU15 countries.

In this section we shall present CO_2 emission trends of EU15 countries. Our analysis is here based on UNFCCC database (years 1990-97) and IEA database (years 1987-1997).

In accordance with Articles 4 and 12 of the Convention, and the relevant decisions of the Conference of the Parties, Parties to the Convention submit national greenhouse gas (GHG) inventories to the Climate Change secretariat. These inventory data are provided in the national communications under the Convention by Annex I and non-Annex I Parties. In addition, Annex I Parties submit annual national greenhouse gas inventories. Data is in general available for the years 1990-1997 (UNFCCC data, http://www.unfccc.de/resource/index.html).

During 1990s the major leader in promoting international climate policy has been the European Union (Oberthur & Ott 1999, 14). Here we shall present current CO_2 trends of EU15 countries based on UNFCCC and IEA data. We have used UNFCCC database, because it is the "official database" in climate change policy reporting. UNFCCC data covers the years 1990-1997, but there are some missing observations in that database. The IEA database that we have used covers years 1987-97 (International Environmental Agency 1999). We shall present extrapolations, which are based upon historical data for the event that is of interest (CO_2 emissions). Our analysis is based on typical starting point of foresight studies: "What, if…". Here we shall study the issue what kind of general CO_2 emission trade market situation may emerge in the European Union, if current trends will continue till the year 2010. Trend extrapolations are here based on logarithmic trend estimates. Possible explanatory reasons for the trends are given in Chapter 4 based on decomposition analyses of the data.

2.1. Trends based on UNFCCC data (Trend 1) and IEA data (Trend 2)

In Figure 1a are presented CO_2 emissions and logarithmic trends of France, Germany, Italy and United Kingdom till the year 2012 based on UNFCCC data.

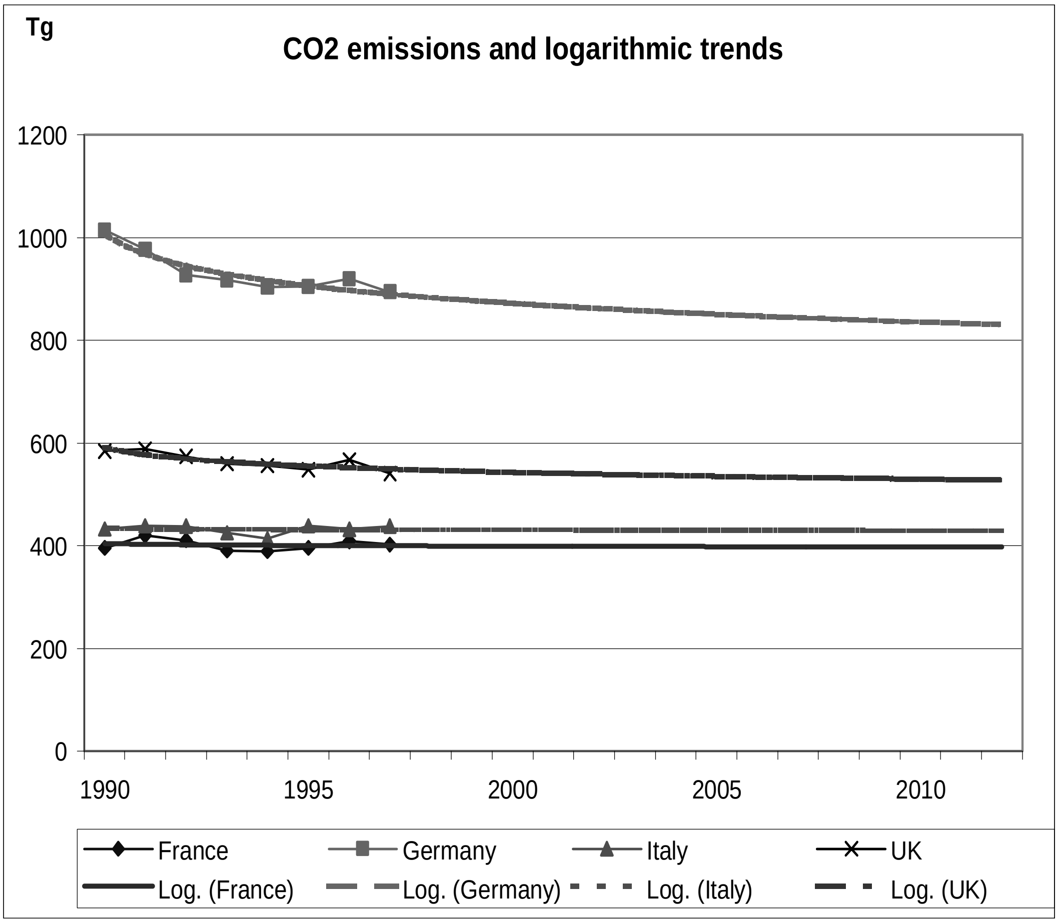


Figure 1a. CO_2 emissions and logarithmic trends of France, Germany, Italy and United Kingdom (till the year 2012), Source: UNFCCC data.

The results show that the large EU countries France, Germany, Italy and United Kingdom have stable or downward sloping trends in CO_2 emissions. Highest level of CO_2 emissions has Germany and then (in order) United Kingdom, Italy and France. The trend shows 17 % decrease of CO2 emissions in Germany, 9 % decrease in UK 0.6 % decrease in Italy and 0.6 % increase in France. Logarithmic trend estimates of the year 2010 are the following: Germany 838,1 Tg, United Kingdom 530,9 Tg, Italy 429,8 Tg and France 397,9 Tg.

CO_2 emissions and logarithmic trends based on IEA data for France, Germany, Italy and United Kingdom till the year 2012 are presented in Figure 1b.

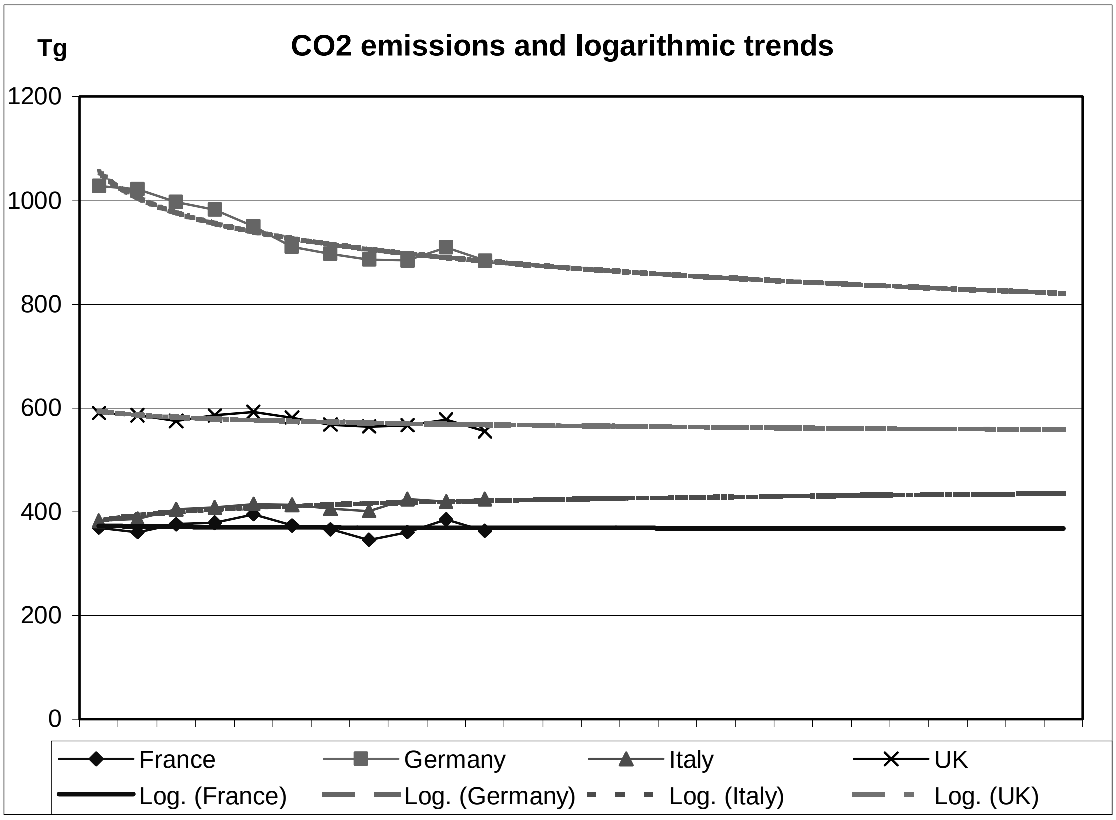


Figure 1b. CO_2 emissions and logarithmic trends of France, Germany, Italy and United Kingdom (till the year 2012), Source: IEA (1999).

The results show 1.5 % decrease of CO2 emissions for Germany, 2.7 % decrease for France, 0.4 % increase for UK and 6.1 % increase for Italy. Logarithmic trend estimates of the year 2010 are the following: Germany 829,6 Tg, United Kingdom 559,3 Tg, Italy 433 Tg and France 367,9 Tg. These trend estimates are based on the years 1987-1997 data base.

CO_2 emissions and logarithmic trends of Austria, Belgium, Ireland, Luxembourg and Netherlands till the year 2012 based on UNFCCC data are presented in Figure 2a.

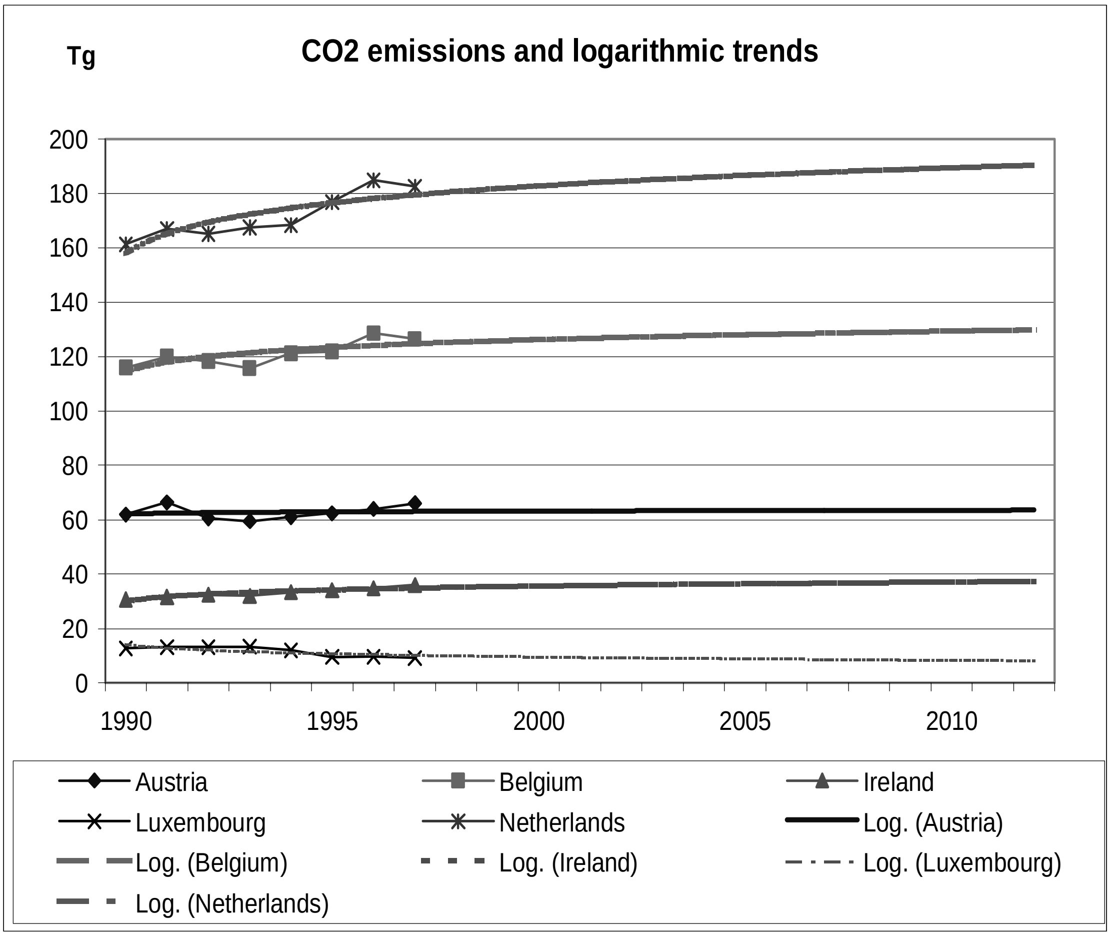


Figure 2a. CO_2 emissions and logarithmic trends of Austria, Belgium, Ireland, Luxembourg and Netherlands (till the year 2012), Source: UNFCCC data.

The results show that EU countries Austria, Belgium, Ireland, Luxembourg and Netherlands have stable or slightly upward sloping trends in CO_2 emissions. Highest level of CO_2 emissions in this country group has Netherlands and then (in order) Belgium, Austria, Ireland and Luxembourg. The trends show an increase of 17 % for the Netherlands, 11 % for Belgium and 20 % for Ireland. Logarithmic trend estimates of the year 2010 are the following: Netherlands 188,9 Tg, Belgium 129,1 Tg, Austria 63,5 Tg, Ireland 37 Tg and Luxembourg 8,4 Tg.

In Figure 2b are presented CO_2 emissions and logarithmic trends of Austria, Belgium, Ireland, Luxembourg and Netherlands till the year 2012 based on IEA data.

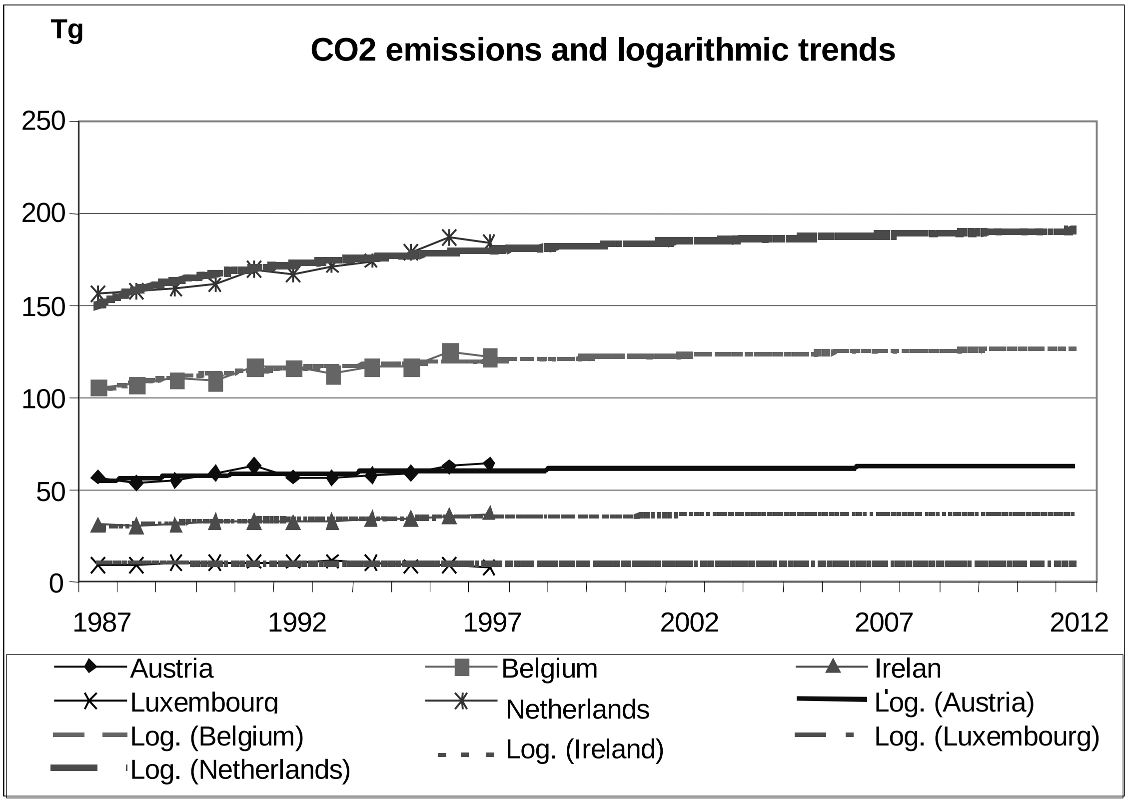


Figure 2b. CO_2 emissions and logarithmic trends of Austria, Belgium, Ireland, Luxembourg and Netherlands (till the year 2012), Source: IEA (1999).

