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Abstract

The EU Emissions Trading Scheme (EU ETS) has been in operation since January 2005. The data analysis of the allocated allowances and verified emissions for the first trading period shows that the EU ETS was in an overall long position implying very low carbon prices. The average long position for 2005-2007 for the EU total is the balance of a 12.1 percent long and an 8.7 percent short position of the total emissions. The allocation differences vary between countries, sectors and installations. Another feature of the EU ETS is the pronounced inequality in the distribution of the size of installations when ranked according to their emissions.

When looking at competitiveness effects of the EU ETS it is important to differentiate between sectors. In the report we chose two sectors as case studies – electricity and cement. From the empirical analysis it seems that the EU ETS so far did not generate large incentives to enforce the long-term developments in these sectors. This has to be seen in the context of low or close to zero CO2 prices in the first trading period.

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1 Introduction

The EU Emissions Trading Scheme (EU ETS) which has been in operation since January 2005 represents in several respects a unique experiment: it is the first international implementation of an innovative policy instrument; it is a test ground for the even bigger emissions trading market starting in 2008 under the Kyoto Protocol; and it challenges research on issues ranging from investigating the inherent incentives that drive the allocation of emission allowances (EUAs) to analyzing the economic impact on countries, sectors and individual installations.

With the results for the first trading period, having become available, a lot of early enthusiasm has turned into cautious analysis: because of substantial over-allocation of EUAs in most Member States the overall emissions cap was not stringent and created a lot of market volatility which in turn added uncertainty to companies' decisions about their emissions policy; the expected incentives for investments in low energy and low emissions technologies are at least questioned; but above all evidence seems to be emerging that underestimated transaction costs and observed inequalities in the allocation procedures of Member States create a much higher impact on the competitive position of sectors and installations as previously expected.

In this study we are investigating the impact of the EU ETS on economic competitiveness in three steps: first, we create a comprehensive database for the more than 10,000 installations involved in the EU ETS. Second, based on the 2005-07 results, we analyze the issue of short and long positions of emission allowances between and within Member States both on an aggregate and sectoral level and draw first conclusions as to their impact on competitiveness.

Third, we investigate competitiveness issues and take a closer look on the case studies for the electricity and cement sector.

The results obtained will serve the ongoing evaluation process of the EU ETS. By identifying and reducing currently distorting impacts on economic competitiveness the EU ETS could not only become more efficient and effective but evolve into a viable instrument for stimulating technological innovation.

The EU Emissions Trading Scheme (EU ETS) that covers about 5% of total global greenhouse gas (GHG) emissions, 11% of developed nations' GHG emissions and 40% of total EU GHG emissions is the biggest implementation worldwide of a cap-and-trade mechanism to curb emissions. This policy instrument is both a milestone and a strong incentive for starting similar activities in other regions of the world.

Although the introduction of the EU ETS was motivated by climate policy, the process of designing a CO_2 regulation scheme was also accompanied by economic considerations. The aim was to achieve the CO_2 reduction targets within the European Union with an economically efficient instrument for the regulated industries.

The EU ETS can thus be evaluated from two perspectives. First, it has to be analyzed whether the EU ETS contributed to the CO_2 reduction targets by limiting CO_2 emissions from regulated industries; second, possible adverse effects on the firm, sector and country level also have to be evaluated.

The study is organized as follows. Chapter 2 presents the main features of the EU ETS. After describing the first trading period (Chapter 3) an analysis on short and long positions in the EU ETS in the first trading period follows (Chapter 4). In Chapter 5 the main lessons learnt from the EU ETS pilot phase (2005-2007) are discussed and an outlook to future trading periods is presented. Chapter 6 summarizes possible impacts of the EU ETS on competitiveness based on a literature review. Chapters 7 to 10 take a closer look at two sectors of interest - electricity and cement - by first discussing specific competitiveness issues and then giving empirical evidence on the sectors. Chapter 11 concludes the main findings of this study. Appendix 1 and appendix 2 extensively depict the peculiarities of the EU countries for the analysis from chapter 8.

2 The EU Emissions Trading Scheme (ETS) - main features

Already in 1992 the Commission proposed an EU-wide carbon tax. This proposal, however, was neither supported by Member States seeing their tax sovereignty in danger nor by industry lobbying groups. Finally, in 1997 the carbon tax proposal was formally withdrawn (Convery et al. 2008). In comparison to these first discussions in the European Commission on CO_2 regulation the EU ETS has a surprisingly short history. Following the Kyoto Protocol in 1997, which set quantitative, binding reduction targets for greenhouse gas emissions in the industrialized and transition countries, the EU started an internal process of analyzing policies and measures in order to reach the set emission reduction targets. As one of the policy instruments an emissions trading scheme for industry was discussed. In the year 2000 the "Green Paper on greenhouse gas emissions trading within the European Union" (EC, 2000) was issued and several design issues for such a system were analyzed (Stewart and Sands, 2000). The decision making process led to a proposal for a framework Directive for greenhouse gas emissions trading within the European Community in 2001 (EC, 2001), and after the subsequent discussion process to the adoption of "Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC" (EC, 2003a), which defines the main features and criteria used to operate the system and identifies the framework governing national legislation. It is considered the cornerstone of EU climate policy for achieving the reduction targets of the Kyoto Protocol.