The results are quite similar to those in Figure 2a. Logarithmic trend estimates of the year 2010 are the following: Netherlands 189,2 Tg, Belgium 125,5 Tg, Austria 62,9 Tg, Ireland 37,3 Tg and Luxembourg 10,1 Tg.

In Figure 3a are presented CO_2 emissions and logarithmic trends of Denmark, Finland and Sweden till the year 2012 based on UNFCCC data.

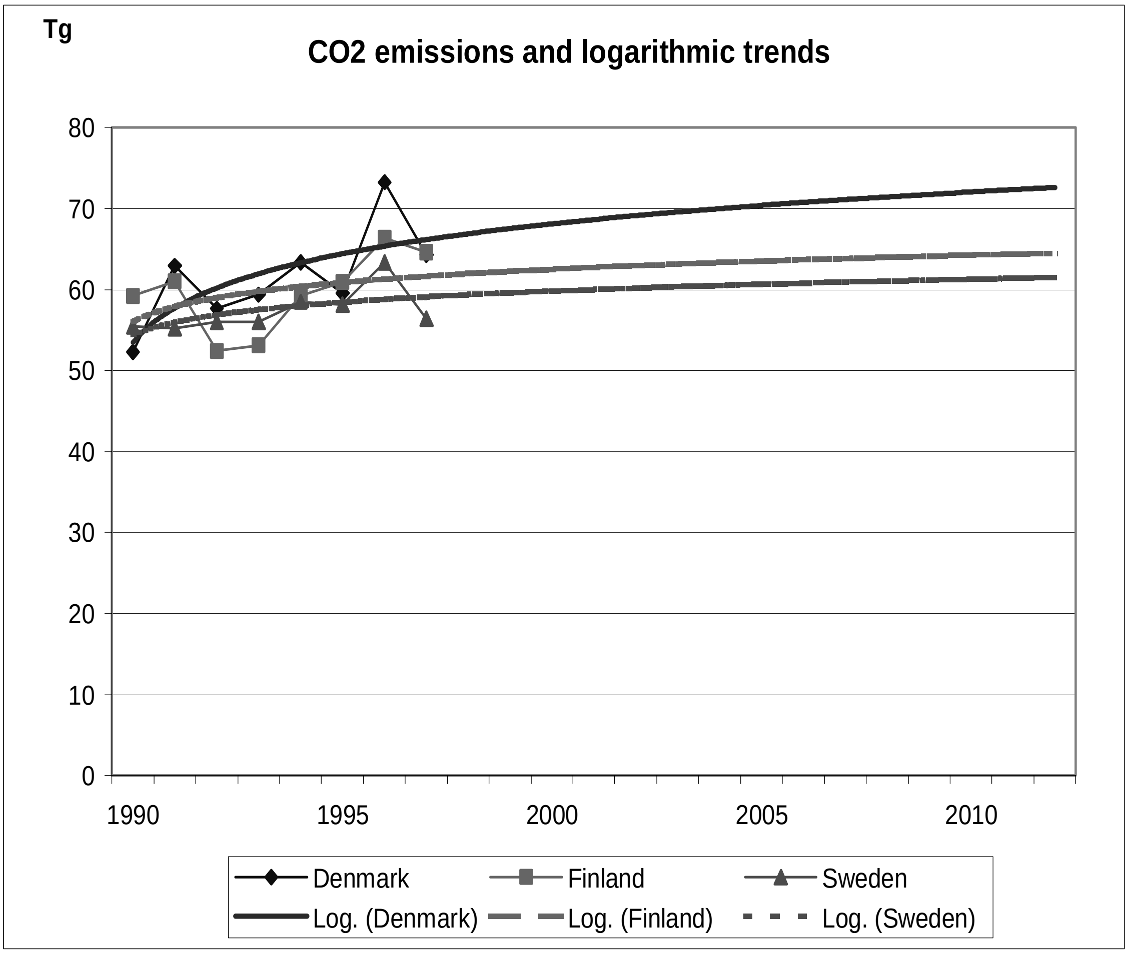


Figure 3a. CO_2 emissions and logarithmic trends of Denmark, Finland and Sweden till the year 2012), Source: UNFCCC data.

The results show that Nordic EU countries have slightly upward sloping trends in CO_2 emissions. The emissions of all the three countries are of the same magnitude. According to the trends the growth seems to be highest in Denmark (+37 %). This is partly due to the increase in electricity export. Denmark has announced that it takes electricity export and import into account in emission calculations (see Denmark's Second National Communication to UNFCCC). Logarithmic trend estimates of the year 2010 are the following: Denmark 71,7 Tg, Finland 64,1 Tg and Sweden 61,1 Tg.

For all the three Nordic countries the yearly variations of emissions seem to be larger than for other countries. This partly due to the large share of hydropower in the common Nordic electricity markets, which causes variations depending on yearly precipitation.

In Figure 3b are presented CO_2 emissions and logarithmic trends of Denmark, Finland and Sweden till the year 2012 based on IEA data.

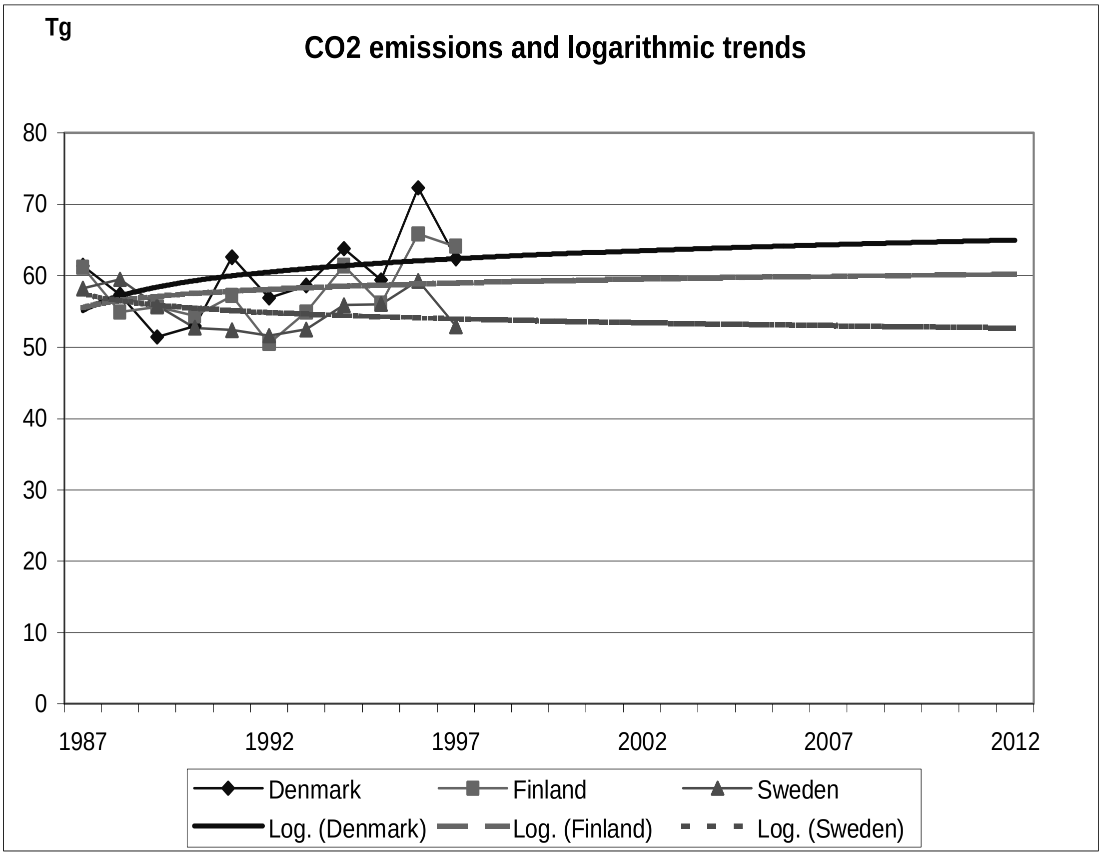


Figure 3b. CO_2 emissions and logarithmic trends of Denmark, Finland and Sweden till the year 2012), Source: IEA (1999).

The trends based on IEA data show lower growth rates of emissions than UNFCCC data. This is due to the different time span of the data and the large yearly variations giving rise to uncertainties in trend estimation. The trends show 22 % increase for Denmark, 10 % increase for Finland and only 0.4 % increase for Sweden compared with the base year figures. Logarithmic trend estimates of the year 2010 are the following: Denmark 64,6 Tg, Finland 60 Tg and Sweden 52,9 Tg.

The differences of the trends in Figures 3a and 3b show that the selection of the base year for the comparisons is crucial for the Nordic countries.

In Figure 4a are presented CO_2 emissions and logarithmic trends of Greece, Portugal and Spain till the year 2012 based on UNFCCC data.

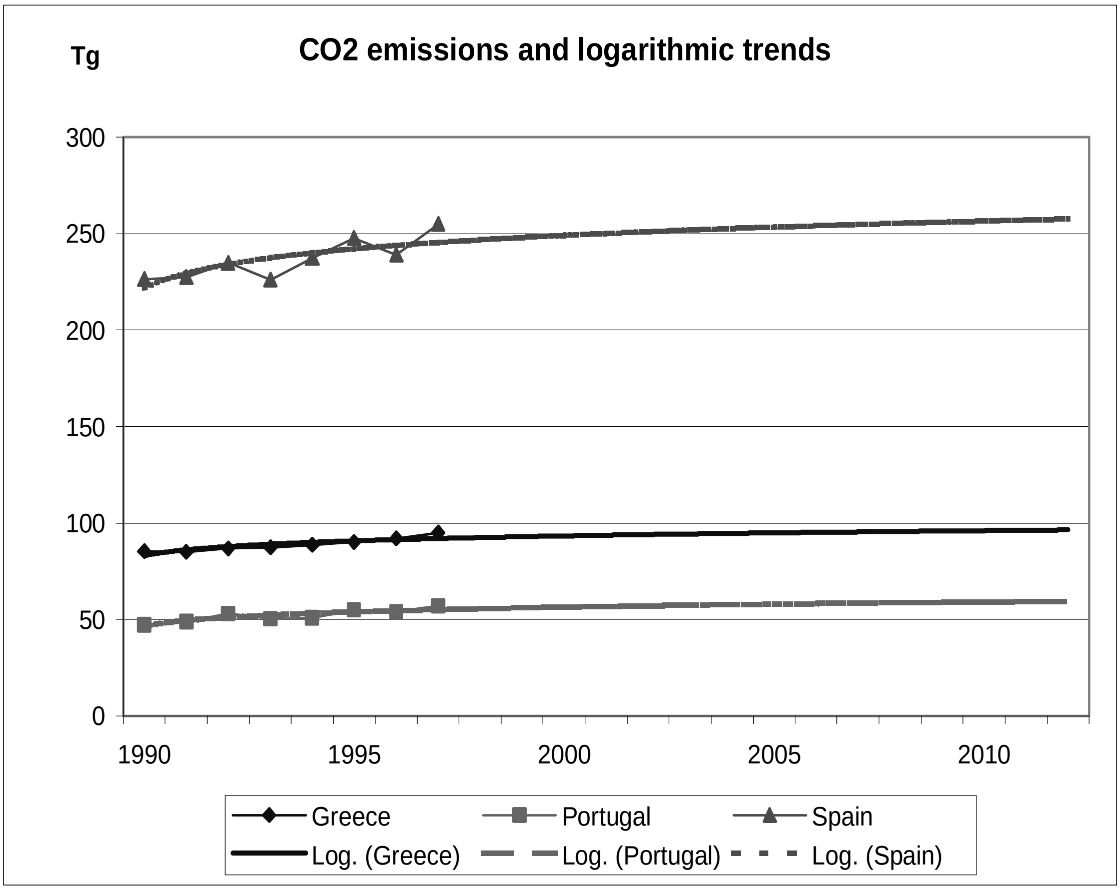


Figure 4a. CO_2 emissions and logarithmic trends of Greece, Portugal and Spain (till the year 2012), Source: UNFCCC data.

The results show that southern EU countries have upward sloping trends in CO_2 emissions resulting in 25 % increase in Portugal, 13 % increase in Spain and 12 % increase in Greece. Logarithmic trend estimates of the year 2010 are the following: Spain 255,9 Tg, Greece 95,9 Tg and Portugal 58,8 Tg.

In Figure 4b are presented CO_2 emissions and logarithmic trends of Greece, Portugal and Spain till the year 2012 based on IEA data.

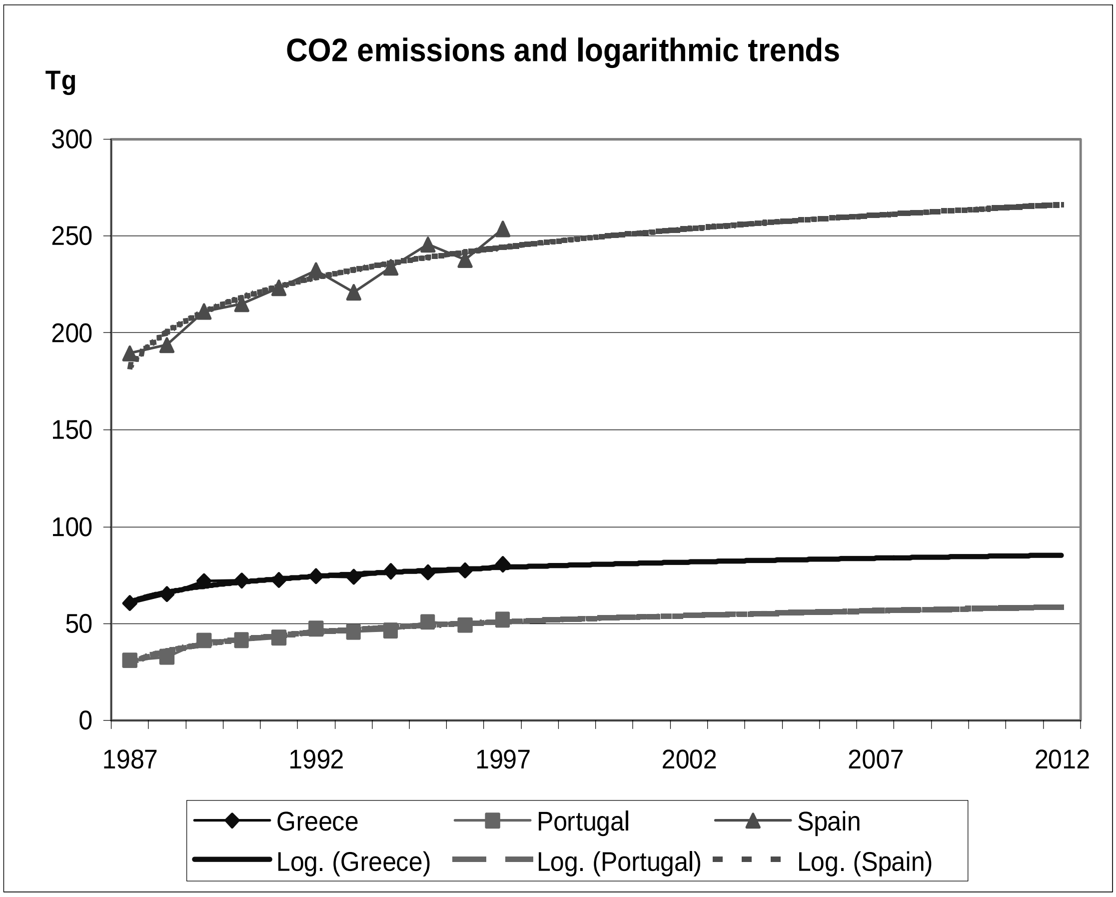


Figure 4b. CO_2 emissions and logarithmic trends of Greece, Portugal and Spain (till the year 2012), Source: IEA (1999).

The results show faster growth of CO_2 emissions than in the UNFCCC based trends. The trends show growth of emissions of 38 % in Portugal, 22 % in Spain and 17 % in Greece. Logarithmic trend estimates of the year 2010 are the following: Spain 263,1 Tg, Greece 84,4 Tg and Portugal 57,4 Tg.

As a summary of the results we can present a following Tables 2a and 2b. Table 2b also includes trends for other main Annex B countries (Australia, Canada, Japan, USA, Russia and Ukraine). These countries are included to get a wider perspective of possible emission trading market.

Table 2a. CO_2 emissions of EU15 countries in 1990, in 1997 and logarithmic trend estimates of the year 2010, and Target levels of EU, Mg (The data source: UNFCCC).

	1990	1997	Trend 2010	Target level
Austria	62.0	66.1	71.7	59.8
Belgium	116.1	126.5	129.1	107.4
Denmark	52.3	57.0	61.1	54.0
Finland	59.2	64.6	64.1	59.2
France	395.5	402.2	397.9	395.5
Germany	1014.5	894.0	838.1	801.4
Greece	85.3	95.0	95.9	106.7
Ireland	30.7	36.0	37.0	34.7
Italy	432.6	438.0	429.8	404.5
Luxembourg	12.8	9.2	8.4	9.2
Netherlands	161.4	182.5	188.9	151.7
Portugal	47.1	56.4	58.8	41.3
Spain	226.4	255.0	255.9	260.4
Sweden	55.4	64.3	63.5	57.7
UK	584.2	540.6	530.9	511.1

According to table 2b potential sellers of AAUs are France, Greece, Ireland, Sweden, Russia and Ukraine. Other countries are potential buyers. USA seems to be the most important potential buyer with about 870 Mtons of CO_2. Japan seems to be a bigger buyer than EU15 as a total. Russia has possibilities for a large sell of "hot air" – almost three times the gap of EU15 and 75 % of the gap of USA. Ukraine is also a remarkable potential seller with one and half times the EU15 gap or over 40% of the USA gap. Russia and Ukraine could together fill the gap of USA giving a possibility for a strategic bubble.

Table 2b. CO_2 emissions of EU15 countries and other main Annex B countries in 1990, in 1997 and logarithmic trend estimates of the year 2010, and Target levels of EU and Gaps in 2010, Tg. Gaps are positive if trend is higher than target value. Trend estimates for Russia and Ukraine are educated guesses (The data source: IEA).

	1990	1997	Trend 2010	Target level	Gap tons	Signal
Austria	59.4	64.1	62.9	51.7	11.2	☹
Belgium	109.1	122.6	125.6	100.9	24.7	☹
Denmark	52.9	62.4	64.6	41.8	22.8	☹
Finland	54.4	64.1	60	54.4	5.6	☹
France	378.3	362.9	367.9	378.3	-10.4	☺
Germany	981.4	884	829.6	775.3	54.3	☹
Greece	72.3	80.6	84.4	90.4	-6.0	☺
Ireland	33.2	37.6	37.3	37.5	-0.2	☺
Italy	408.2	424.3	433	381.7	51.3	☹
Luxembourg	10.9	8.6	10.1	7.8	2.3	☹
Netherlands	161.3	184.3	189.2	151.6	37.6	☹
Portugal	41.5	52	57.4	52.7	4.7	☹
Spain	215	253.8	263.1	247.3	15.9	☹
Sweden	52.7	52.9	52.9	54.8	-1.9	☺
UK	585.3	554.7	559.3	512.1	47.2	☹
EU15	3216	3208.9	3197.3	2958.6	238.7	☹
Australia	263	306.1	320	284	36.0	☹
Canada	427.5	477.4	470	401.8	68.2	☹
Japan	1061.8	1172.6	1250	998.1	251.9	☹
United States	4873.4	5470.5	5400	4532.3	867.7	☹
Russia	2198.9	1456.2	1550	2198.9	-648.9	☺
Ukraine	703.8	322.9	330	703.8	-373.8	☺
Total	12744.	12414.6	12517.3	12077.6	439.7	☹

In Figure 5a a graphic summary of the results of UNFCCC based trends is presented.

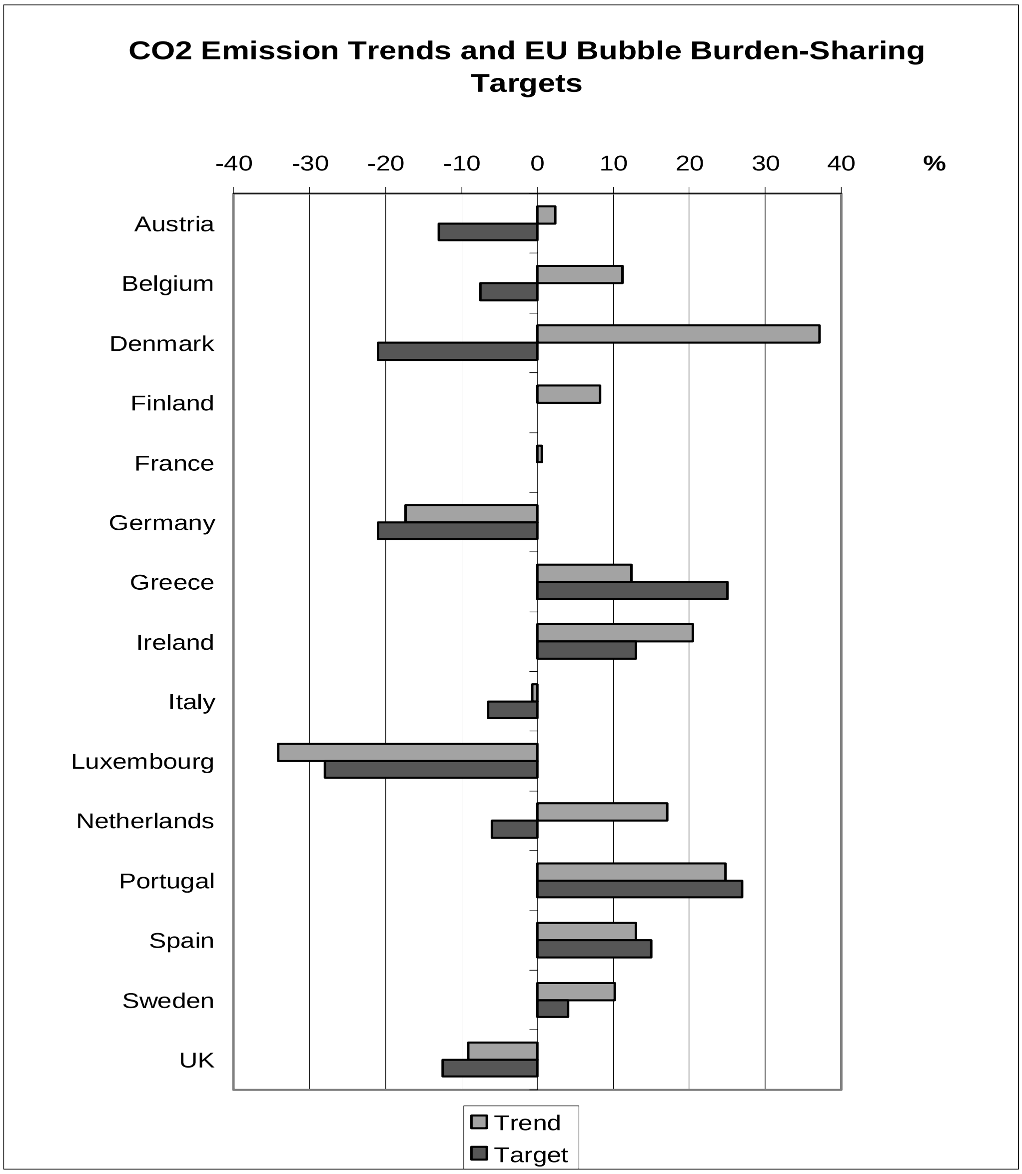


Figure 5a. CO_2 emission trends and EU Bubble Burden-Sharing targets based on trends calculated from UNFCCC data.

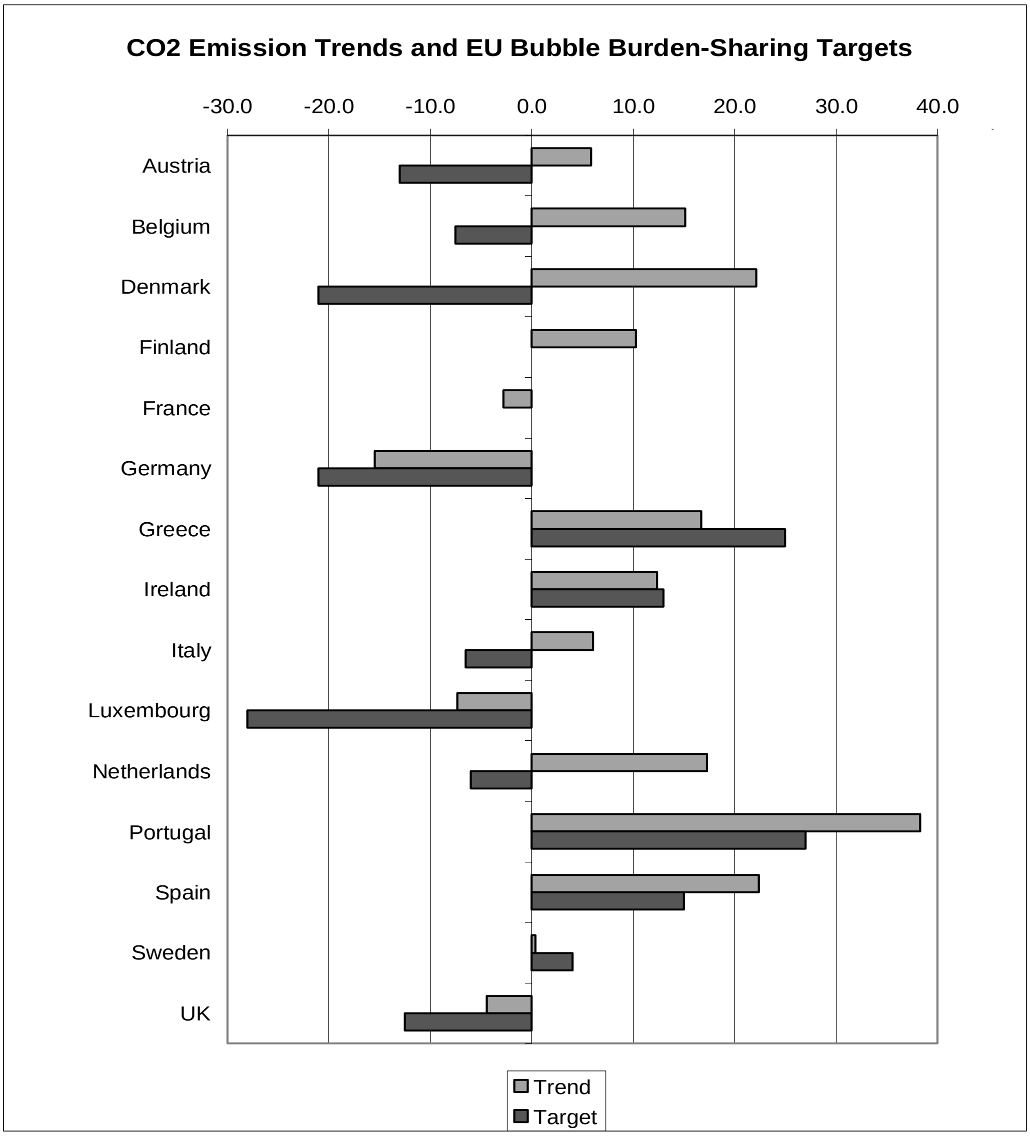


Figure 5b. CO_2 emission trends and EU Bubble Burden-Sharing targets based on trends calculated from IEA data.

In figure 6a and 6b graphic summaries of the results are presented. Figure 6a and 6b show us the potential trend based carbon gaps in EU15 countries.

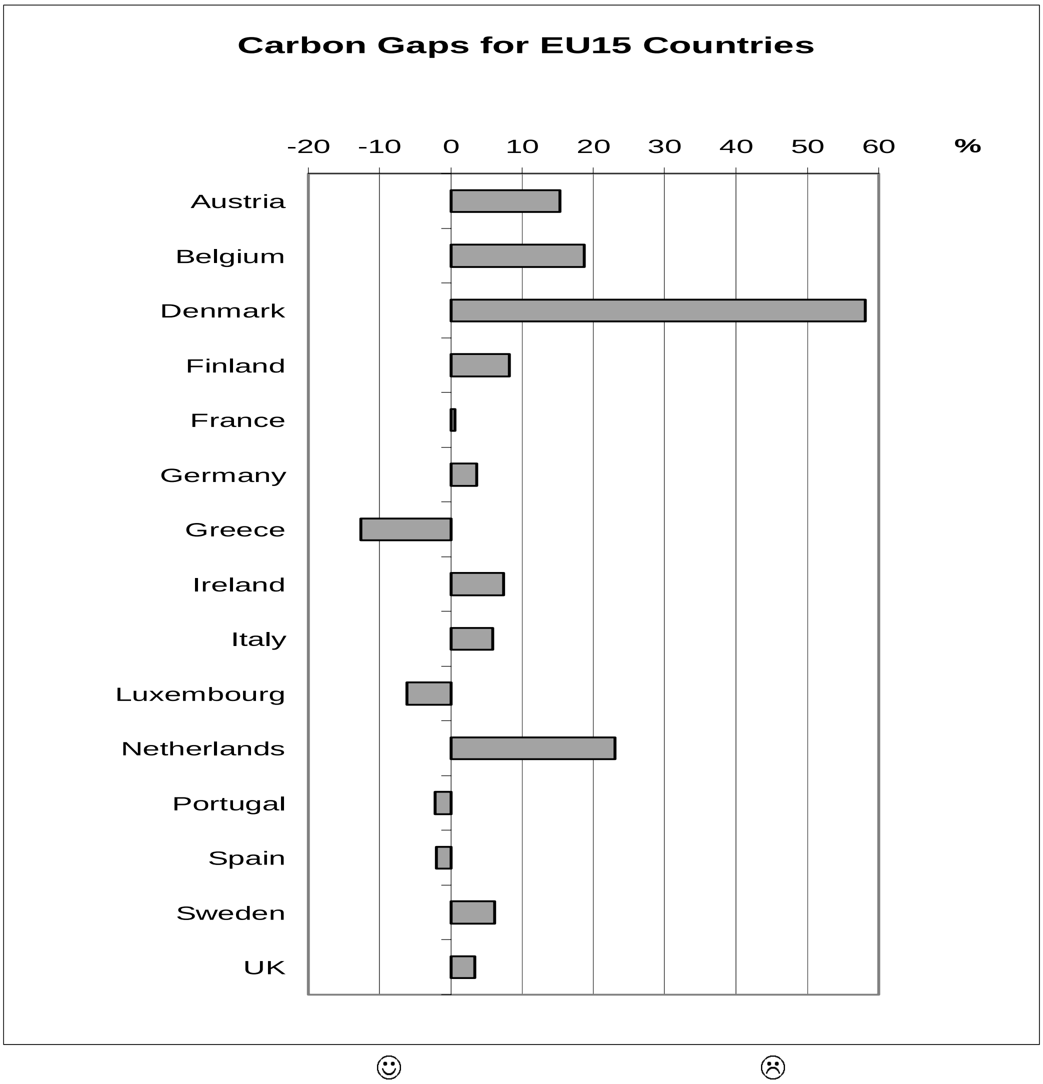


Figure 6a. Carbon Gaps for EU15 countries (on the basis of trends calculated from UNFCCC data).