Since the beginning of 2005 the European Union has regulated CO_2 emissions from energy intensive industries in the framework of the EU ETS with the following key design elements:

Limitation to four industrial sectors

- Energy activities (combustion installations with a rated thermal input exceeding 20 MW, mineral oil refineries, coke ovens),
- Production and processing of ferrous metals (metal ore sintering or roasting, production of pig iron and steel),
- Mineral industry (cement clinker, glass, ceramic products),
- Other activities (pulp and paper).

A cap and trade system

Using guidelines provided by the Commission, each Member State decides for the first two trading periods 2005-07 and 2008-12 on the total amount of national emission allowances to be allocated to the installations covered. The respective National Allocation Plans have to be approved by the European Commission. The EU Allowances (EUAs), which correspond to one ton of CO_2, are tradable. At least 95% of allowances in Phase 1 (2005-2007) and 90% in Phase 2 (2008-2012) are allocated free of charge in accordance with the installations' historical emissions ("grandfathering"). Banking and borrowing – the transfer in time – of allowances is only allowed within a trading period but not between different trading periods.[1]

National Allocation Plans (NAPs)

In Annex III of the Directive criteria for the design of the National Allocation Plans are provided. These include consistency with the Member State's emission target and projected progress towards fulfilling the target, considerations regarding the activities' (technical) potential for reducing emissions, consistency with other Community legislation and policy instruments, avoidance of unduly favoring certain undertakings (related to State aid provisions), required information on the treatment of new entrants, and early action. Each Member State has to develop a national registry. In this registry each installation has to open an account and report all allowance movements thus all sales and purchases of allowances. It is worth noting that the National Allocation Plans also implicitly determine the reduction requirements for sectors not covered by the EU ETS (EC, 2008b).

Linking with the Kyoto Mechanisms

Certified Emission Reductions (CERs) from the Clean Development Mechanism (CDM) have been acknowledged in the EU ETS since 2005, and Emission Reduction Units (ERUs) from the Joint Implementation (JI) mechanism for offsetting domestic emissions will be acknowledged starting in 2008, with Member States determining the limit on the linkage[2] which in turn has to be approved by the Commission.

Compliance provisions

Emissions from regulated installations are strictly monitored and must be verified. Penalties for non-compliance, i.e. when verified emissions exceed the amount of allowances an installation surrenders, are €40 per ton of CO_2 in Phase 1 and €100 per ton of CO_2 in Phase 2.

The Member States are responsible for allocating emission allowances to sectors and installations in a National Allocation Plan. Although the EU provides guidelines (EC, 2003b) for the allocation process, the allocation details (e.g. choice of the base period, opt-in or opt-out provisions, new entrants provisions etc.) are left up to Member States to define. Nevertheless, National Allocation Plans must be approved by the Commission before they enter into force.

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[1] Banking is possible between the Kyoto compliance period (2008-2012) and following trading periods

[2] Linkage refers to the amount of emissions credits from the Flexible Mechanisms JI and CDM that can be used in the EU ETS to cover verified emissions from installations.

3 The first trading period 2005-07

Directive 2003/87/EC (EC, 2003a) established a scheme for greenhouse gas emission allowance trading within the Community. The EU Emissions Trading Scheme (EU ETS) started in January 2005. There were three major problems for Member States before the first trading period. First, there was a very tight time frame to set up the National Allocation Plans (NAPs). Second, data availability on installation level was very limited although aggregated CO_2 inventories were available. And third, the definitions of installations to be covered turned out not to be clear enough. The allocation process in the first trading period took place on two levels. Member States allocated allowances to installations as a result of a government-industry discussion; the Commission checked the proposed allocation plans to ensure scarcity in the market (Convery et al. 2008).

By setting emission caps, the Member States' National Allocation Plans determined the market for CO_2 allowances. For a detailed elaboration on the Member States' National Allocation Plans of the first trading period see e.g. Betz et al. (2004) and German Emissions Trading Authority (2005).

In general, emissions trading under the EU ETS covers 30-50% of the total greenhouse gas emissions in each of the member states, including a minimum of 2 installations in Malta and a maximum of over 1,800 installations in Germany.