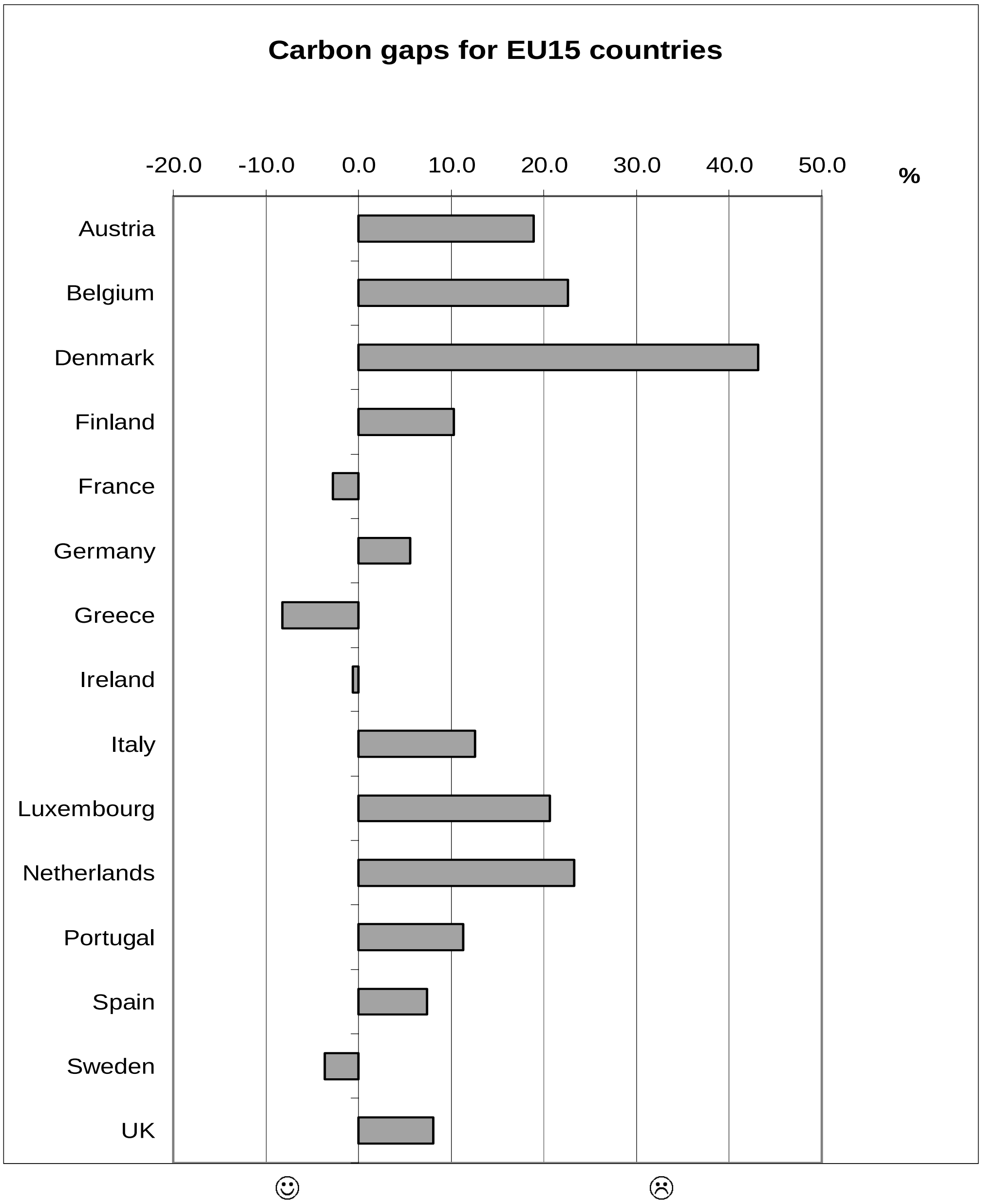


Figure 6b. Carbon Gaps for EU15 countries (on the basis of trends calculated from IEA data).

2.2. Implications to CO_2 emission trade?

On the basis of current trends in CO_2 emissions of EU15 countries we can evaluate trends in CO_2 emission trade. In Table 3 there are presented expected percentage change in CO_2 emissions, target change level (%) and estimated carbon gap (%) of different EU countries. Trend estimates are based on UNFCCC data. The target level is based on the EU Burden-Sharing Agreements of June 1998. The range of reductions of EU countries is –21 to +27% (Oberthür & Ott 1999, 148, European Community 1998).

Table 3a. Percentage changes of CO_2 emissions in 1990-2010: trends, targets and expected carbon gaps on the basis of trends calculations from UNFCCC data.

	Trend %	Target %	Gap %
Austria	2.4	-13.0	15.4
Belgium	11.2	-7.5	18.7
Denmark	37.2	-21.0	58.2
Finland	8.3	0.0	8.3
France	0.6	0.0	0.6
Germany	-17.4	-21.0	3.6
Greece	12.4	25.0	-12.6
Ireland	20.4	13.0	7.4
Italy	-0.6	-6.5	5.9
Luxembourg	-34.1	-28.0	-6.1
Netherlands	17.1	-6.0	23.1
Portugal	24.8	27.0	-2.2
Spain	13.0	15.0	-2.0
Sweden	10.2	4.0	6.2
UK	-9.1	-12.5	3.4

According to trend estimates based on UNFCCC data the range of percentage change of trend CO_2 emissions is –34 to +37 %.

In Table 3b there are presented expected percentage change in CO_2 emissions, target change level (%) and estimated carbon gap (%) of different EU countries. Trend estimates are here based on IEA data.

Table 3b. Percentage changes of CO_2 emissions in 1990-2010: trends, targets and expected carbon gaps on the basis of trends calculated from IEA (1999) data.

	Trend	Target	Gap
Austria	5.9	-13.0	18.9
Belgium	15.1	-7.5	22.6
Denmark	22.1	-21.0	43.1
Finland	10.3	0.0	10.3
France	-2.7	0.0	-2.7
Germany	-15.5	-21.0	5.5
Greece	16.7	25.0	-8.3
Ireland	12.3	13.0	-0.7
Italy	6.1	-6.5	12.6
Luxembourg	-7.3	-28.0	20.7
Netherlands	17.3	-6.0	23.3
Portugal	38.3	27.0	11.3
Spain	22.4	15.0	7.4
Sweden	0.4	4.0	-3.6
UK	-4.4	-12.5	8.1

According to trend estimates based on IEA data the range of percentage change of trend CO_2 emissions is –15,5 to +38,3 %.

2.3. The price estimates of the marginal damage of climate change related to EU target

Eyre et al (1998) have estimated marginal damage costs of greenhouse gas emissions. According their calculations marginal damage from their model (euro/tonne CO2 e.g.) is the following:

Table 4. Marginal damage from model (Euro/tonne CO_2 eq.).

Model	FUND	FUND	OPEN FRAMEWORK	OPEN FRAMEWORK
Discount rate	1%	3%	1%	3%
Carbon dioxide CO_2	46	19	44	20

The marginal damage costs are calculated on the base of estimated costs caused by climate change. To avoid these costs the suggestions by IPCC are to reduce GHG emissions by 60-80 % immediately and after that continue the reductions. If we assume that the Kyoto targets are the first steps towards achieving the reductions suggested by IPCC we could calculate the damage costs related to not achieving the Kyoto targets. The gaps calculated above could be interpreted as increased damage of not achieving the first target in the long emission reduction process. The actual damage costs could, of course, be estimated on the basis of IPCC reduction targets, resulting in more than ten times higher figures.

If we use presented estimates, we obtain the following damage cost estimations for EU15 for not achieving Kyoto target. In Table 5a there are presented marginal cost estimates of in the European Union, if carbon gaps cannot be closed. Cost estimates are here based on the UNFCCC trend estimates (Trend 1).

Table 5a. Marginal damage costs, of carbon gaps on the basis of UNFCCC trend estimates, MEURO.

	Marginal Damage from Model (euro/ton CO2)			
	FUND	FUND	OPEN FRAMEWORK	
Discount rate	1 %	3 %	1 %	3 %
	MEURO			
Austria	438	181	419	190
Belgium	999	413	956	434
Denmark	1398	578	1338	608
Finland	225	93	216	98
France	110	46	105	48
Germany	1686	696	1612	733
Greece	-496	-205	-475	-216
Ireland	105	43	101	46
Italy	1164	481	1114	506
Luxembourg	-36	-15	-34	-16
Netherlands	1712	707	1638	744
Portugal	-48	-20	-46	-21
Spain	-206	-85	-197	-90
Sweden	158	65	151	69
UK	909	375	869	395
EU15	8119	3353	7766	3530

By using the IEA trend estimates we obtain the following damage cost estimations for EU15 for not achieving Kyoto targets (Table 5b). Cost estimates are here based on the IEA trend estimates (Trend 2)

Table 5b. Marginal damage cost of carbon gaps on the basis of IEA trend estimates, MEURO.

	Marginal Damage from Model (euro/ton CO2)			
	FUND	FUND	OPEN FRAMEWORK	
Discount rate	1 %	3 %	1 %	3 %
	MEURO			
Austria	516	213	494	224
Belgium	1135	469	1086	494
Denmark	1049	433	1004	456
Finland	258	106	246	112
France	-478	-198	-458	-208
Germany	2498	1032	2389	1086
Greece	-275	-114	-263	-120
Ireland	-10	-4	-10	-4
Italy	2361	975	2259	1027
Luxembourg	104	43	99	45
Netherlands	1729	714	1653	752
Portugal	216	89	207	94
Spain	729	301	697	317
Sweden	-88	-36	-84	-38
UK	2169	896	2075	943
EU15	11913	4921	11395	5180

According to these cost estimates EU is going to have a hard economic pressure for policy integration in climate change policy. If carbon gaps cannot be closed in the EU countries, costs will be according these trend estimates about 7 to 8 billion EURO or 11 to 12 billion EURO (with 1 % percent discount rate) or 3.5 to 5 billion EURO (with 3 % percent discount rate) depending on the trend. Eyre (2000) has, however, noted that uncertainty analysis indicates that the range of uncertainty is very large (http://externe.jrc.es/nletter6.html).

Concerning the emission trade we can draw conclusions of the possibilities of different EU countries to participate as buyers or sellers on the market based on the trend calculations. In Table 6 is presented an assessment of potential buyers and sellers of their emission allowance. Emission trading allows Parties to the Kyoto Protocol that reduce greenhouse gas emissions (especially CO_2 emissions) below their assigned amount to sell part of their emission allowance to other parties. A Party could also buy additional emission allowance from other Parties for the purpose of meeting its Kyoto commitment. Emission trading of intended to improve amongst Annex B Parties (industrialised countries) the efficiency of resource allocation. Some countries, for example Russia, could have large quantities of unused assigned amounts of emissions available for trading. Our results indicate that among EU15 countries such seller countries might be Greece, Luxembourg, Portugal and Spain or France, Greece, Ireland and Sweden (see Table 6).

Table 6. Potential buyers and sellers of emission trading in EU15.

Trend 1 assessment (UNFCCC database)		Trend 2 assessment (IEA database)	
Buyers	**Sellers**	**Buyers**	**Sellers**
Austria Belgium Denmark Finland France Germany Ireland Italy Netherlands Sweden UK	Greece Luxembourg Portugal Spain	Austria Belgium Denmark Finland Germany Italy Luxembourg Netherlands Portugal Spain UK	France Greece Ireland Sweden

3. COMPARATIVE ANALYSES OF CARBON GAPS

In this Chapter we compare the trends described in the previous Chapter with four other trend scenarios. The aim is to produce more information for assessing the future development of emissions and to evaluate possible policy relevant means for reaching the Kyoto targets.
The different scenarios that are compared are listed in Table 7.

Table 7. Scenarios compared in the analysis:

1. **Trend1**. The trend calculation is based on UNFCCC data on total national CO_2 emissions from 1990 to 1997. The trend calculation, carried out by the authors, is based on logarithmic trend extrapolation. Source: http://194.95.39.33/ at 14.2.2000
2. **Trend2**. The data is based on IEA energy statistics (IEA 1999). The projections for year 2010 were estimated from the data in years 1987 to 1997 using logarithmic trend extrapolation. The calculations include estimates of CO_2 emissions from fuel combustion. Source: International Energy Agency (1999). CO_2 Emissions from Fuel Combustion. 1971-1997 highlights. IEA statistics. OECD. Paris. France.
3. **EEA-Trend**. The data is based on CO_2 emissions reported (1990) and projected (2000), which are presented in the EEA environmental assessment report (p. 93). The projections for year 2010 were estimated from this data. The projections represent so called "with measures" projections, that is taking into account the policies and measures that were already adopted by the Member States and for which an estimation of reduction potential was available from national programmes (1997/1998). Source: EEA (1999). Environment in the European Union at the turn of the century. Environmental assessment report no. 2. EEA Copenhagen. Denmark.
4. **Grid-BA**. The calculations is based on data and projections from United Nations Environment Programme Global Resource Information Database (GRID) in Arendal Norway. GRID produced the data in the light of (COP-4) held in Buenos Aires, at 2-13 November 1998. GRID has been collected from the database of the Climate Change Secretariat, which is built on the information available in the National Communications presented by the Parties to the Convention. In some cases, where projections or emissions estimates have not been provided, they have been interpolated based on the trends from the reported years. The calculations show the actual emissions of Carbon dioxide (CO_2), Methane (CH4) and Nitrous oxide (N2O), and in the case of Netherlands also emissions of sulphur hexafluoride (SF6), hydrofluorocarbons (HFC's) and perfluorocarbons (PFC's). Projections represented so called "with measures" projections, which take into consideration proposed or potential measures for mitigating emissions. In the case of Greece the projection is "without measures", not assuming any implementation of measures for mitigating emissions. Source:http://www.grida.no/db/maps/collection/climatechange/ at 17.2.2000.

5. Grid-Bonn. The calculations is based on data and projections from United Nations Environment Programme Global Resource Information Database (GRID) in Arendal Norway. GRID produced the data in the light of (COP-5) held in Bonn at 25th October to 6th November 1999. GRID has collected the data from the database of the Climate Change Secretariat, which is built on the information available in the National Communications presented by the Parties to the Convention. The calculations show the actual emissions of Carbon dioxide (CO_2), Methane (CH4) and Nitrous oxide (N2O). Projections represented so called "with measures" projections. Source: http://www.grida.no/db/maps/collection/climate5/index.htm at 17.2.2000.

6. Re-Trend. The data is based on Reinstein & Associates International estimates (Pirilä & Reinstein 2000, 184). It includes CO_2 emissions from fuel consumption. The projection is based on "trend scenario", where it is assumed that current trend continue, including additional reasonable measures that can be justified for other reasons, according to national political factors (continued good efforts).
Source: Pirilä, P. & Reinstein, R. (2000). Meeting the target – elements of national policies. In Pirilä (ed.). Climate Change. Socio-economic dimensions and consequences of mitigation measures. Helsinki. Edita. pp.173-207.

7. Re-Pain. The data is based on Reinstein & Associates International estimates (Pirilä & Reinstein 2000, 184). It includes CO_2 emissions from fuel consumption. The projection is based on "pain scenario", where it is assumed that a country does all that it reasonably can to limit emissions up to the point where further actions would have unacceptable economic and social consequences (job losses, disproportional regional impacts, individual hardship, etc.)
Source: Pirilä, P. & Reinstein, R. (2000). Meeting the target – elements of national policies. In Pirilä (ed.). Climate Change. Socio-economic dimensions and consequences of mitigation measures. Helsinki. Edita. pp.173-207.

The resulting carbon gaps of the different scenarios are shown in Table 8.

Table 8. Carbon gaps between the estimated CO_2 emissions in 2010 of the different scenarios and the EU Burden-Sharing targets.

Country	Trend I	Trend2	EEA-Trend	GRID-BA	GRID-Bonn	Re-Trend	Re-Pain
Austria	15.4	18.9	-3.6	16.5	NA	24.9	17.01
Belgium	18.7	22.6	24.9	20.5	NA	26.0	19.53
Denmark	58.2	43.1	36.3	7	7.2	24.8	7.92
Finland	8.3	10.3	3.4	15.5	20	38.3	20.62
France	0.6	-2.7	-7.7	9	12.2	4.7	-0.45
Germany	3.6	5.5	-3.4	23.5	20.4	17.1	9.28
Greece	-12.6	-8.3	4.5	-1	NA	14.6	6.48
Ireland	7.4	-0.7	11.3	3.5	3.4	17.3	11.55
Italy	5.9	12.6	8.9	-5	NA	19.0	16.12
Luxembourg	-6.1	20.7	-89.3	NA	NA	21.4	19.52
Netherlands	23.1	23.3	43.4	25	21.1	30.8	24.77
Portugal	-2.2	11.3	-11.2	-6	NA	20.5	3.59
Spain	-2.0	7.4	11.6	4	4.25	11.1	2.62
Sweden	6.2	-3.6	13.6	15	8.3	9.2	4.08
UK	3.4	8.1	0.5	10	7.2	16.2	6.65

The carbon gaps of the different scenarios are illustrated in graphical form in the following figures for the different EU country groups.