In six countries, the National Allocation Plans contain provisions for opt-ins (additional inclusion of installations not captured by the Directive) and opt-outs (exclusion of installations captured by the Directive). Opt-ins play a major role in Finland and Sweden, where small combined heat and power plants are included on a voluntary basis. Opt-outs are most important for the Netherlands, where smaller installations are instead covered by a voluntary agreement, and the UK, where additional installations were included in the National Emissions Trading System and other installations are covered by voluntary climate change agreements instead of being subjected to the EU ETS.

When designing the allocation process, most Member States started with a total cap for the ETS sectors before allocating the allowances to the individual installations. According to the guidelines of the European Commission, the total cap for each country has to be consistent with its Kyoto target. While most of the new Member States have already substantially "overfulfilled" their Kyoto targets in 2005 (calculations based on data from EEA, 2007), only four countries of the EU-15 (France, Finland, Sweden and the UK) have met their Kyoto targets so far, while the other countries still exceed their reduction target, some by as much as 33% (Austria) or 30% (Spain) in 2006.

All of the 27 Member States allocated the allowances to incumbent installations based on their historical emissions in a certain base period (grandfathering) to which in some cases a sectoral benchmark or a sector-specific growth factor were applied. The base periods covered 1 to 10 years; in some countries the year with the lowest emissions could be excluded. In some countries, process-related emissions and energy related emissions were treated differently in the allocation process.

In general, all Member States allocated allowances free of charge in the first emissions trading period, but Denmark auctioned 5% of its total allocation, Hungary 2.5%, Lithuania 1.5% and Ireland 0.75%. Most countries allocated an equal number of allowances in each year with the exception of Denmark which used a degressive allocation procedure (for Denmark the allocated allowances per installation were 25% lower in 2006 than in 2005).

Allowances for new entrants were also allocated free of charge in all countries generally using some kind of sector benchmark. Some Member States differentiated between known and unknown new entrants, where known new entrants were included in the National Allocation Plan, while unknown new entrants were allocated from the reserve[3]. For the aggregate ETS, the countries' new entrants reserves added up to 102 million tons of CO_2 per year, which equals 4.7% of the total volume of allowances. After having joined the European Union, in 2007 Romania and Bulgaria also implemented the ETS.

Development of CO_2 prices

One intended effect of the introduction of emissions trading is the emergence of a price for CO_2. Figure 1 shows the development of CO_2 prices in the first trading period 2005 to 2007. The price of CO_2 mainly depends on the overall position on the allowance market. The price increases when the overall short position on the market rises – i.e. more installations have a need to buy additional allowances – and vice versa. As will be shown in chapter 4 the allowance market exhibited an overall long position in the first trading period – implying that authorities issued more allowances than were needed by the installations. In such a situation a very low or even zero price for CO_2 can be expected.

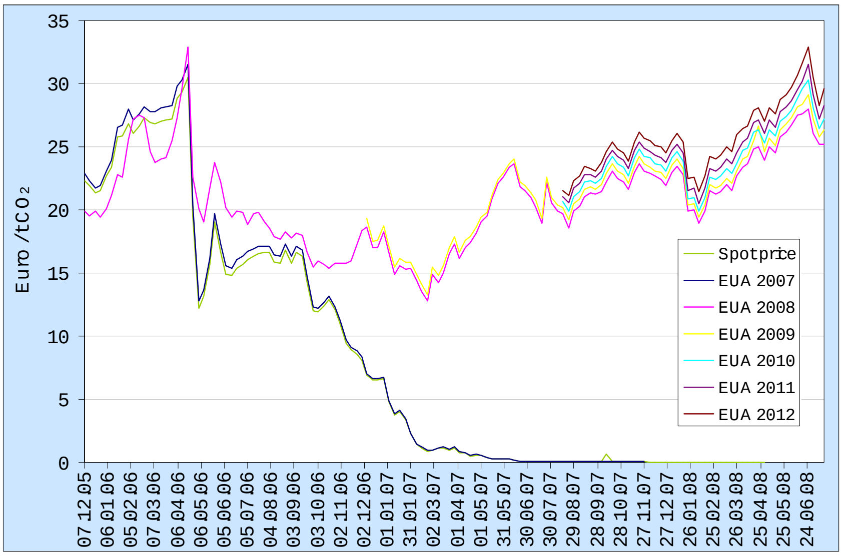
The price development in the first trading period was as follows. Allowance prices were high in the year 2005 and the first quarter of 2006 reaching a maximum of €30.5 per ton of CO_2 in April 2006. This was due to the fact that the power sector started buying allowances to cover emissions exceeding their allocation but those installations having surplus allowances were not yet prepared to sell (Convery et al., 2008). Thus, the scarcity of allowances in this period was partly due to a lack of information and not yet proper functioning of the market. In spring 2006 the verified emissions for the year 2005 were published. At this point in time the market participants realized that the market was in an overall long position causing a sharp decline in prices to €12 per ton of CO_2 in autumn 2006. At the end of 2006 prices for the first period and second period allowances started moving apart. In spring 2007 the verified emission data for the year 2006 were published. The continued overall long position on the market caused a further decline in prices. At the end of the first trading period the spot price for allowances reached almost zero.