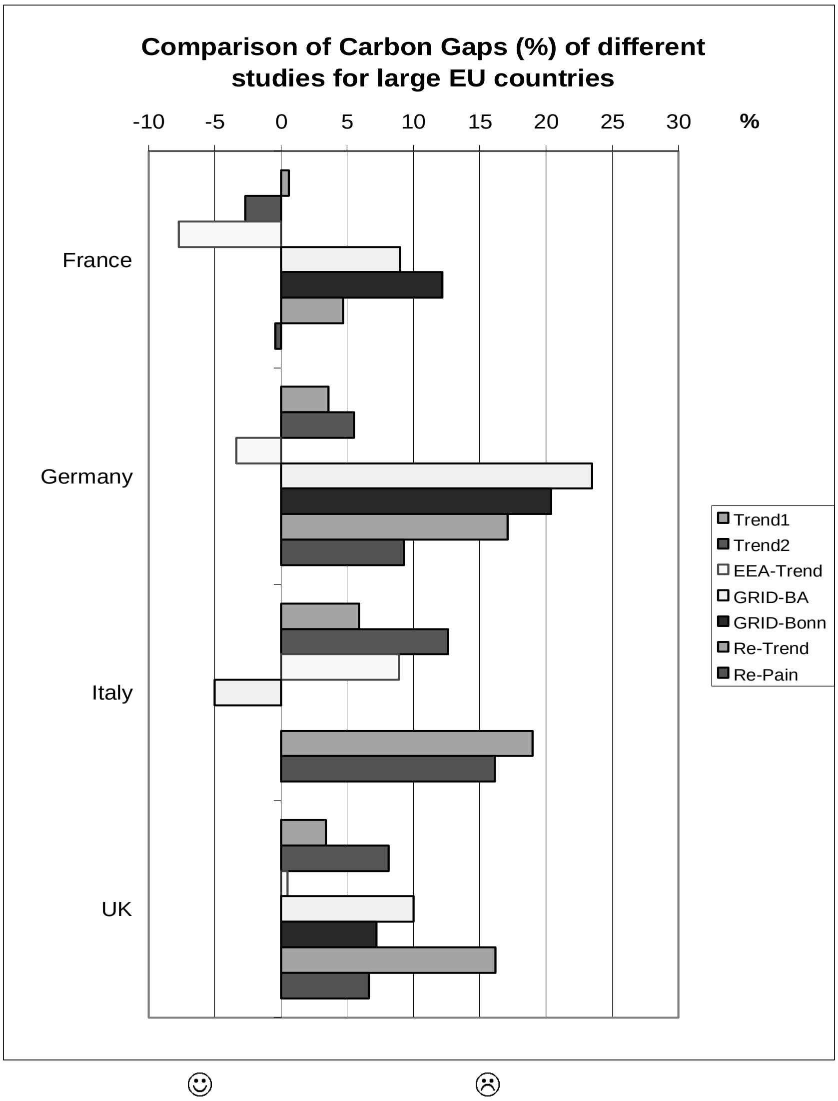


Figure 7. Carbon gaps between the estimated CO_2 emissions in 2010 of the different scenarios and the EU Burden-Sharing targets for the large EU countries.

Figure 7 shows that the possibilities of France to achieve the target are quite probable in the light of the trends calculated by the authors and EEA trend. The GRID estimates seem to produce larger gaps while the Reinstein estimates show that it might be a comparatively easy task for France to achieve the target of 0 %. This means that the possibilities for France to become even a quite big emission seller in the market look promising.

For Germany the trend calculations by the authors and EEA trend show quite a small gap indicating good possibilities for achieving the target of –21 % reduction. On the other hand the GRID and Reinstein estimates show much larger gaps. The reasons for the differences may be due to the fact that the actual emission trend show much more rapid decrease in emissions that were estimated by the authorities and consultants based on older data.

For Italy the GRID and trends estimations show much more promising development that the Reinstein estimates. The possibilities of Italy to achieve the target does not look too negative, especially in the light of further possibilities to increase the energy sector efficiency as discussed in more detail in the following chapter.

In the UK the possibilities to achieve the target seem to be quite positive according to most of the trends, the Reinstein trend being the only exception. In addition to the fuel switch that has already taken place in the UK there is still room for efficiency improvements.

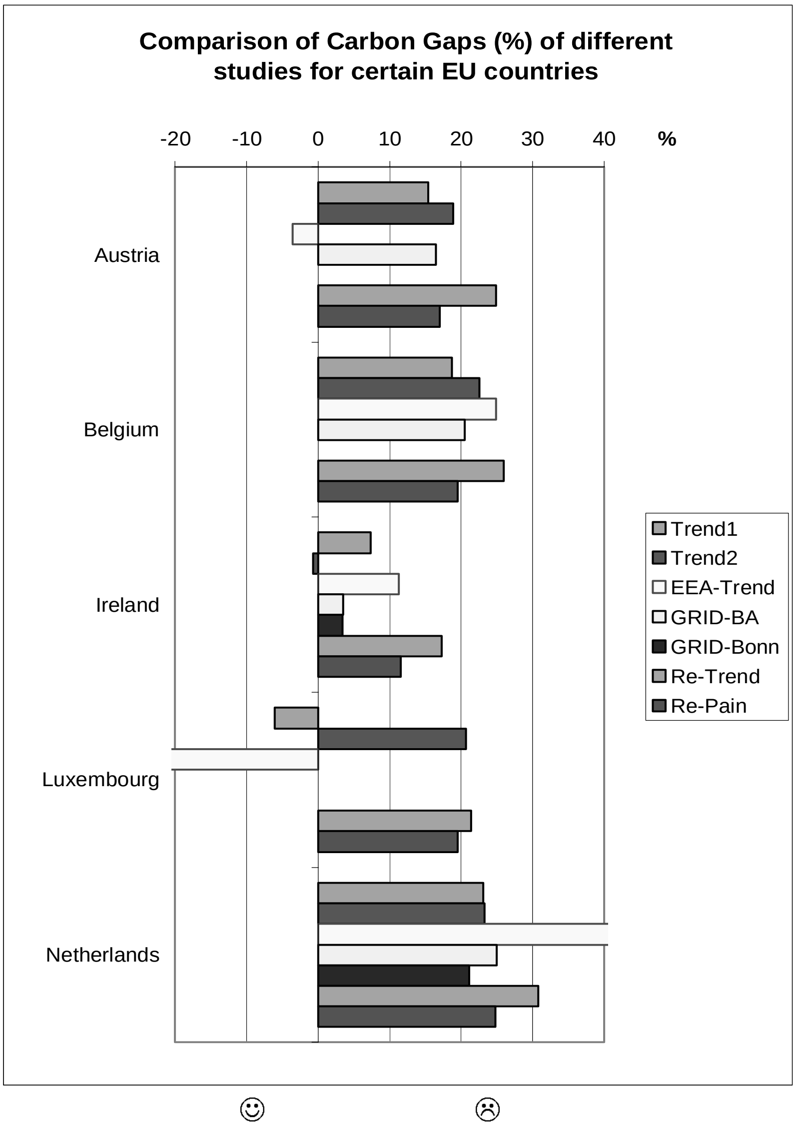


Figure 8. Carbon gaps between the estimated CO_2 emissions in 2010 of the different scenarios and the EU Burden-Sharing targets for Austria, Belgium, Ireland, Luxembourg and the Netherlands.

Figure 8 shows that Austria has quite a lot of difficulties in achieving the target according to all the trends except the EEA trend. It seems that Austria has not been able to carry out the needed policy measures to approach the quite demanding target of –13 %.

It also seems to be quite difficult for Belgium to reach the target of –7.5 %. All the trends show about 20 % gap between the trends and the target.

The case of Ireland is interesting. The trends and GRID estimates show that it might be quite easy for Ireland to achieve the target of +13%, while Reinstein estimates indicate quite a lot of problems.

For Luxembourg the data are quite scattered trends. In any case, the already achieved reductions of emissions indicate good possibilities for achieving the demanding target of -28 %. For the Netherlands all the trends indicate a lot of problems in achieving the target of -6 %. The Netherlands government has been rapid in establishing a climate strategy, but it seems not to have had any effects so far.

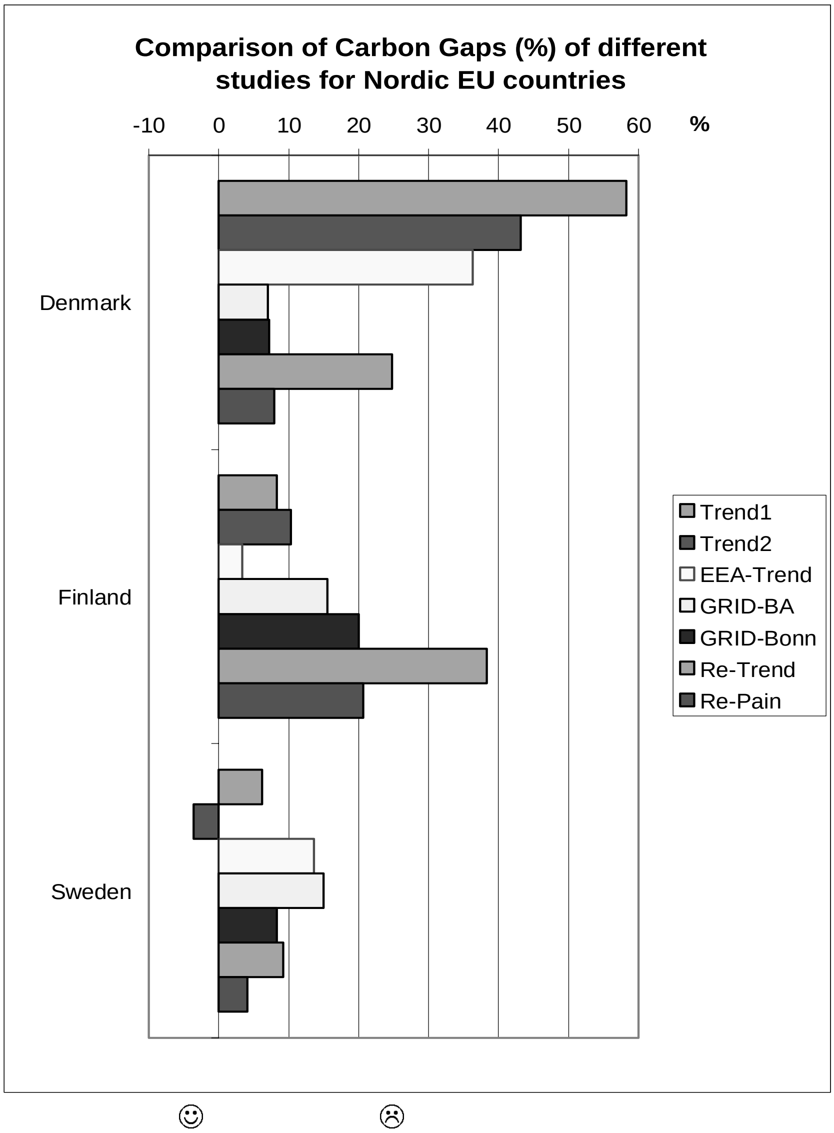
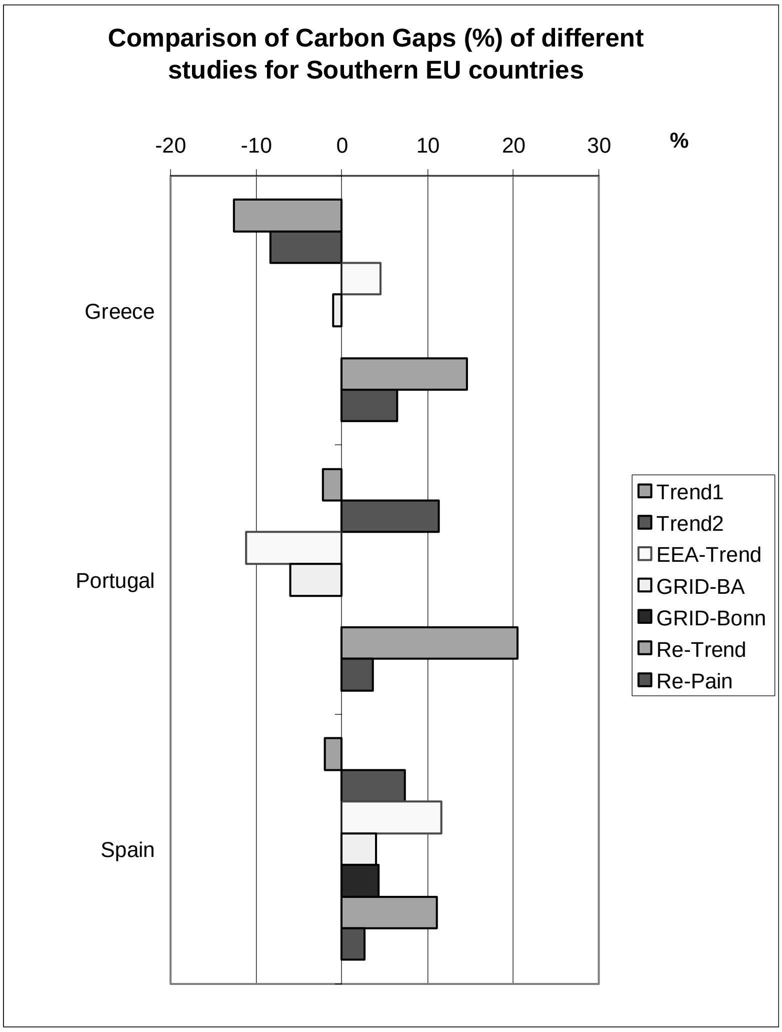


Figure 9. Carbon gaps between the estimated CO_2 emissions in 2010 of the different scenarios and the EU Burden-Sharing targets for the Nordic EU countries.

The emission trends for Denmark show almost catastrophic increase of emissions compared with the demanding target of –21 %. The main reason behind the fast growing emissions is the increase of electricity export (produced by condensing coal-fired power plants) from Denmark due to the shortage of hydro power during the dry years in the Nordic countries. This situation does not probably last for very long periods and Denmark is going to decrease its electricity export. In any case, the very demanding target of Denmark requires strong measures to cut the emissions and Denmark has introduced e.g. quota system for power producers in addition to the general CO_2 tax (which, however, does not apply electricity production). The quota system may cause some problems in the liberalised electricity market, and this may require a renewed climate policy system.

The trends indicate quite reasonable policy options for Finland to achieve 0 % target. The emissions in Finland have actually decreased in 1998 and –99 from the level of 1997 indicating even better possibilities to achieve the target. The scenarios by Reinstein indicate very demanding target, but this may be mainly a consequence of the extremely high growth scenarios by the government in early 90's and adopted be Reinstein.

According to the trends and scenarios Sweden seems to be in a quite good position to achieve the target of +4 %. The target showing increase in emissions is due to the plans of closing nuclear power plants in Sweden. The first Barseback reactor has now been closed, but there seems to be no indication of high growth of emissions.



☺ ☹

Figure 10. Carbon gaps between the estimated CO_2 emissions in 2010 of the different scenarios and the EU Burden-Sharing targets for the Southern EU countries.

The trends of emissions in Greece show an easy position for achieving the target of +25%. It seems quite probable that the industrialisation in Greece has not been based to a very large extent on energy intensive industry, which means lover growth rates for emissions. It looks probable that Greece might be in a seller position in the emission trade market.

Portugal seems to be in a quite good position regarding the possibilities of achieving the target of +27 %. The same applies also for Spain and its +15 % target. Generally all the Southern EU countries may acquire the position of sellers in the emission markets if the climate policy measures are used to increase the productivity of energy use.

We could divide the EU countries according to the possible problems of achieving the targets in the following groups:

Difficult problems:
The Netherlands
Belgium
Austria
Denmark (depending on electricity export)

Some problems:
Finland
Italy
UK
Germany

Low problems or possible sellers:
France
Ireland
Luxembourg
Sweden

Probable sellers:
Greece
Portugal
Spain

4. DECOMPOSITION ANALYSES OF EU15 EMISSION EFFICIENCY

In this paper a decomposition model has been used to analyse the CO_2 emissions. In the article dynamic time-series based decomposition analysis has been used to reveal the structural and efficiency changes in the production processes of different Member States. We have developed a modified version of the so-called 'Complete Decomposition Model' (see Sun 1996, 1997), where no residual term remains.

Using the decomposition analysis different production related factors (in this case CO_2 emissions) can be decomposed in three explanatory factors: (i) activity effect (Q_{effect}), that describes the effect of the total economic growth (in EU) on the use or output of the factor, (this does not directly depend on the own production of the country); (ii) intensity effect (I_{effect}) that describes the impacts of the technological change and the change of production systems on the production factor use or output; and (iii) structural effect (S_{effect}) that describes the impact of the changes in the sectoral or county wise share of total production on the factor use or output.

Figure 11 shows the activity effect on CO_2 emissions for the whole EU. The activity effects on CO_2 emissions in different Member States are quite similar to the whole EU figure due the method. The variations due to the differences in economic growth in different countries are taken into account in the structural effect.

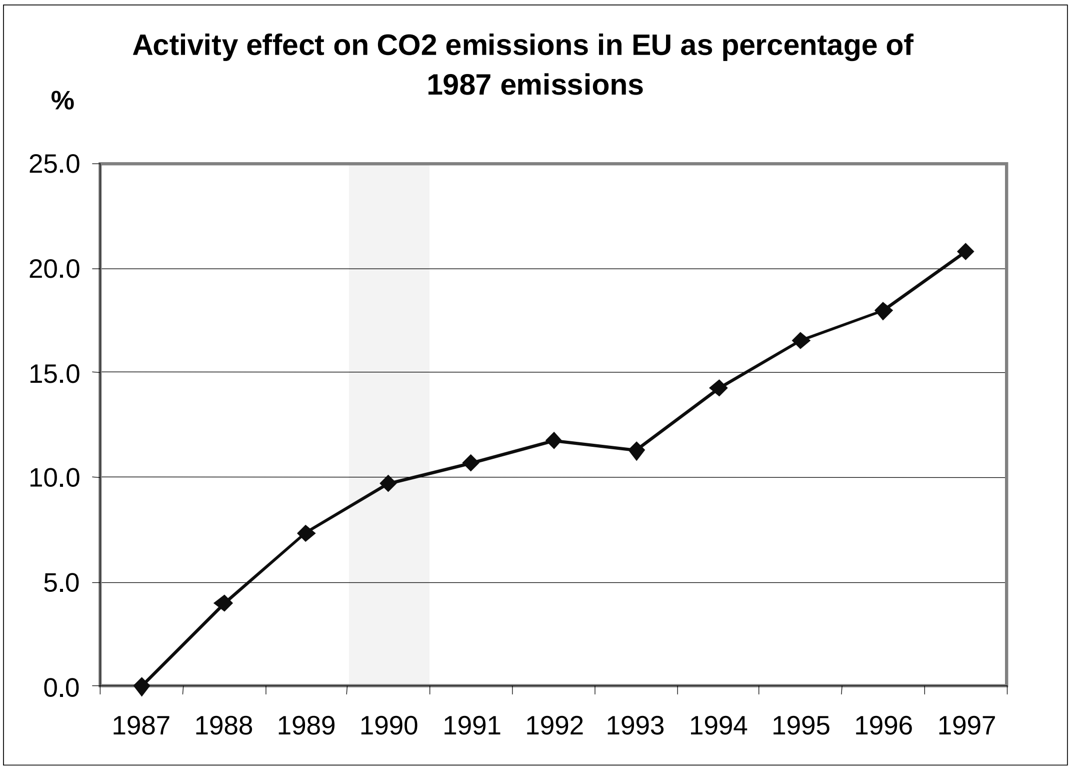


Figure 11. Activity effect (Qeff) on the CO2 emissions in the European Union shown as percentage changes from 1987 emissions.

Figure 11 shows that if there had been no efficiency improvement in EU the CO_2 emissions would have grown over 20 % during the period 1987-97.

Production related CO_2 emission intensities vary remarkably in different countries due to the different use of energy sources, different energy intensities of production, different sectoral shares of production, different transport structures, etc. Figure 12 shows the vast variations and changes of CO2 intensities in different EU countries measured as CO_2 tons per one US dollar (1990) output.

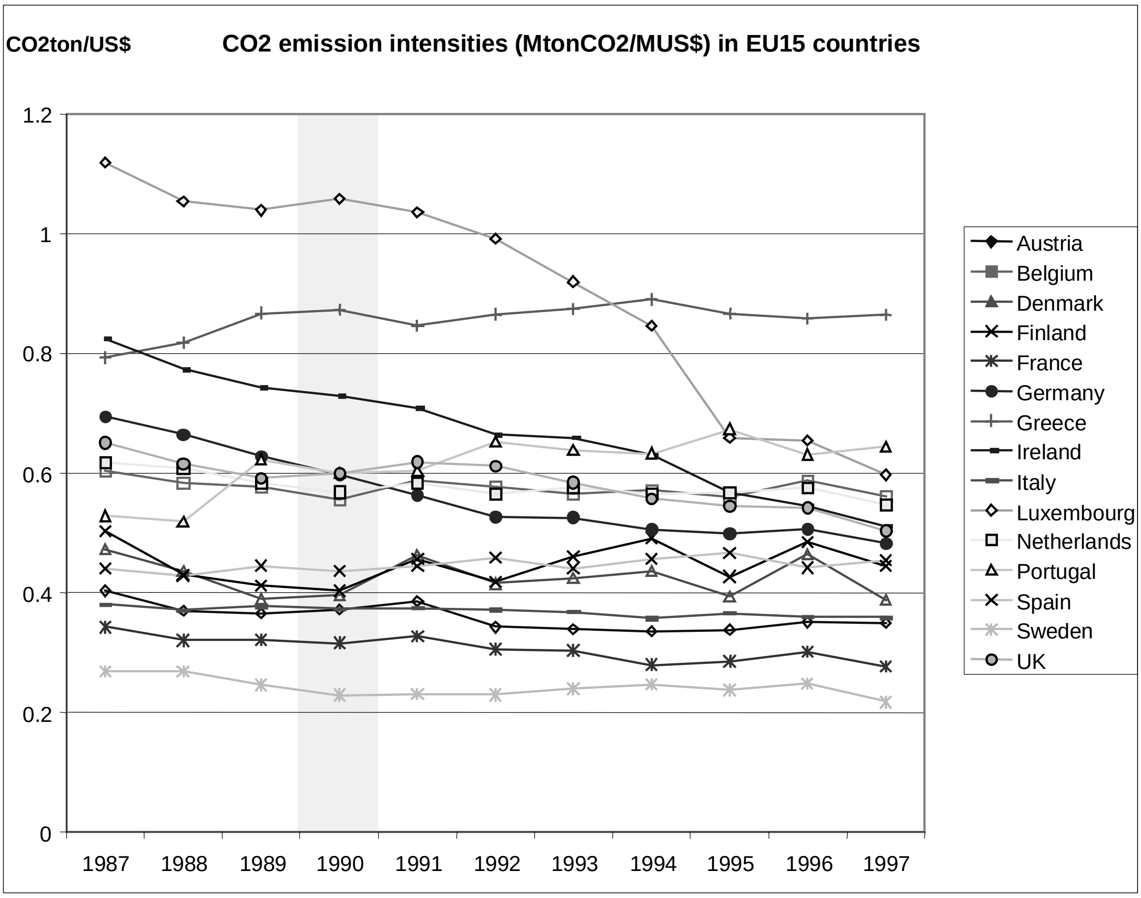


Figure 12. CO_2 emission intensities (CO_2 tons/US$(1990) output) in EU15 countries.

The effects of technological changes, production process changes, changes in the shares of production within a country etc. can be analysed by the decomposition analysis using the *intensity effect* (Ieff). Negative intensity effect indicates increase of efficiency, i.e. increase in production output compared with CO_2 emissions.

The decomposition analyses show interesting changes of intensity effects on the CO_2 emissions in different countries. The intensity effects of the large EU countries are shown in Fig. 13.

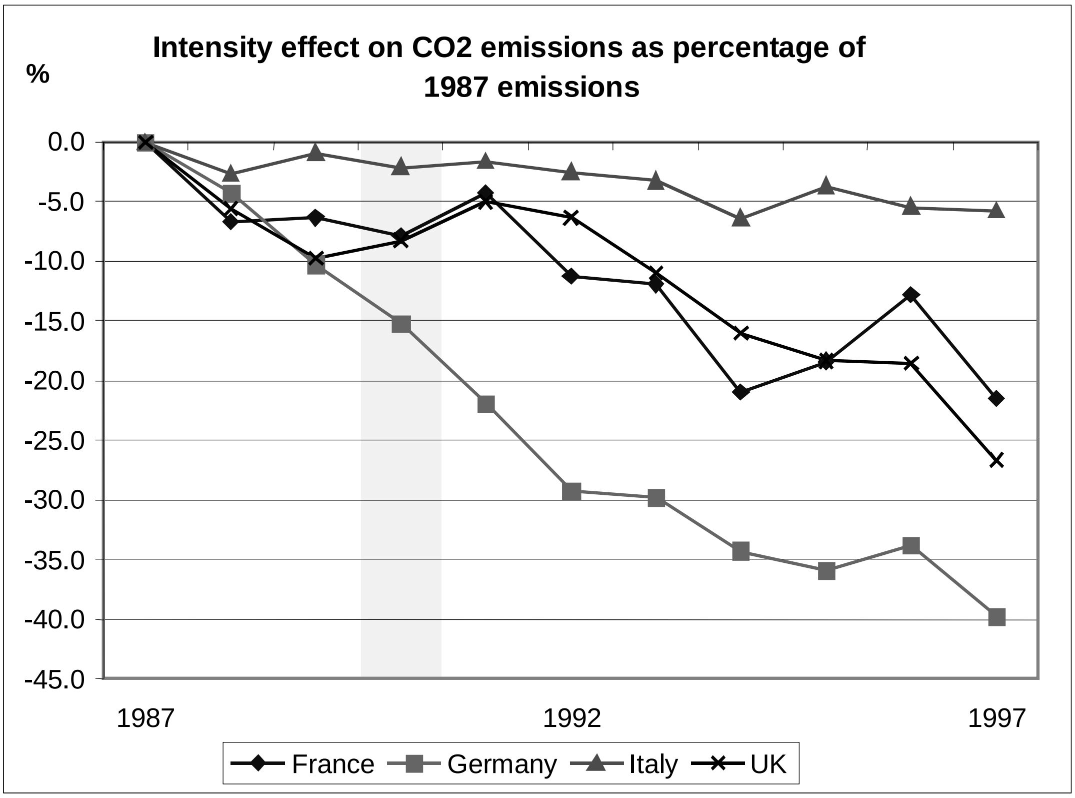


Figure 13. Intensity effects on CO_2 emissions in large EU countries as a percentage change compared with 1987 emissions. Negative intensity effect indicates improving efficiency.

Fig. 13 shows that especially in Germany the production efficiency in relation to CO_2 emissions has increased remarkably. This is partly due to the techno-economic changes in the former East Germany. Also in France and UK the production efficiency has increased remarkably. The same economic output could have been produced with 20-25 % less CO_2 emissions in 1997 compared with 1987. In UK the reason for improved efficiency in this respect has been partly due to the switch from coal to natural gas. Also in France the emission intensity of energy use (CO_2/TPES[1]) has decreased. In Italy the development of efficiency in this respect has not been very remarkable.

Fig. 14 shows the changes of intensity effects in Austria, Belgium, Ireland and the Netherlands.

[1] TPES is Total Primary Energy Supply.

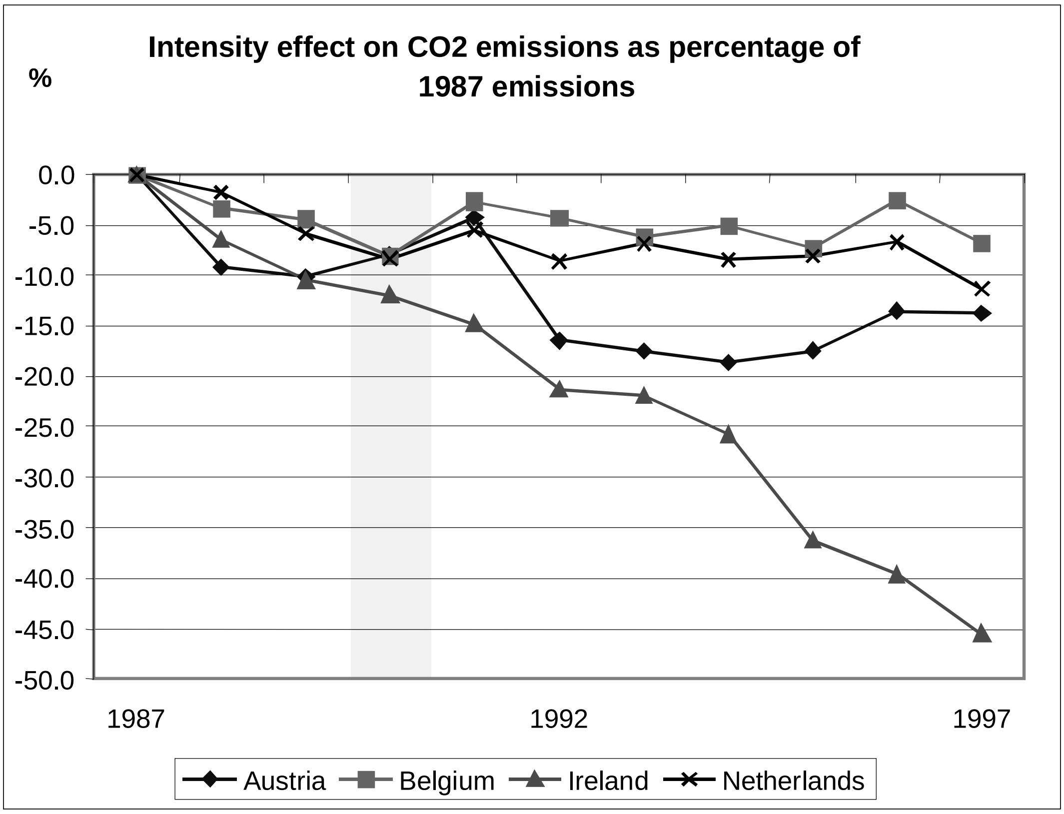


Figure 14. Intensity effects on CO_2 emissions in Austria, Belgium, Ireland and the Netherlands as a percentage change compared with 1987 emissions. Negative intensity effect indicates improving efficiency.

Fig. 14 indicates that especially in Ireland the production efficiency in relation to CO_2 emissions has increased remarkably. This is not so much due to the fuel switch but due to the increased efficiency of production in relation to energy use. In Austria there has been some increase in energy efficiency, but not much fuel switch effect resulting in moderate intensity effect changes. In the Netherlands the intensity effect change is due to energy efficiency improvement without any fuel switch effect. In Belgium the changes have been considerable small.

Figure 15 shows the intensity effect changes in the Nordic EU countries.

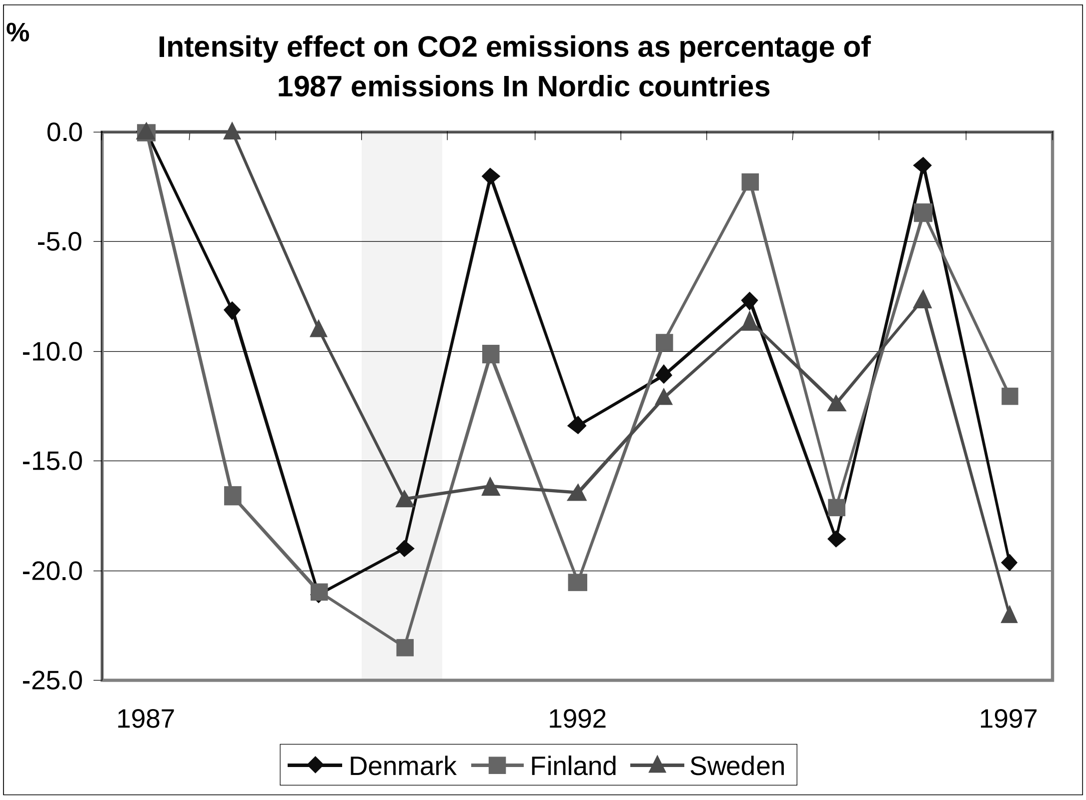


Figure 15. Intensity effects on CO_2 emissions in the Nordic EU countries as a percentage change compared with 1987 emissions. Negative intensity effect indicates improving efficiency.

In the Nordic countries the intensity effect seems to fluctuate remarkably. This is mainly due to the variations in precipitation levels, which have an important effect on hydro power production resulting in changes in fuel consumption in electricity production in the common Nordic electricity markets. For instance year 1996 was very dry in the Nordic countries increasing the use of coal for power production and resulting in increase (loss of efficiency in relation to CO_2 emissions) in intensity effect. There seems to be no clear trend in intensity effect changes in any Nordic country. There is no indication of either fuel switch or energy efficiency improvements in the Nordic countries.

Figure 16 shows the intensity effect changes in the Southern EU countries.

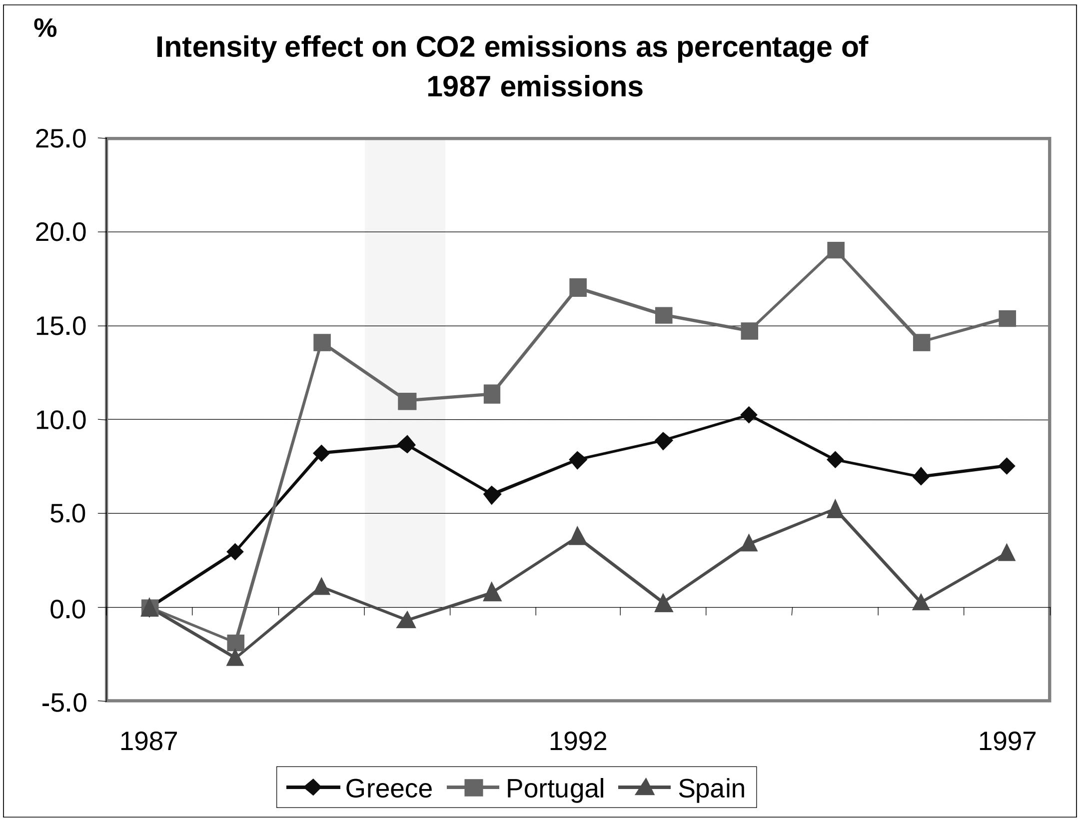


Figure 16. Intensity effects on CO_2 emissions in the Southern EU countries as a percentage change compared with 1987 emissions. Positive intensity effect indicates decreasing efficiency.

In the Southern EU countries the intensity effects seem to have increasing trends indicating decreasing efficiency of production in relation to CO_2 emissions. In the Southern countries there seems to be no fuel switching taking place and the increase is mainly due to the increased amount of energy used for producing one dollar of output. This trend is mainly caused by the process of industrialisation – the share of energy intensive industry in the total production volume increases.

The *structural change effect* in decomposition analysis shows how the shares of the different production units (countries, sectors) of the total production volume change in the course of time. Figure 17 shows the structural effect of the large EU countries.

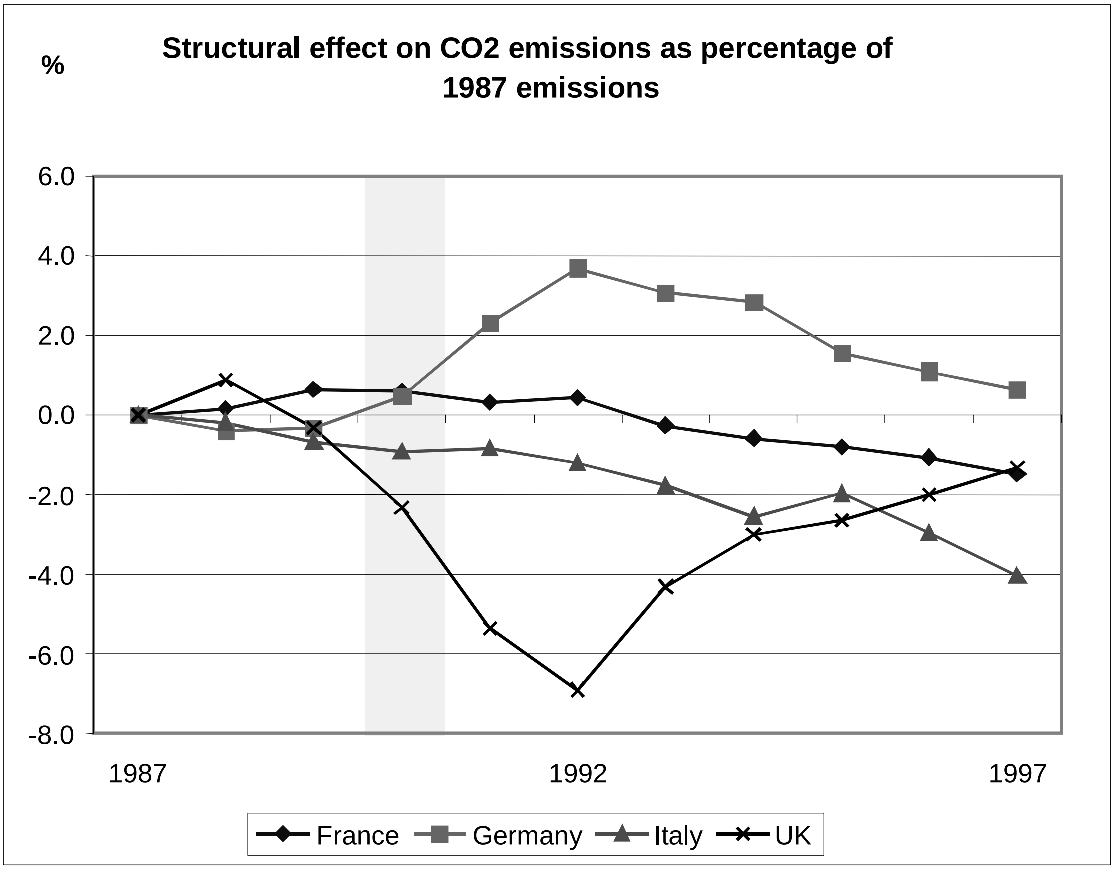


Figure 17. Structural effect of large EU countries on the CO_2 emissions as a percentage change compared with 1987 emissions. Positive structural effect indicates growth of the share of EU's total economic activity and vice versa.

Figure 17 indicates that the economic recession in UK in the beginning of 90's had a quite large effect on CO_2 emissions. In Germany the reunification increased the share of the economy in the EU scale and increased the emissions. The shares of France and Italy have been decreasing in the 90's.

Figure 18 shows the structural effect on CO2 emissions in Austria, Belgium, Ireland, Luxembourg and the Netherlands.

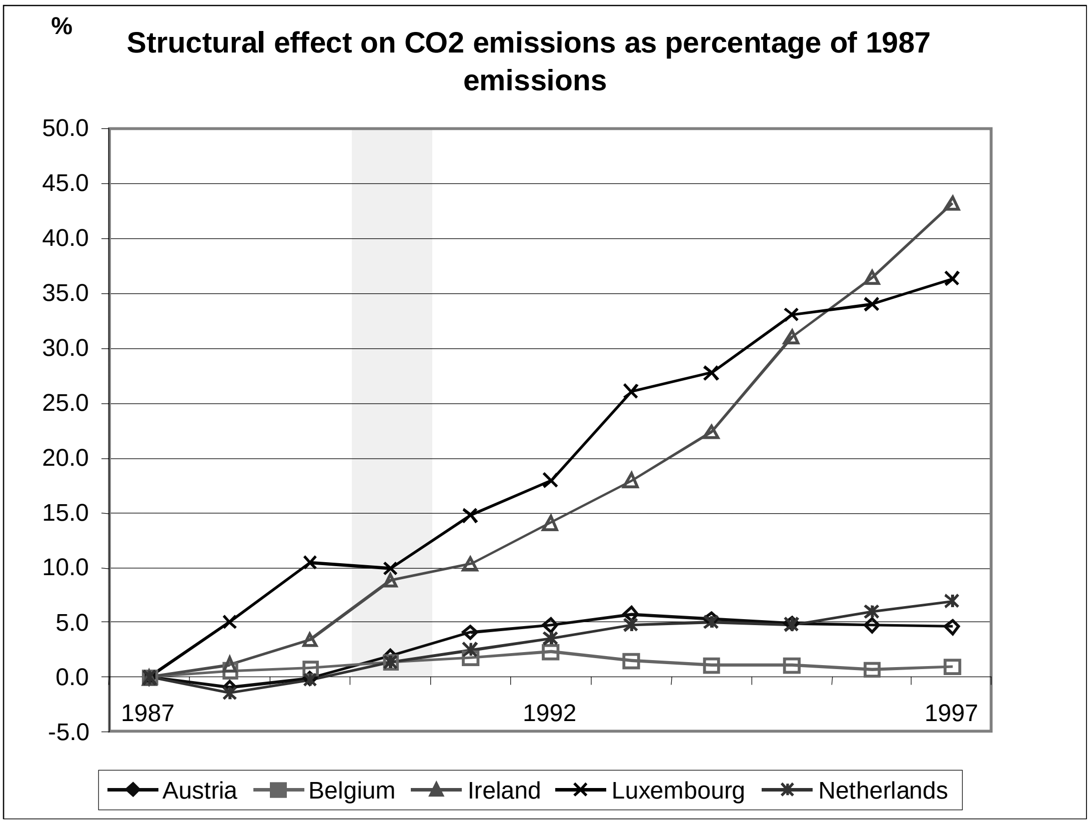


Figure 18. The structural effect on CO_2 emissions in Austria, Belgium, Ireland, Luxembourg and the Netherlands as a percentage change compared with 1987 emissions. Positive structural effect indicates growth of the share of EU's total economic activity and vice versa.

In Ireland and Luxembourg the intensive economic growth has increased the CO_2 emissions remarkably. In Austria and the Netherlands the growth of the share of total EU economic output has had a moderate effect on the increase of emissions.

Figure 19 shows the structural effect on CO_2 emissions in the Nordic EU countries.

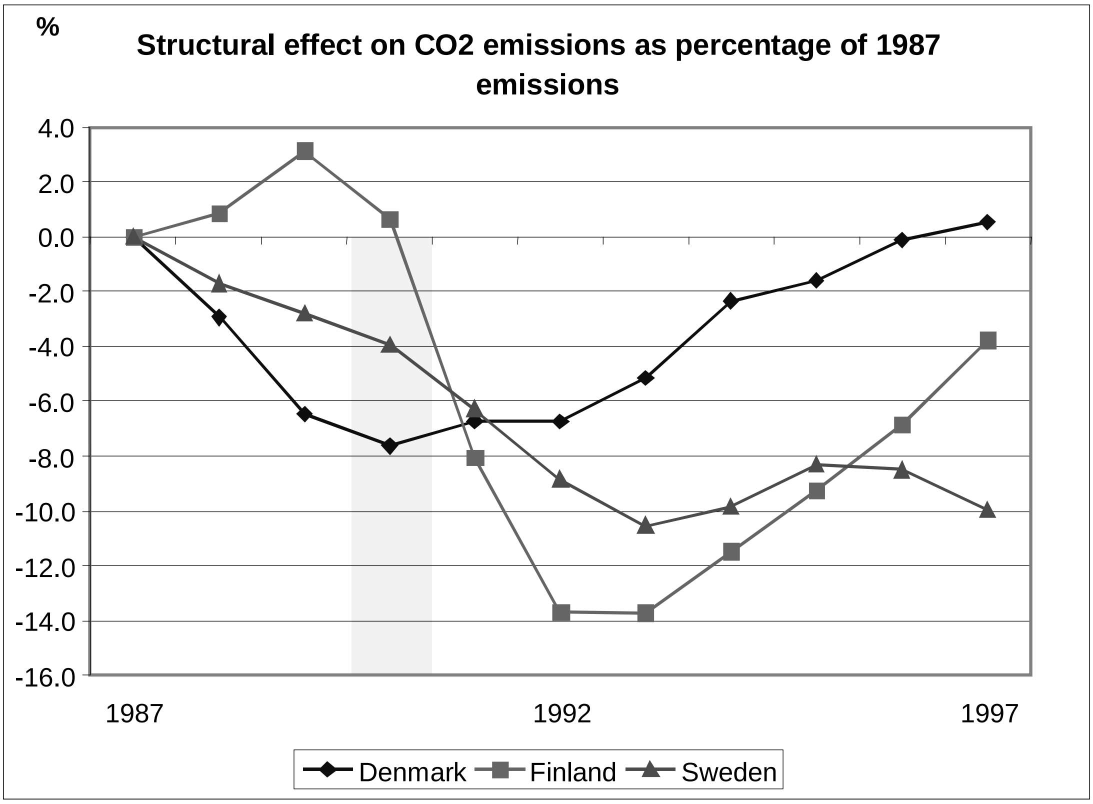


Figure 19. The structural effect on CO_2 emissions in the Nordic EU countries as a percentage change compared with 1987 emissions. Positive structural effect indicates growth of the share of EU's total economic activity and vice versa.

In all the Nordic EU countries the economic recession in the early 90's has had a remarkable effect on CO_2 emissions. Especially in Finland the drop of the economic output was very fast and deep, but after 1993 the growth has also been quite rapid. In Sweden the level of economic output in the EU comparison has remained in a lower stage.

Figure 20 shows the structural effect on CO_2 emissions in the Southern EU countries.

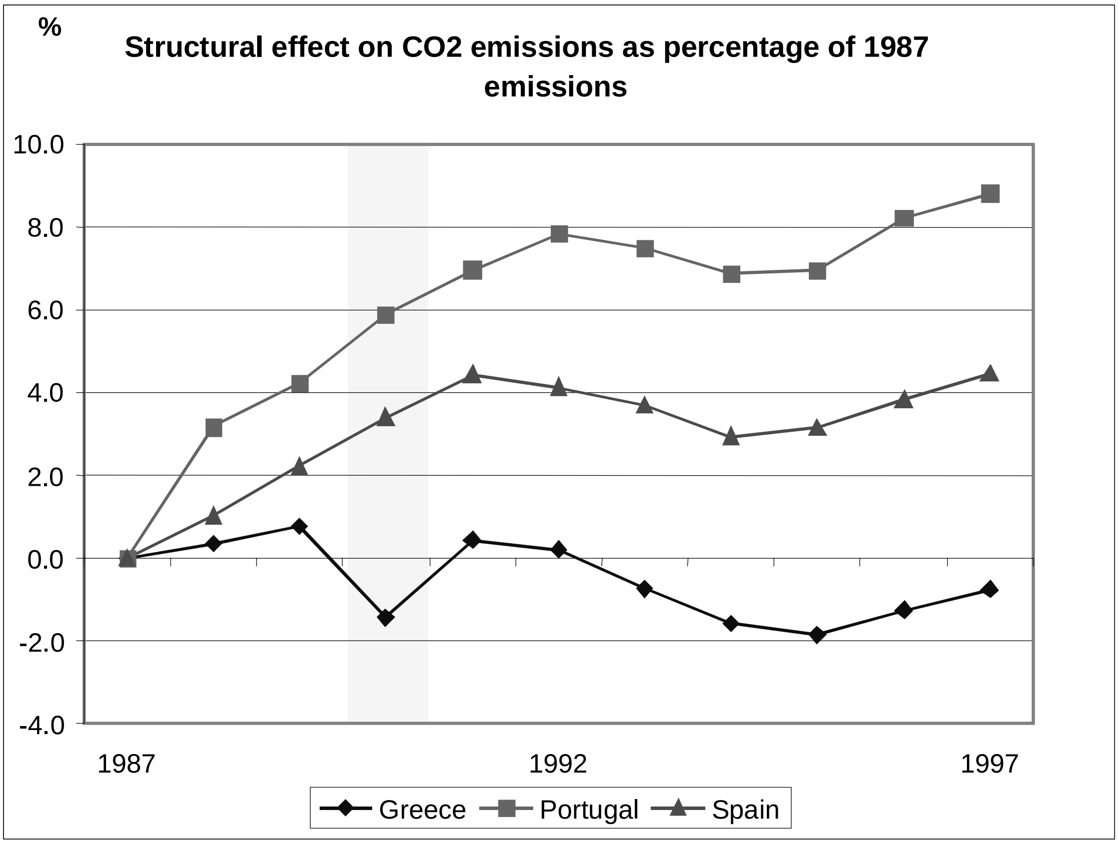


Figure 20. The structural effect on CO_2 emissions in the Southern EU countries as a percentage change compared with 1987 emissions. Positive structural effect indicates growth of the share of EU's total economic activity and vice versa.

In Portugal and Spain the economic growth has been larger than the EU average. This has resulted in the rapid increase in emissions. On the other hand, in Greece the growth has not exceeded the average EU level, which can be seen also in the total emissions level in Greece.

5. CLIMATE POLICY IMPLICATIONS AND FURTHER DISCUSSION

According to this paper the main results are the following:

1) According to our trend analyses, the majority of EU member states are going to be potential buyers within the EU burden sharing commitments. According to our results in the EU there will be "overdemand situation" in the common CO_2 emission market. It is also worth of consideration that the 'JUSSCANNZ' countries, most OECD countries outside the EU, can form some kind of a bubble with Russia and Ukraine (Grubb et al 1999, 124). The EU15's potential overdemand situation in the global CO_2 emission market can be a problematic in the near future because the competing 'bubbles' and other Parties of Kyoto Protocol must make some kind of emission trade agreements. The relative role of the Kyoto mechanisms (Joint implementation, the Clean Development Mechanism and Emission Trading) is a very crucial strategic issue for the EU.

2) Our analyses reveal that there are considerable differences in different carbon gap estimates. Generally the results are coherent but the some trend estimates seem to give higher carbon gaps than the average. Especially the estimates by Reinstein (Pirilä & Reinstein 2000) exceed the average trend estimates for many countries.

3) On the basis of IEA statistics trend estimates the potential sellers of AAUs are France, Greece, Ireland, Sweden, Russia and Ukraine. Other analysed countries are potential buyers. USA seems to be the most important potential buyer with about 870 Mtons of CO_2. Japan seems to be a bigger buyer than EU15 as a total. Russia has possibilities for a large sell of "hot air" – almost three times the gap of EU15 and 75 % of the gap of USA. Ukraine is also a remarkable potential seller with one and half times the EU15 gap or over 40% of the USA gap. Russia and Ukraine could together fill the gap of USA giving a possibility for a strategic bubble.

4) Trend estimates of the EU15 countries indicate that there is a group of countries, which may have difficult problems of achieving the emission target: The Netherlands, Belgium, Austria and Denmark (depending on electricity trade). Countries, which may have some problems of achieving the target, are Finland, Italy, UK and Germany. Countries which have low problems of achieving the target or which are possible sellers are France, Ireland, Luxembourg and Sweden. The probable seller countries are Greece, Portugal and Spain.

5) The study of the intensity effect of the different countries reveals the efficiency changes of CO_2 emissions in relation to value added among EU15 countries. The majority of EU15 countries have had positive development of efficiency improvement. The Nordic EU countries have had large variations in the intensity effect due to large variations in hydropower production in Sweden and Norway for the common Nordic electricity markets. Only Greece, Portugal and Spain have had negative development of efficiency indicating that they

produce increasing amounts of CO_2 emissions for the same economic output. This is an issue that EU should consider carefully in its common policy and in directing the structural fund allocations. The development of the efficiency of the system may depend on either the more inefficient energy system or structural shift towards more energy consuming economic structure. This question requires more detailed investigation because there is a danger that EU is supporting inefficient energy production systems in these countries. It would be important to include climate change emission reductions as a criterion in the allocation of structural funds to hinder undesirable development of CO_2 efficiency.

6) The analyses of structural effect of EU15 in comparison with the intensity effects reveal that there can be different types of growth processes in relation to CO_2 emissions. The fast growth in Ireland is connected with fast improvement in CO_2 efficiency while e.g. in Portugal and Spain the growth is associated with decreasing CO_2 efficiency.

There are different options for EU to reach the target of 8% reduction in GHG emissions by commitment period. The various strategies for EU15 may be co-operative or non-co-operative. If there are no clear guidelines for co-operation we cannot expect rational choices in policy formulation in the Member States. Crucial policy factors inside EU15 counties are (1) evidence and information concerning different common and co-ordinated climate policies and measures (CCPMs), (2) the beliefs of different country level agencies, (3) the desires of different country level agencies and (4) political decision-mechanisms of EU15 countries. Large uncertainties in climate policy may lead to "wait and see" policies during which country agencies seek more evidence and information. For instance, emission trading is the crux on which Kyoto Protocol stands. However, in the EU, the challenge is to define the relevant principles, rules, modalities and guidelines governing emission trading.

EU member countries vary according to certain economic and institutional factors. Especially the poorer 'Cohesion' countries do not want to bear the responsibility for past emissions of other EU countries, and they fear that any constraint of energy consumption is an obstacle to the main aim of economic growth (Grubb et al 1999, 30). Climate policy declarations in the EU have recognised this disparity, aware that emission from these 'Cohesion' countries are likely to grow in the context of overall reductions, requiring bigger reduction from some other member states, if the EU target is to be achieved.

The de-linking and structural change in the European economies is one possibility of achieving the targets. In the de-linking process more welfare is achieved with less use of nature (see e.g. Femia, Hinterberger & Luks 1999). The aim should be to find key transition paths towards sustainability in European Union, and to promote wider policy harmonisation of EU's Common Policy. One obvious key transition path will be policy relevant macroeconomic information that promotes eco-efficiency strategies including both consumption and production in EU countries. The target should be a contribution to Factor-Four and Factor-Ten processes in the European scale (see e.g. Schmitd-Bleek 1996 and von Weizsäcker, Lovins & Lovins 1997).

There is a fairly long tradition on the "de-linking" debate as well as on the role of economic structural change for environmental sustainability. The de-linking discussion has been ongoing for around 20 years. De-linking discussion is connected to the question whether (on the aggregated level of national economies) a continuous economic growth evolves along with increasing or decreasing use of nature (i.e. energy and materials use, emissions of greenhouse gases, wastes etc.). It is suggested that the more advanced an economy is the less environment burden is attached to the production and consumption patterns, at least after a certain level of economic welfare (Environmental Kuznets Curve hypothesis, see e.g. Ekins 1997, Rothman & de Bruyn 1998).

In any case, one can recognise a notion of normative imperative for de-linking from the political discussion. A remarkable and increasing amount of policy documents perceives it, as a pre-condition for sustainable development, to de-link economic development from use of nature (e.g. 5th EAP). This means that the more policy relevant question is how and under which conditions a de-linking can be achieved.

Hence, a more thorough analysis of the de-linking phenomenon is needed - a more disaggregated analysis going beyond the aggregated national economy. At this stage, the subject of economic structural change enters the scene. The aggregated economic development is a composition of sectoral economic developments. If on an aggregated level the economic growth is de-linking from – for instance – energy and materials use, this might be due to only a few sectors of the economy (e.g. service sector). In general, the overall change has been decomposed in three effects (e.g. Binswanger 1993, Jaenicke 1998):

- intra-sectoral change effect, i.e. the contribution of eco-efficiency improvements within the sectors;
- inter-sectoral change effect, i.e. the contribution of an increased share of more eco-efficient sector or the changed sectoral composition of the entire economy;
- growth or scale-effect, i.e. the contribution of the overall economic growth.

This means that more disaggregated decomposition analysis is needed in order to produce policy relevant information for the planners and decision-makers.

Sustainability, as in the spirit of the Amsterdam Treaty, requires a real integration of the three sustainability dimensions- social, economic and environmental aspects. Hence the policy towards achieving the Kyoto target should be reconciled with the objectives of a competitive European economy, a sufficient level of employment and remaining in the carrying capacities of natural environment.

Integrated Assessment (IA) is needed to integrate social, economic and environmental aspects in the planning process (see e.g. Rotmans 1999). There is a need to further develop the analytical frameworks to integrate, in a triangular way, main socio-economic drivers such as technological development and innovation, the economic, structural and demographic changes and the environmental performance

The eco-efficiency strategies are usually connected to technological development. The results of the trend analyses indicate need for technological development. In many countries the energy efficiency of production (MJ/EURO) is not improving and there are no indications of fuel switching taking place. This means that the role of renewable energy should be improved in the energy sector. Important means of achieving the target could be energy or CO_2 taxation (see comparative analyses in e.g. Vehmas et al 1999). At the EU level this may require changes in the decision making – it seems probable that it is not possible to achieve consensus in the taxation and the only hope might be the transfer to majority decision making.

On the other hand, international and national emission trading will produce a price for CO_2 tons all over the world. This will have same type of consequences as the CO_2 tax. The implementation of Kyoto mechanisms will thus improve the possibilities to increase the efficiency of the production systems. But, on the other hand, there should be tight ceiling for the use of the mechanism, otherwise there will not be incentives to carry out domestic efficiency improvements. The ceiling suggested by EU might be sufficient to produce system, where there is enough room for emission trade, JI and CDM to achieve economic efficiency in emission reduction and producing real price for emissions. On the other hand, it is tight enough to provide incentives for domestic actions (having also an effect on structural change), which in the long run may turn out to be most efficient and economic in emission reduction.

The emphasis of domestic actions also integrates the consumption side of the energy system in the development process. In many cases the domestic energy saving projects are most economic ways of decreasing the emissions from the point of view of national economy. However, the short payback times (2-3 years) required for industrial energy saving investments compared with the much longer payback times for energy production investments (20-30 years) effectively hinder emissions reduction possibilities, which could be the cheapest for the whole economy.

REFERENCES

Binswanger, M. (1993) Gibt es eine Entkopplung des Wirtschaftswachstums von Naturverbrauch und Umweltbelastung? -IWÖ-Diskussionsbeitrag Nr. 12, Hochschule St. Gallen.

Ekins, P. (1997) The Kuznets Curve for the Environment and Economic Growth: Examining the Evidence, Environment and Planning A. Vol. 29, 805-830.

European Community (1998) Council Conclusion of Climate Change. June 1998. Brussels.

European Environmental Agency (1999) Environment in the European Union at the Turn of the Century. Environmental Assessment Report 2. EEA. Copenhagen. Denmark.

Eyre, Nick et al (1998) ExternE Global Warming. Subtask Global Warming Damages. Internet: http://externe.jrc.es/.

Eyre, Nick (2000) Global Warming. Internet: http://externe.jrc.es/nletter6.html

Femia, Aldo, Hinterberger, Friedrich & Luks, Fred (1999) Ecological Economic Policy for Sustainable Development. Potentials and Domains of Intervention for Delinking Approaches. SERI Working Paper No. 1. Sustainable Europe Research Institute, Wien.

Grubb, Michael, Vrolijk, Christiaan & Brack, Duncan (1999) The Kyoto Protocol. A Guide and Assessment. Energy and Environmental Programme. The Royal Institute of International Affairs. Earthscan. London.

International Energy Agency (1999). CO_2 Emissions from Fuel Combustion. 1971-1997 highlights. IEA statistics. OECD. Paris. France.

http://www.grida.no/db/maps/collection/climate5/index.htm at 17.2.2000.

http://www.grida.no/db/maps/collection/climatechange/ at 17.2.2000.

Jänicke, M. (1998): Towards an End to the "Era of Materials"? Discussion of a Hypothesis . - FFU-Report 98-5, Berlin.

International Energy Agency (1999) CO_2 Emissions from Fuel Combustion. 1971-1997 Highlights. IEA Statistics. OECD. Paris. France.

Oberthur, Sebastian & Ott, Hermann E. (1999) The Kyoto Protocol. International Climate Policy for the 21st Century. Springer. Berlin Haidelberg.

Pirilä, P. & Reinstein, R. (2000). Meeting the target – elements of national policies. In Pirilä (ed.). Climate Change. Socioeconomic dimensions and consequences of mitigation measures. Helsinki. Edita. pp.173-207.

Rothman, D.S. & S.M. de Bruyn (1998) Probing into the Environmental Kuznets curve hypothesis, Ecological Economics, Vol. 25(1998), 143-145.

Rotmans, J. (1999) Integrated Assessment. A bird's-eye view. International Centre for Integrative Studies (ICIS) University of Maastricht. Maastricht.

Schmidt-Bleek F. (1996). MIPSbook or The Fossil Makers - Factor 10 and more. Wuppertal Institute for Climate, Environment and Energy. Wuppertal.

Sun, JiWu (1996) Quantitative Analysis of Energy Consumption Efficiency and Saving in the World, 1973-90. Publications of Turku School of Economics and Business Administration, Series A-4:1996, Turku.

Sun, Jiwu (1997) Changes in Energy Consumption and Energy Intensity: A Complete Decomposition Model. Energy Economics, Vol. 20, No. 1, pp. 85-100.

Vehmas, J. Kaivo-oja, J. Luukkanen, J. & Malaska, P. (1999) Environmental Taxes on Fuels and Electricity – Some experiences from the Nordic Countries. Energy Policy Vol 27/6, pp. 343-355.

Weizsäcker von, Ernst, Lovins, Amory B. & Lovins, L. Hunter (1997) Factor Four. The New Report to the Club of Rome. Earthscan, London.

PREVIOUS TUTU PUBLICATIONS:

-