It is, however, interesting to look at future allowance prices as traded within the ETS. At the end of June 2008 prices for 2008 allowances are between €20 and €25 and future prices for the years 2008 to 2012 are also positive at a level of between €20 and €33 per ton of CO_2. Market participants thus do not expect a continued long position on the allowance market

[3] The reserve is the amount of allowances that are set aside for new entrants to the trading scheme that are not known at the set up of the allocation plan.

but an increase in prices due to allowance scarcity in the second trading period. This expectation is caused by the more stringent allocation for the second trading period and the long term commitments of the EU concerning CO_2 emission reductions (Convery et al. 2008). Thus, more certainty about future CO_2 reduction commitments and the future design of the EU ETS can reduce the volatility of the carbon prices (Neuhoff et al., 2007). In the literature (Reinaud, 2003) the price level of €20 per ton of CO_2 is expected to trigger some of the intended effects of the EU ETS (e.g. fuel shift from coal to natural gas).

Figure 1: Development of CO_2 prices, Dec 2005 – Jun 2008



Source: Point Carbon

4 Empirical Evidence about short and long positions in the EU ETS for the first trading period 2005-07

Since March 2008 results for the first trading period's (2005-2007) verified emissions on installation level and thus indications about short and long positions on country, sector and installation level have become available.

Based on data available for 24 Member States by June 2008, this part of the report uses a thorough data analysis for more than 10,000 installations - with data for 2005, 2006 and 2007 - to investigate evidence on two issues:

- First, the stringency of the total emission cap and differences both among the Member States and a selection of emission intensive sectors by identifying patterns of allocation discrepancies, i.e. the difference between allocated emission allowances and actual emissions.
- The distribution of the size of installations which is in particular relevant for dealing with very small and very large installations.

For a detailed analysis of the years 2005 and 2006 see Kettner et al. (2008).

The structure of this chapter is as follows. First, we present the methodology for the data analysis and indicators for the stringency of allocation and the distributional characteristics of installations. After providing some caveats as to the interpretation of the results for the first trading period regarding competitiveness and abatement issues we present conclusions.

4.1 Method of the data analysis

Installations covered by the EU ETS need to have an account with their national registries, which record the verified emissions per installation and every transaction of allowances between installations. Data collected by national registries are transferred to the European registry, the so-called Community Independent Transaction Log (CITL).

Since April 2008, data on verified emissions for installations for 2005-2007 are available at the CITL. The data basis for the analysis contains more than 10,000 installations for which complete data on verified emissions and allocated allowances are available for at least one year. Using information from the National Allocation Plans, these installations were assigned to sectors.

The data analysis is performed for the first trading period at different levels of aggregation with indicators for the stringency of allocation and the distribution of the size of installations.

Levels of aggregation

The analysis of the installation data is based on indicators for three levels of aggregation:

- the total of all EU Member States
- the individual Member States and
- a cross-country selection of emission-intensive sectors

Indicators for the stringency of allocations

The following indicators are calculated for the stringency of the allocations:

- the short or long position of an installation as the difference between allocated allowances and verified emissions of an installation
- the gross long position of a country or a sector as the sum of all long positions of installations for a country or a sector
- the gross short position of a country or a sector as the sum of all short positions of installations for a country or a sector
- the net long position of a country or a sector as the difference of gross long positions and gross short positions of a country or a sector if this difference is positive
- the net short position of a country or a sector as the difference of gross long positions and gross short positions of a country or a sector if this difference is negative

With these four indicators (gross long, gross short, net short and net long) the differences between allocated allowances and actual emissions – the allocation discrepancy – are calculated in tons of CO_2 or as a percentage of the total amount of allowances allocated. In the following figures these indicators are illustrated by the following pattern:

Gross short

Net short

Net long

Gross long

Indicators for the size distribution of installations

Both for countries and sectors we rank the installations according to their allocated allowances as a percentage of the country and sector totals as indicators for the size distribution.

4.2 Stringency of the allocation caps

The overall evidence

The Commission guidelines for preparing the National Allocation Plans were aimed at setting a consistent framework for the EU Member States in their preparation of the first National Allocation Plans. Assuming that all countries had a similar interpretation of the EU guidelines, one would anticipate more or less congruent National Allocation Plans that exhibit similar approaches and stringencies of the allocation caps. One could therefore expect that allocation discrepancies, the difference between the amount of allocated EU Allowances (EUAs) and verified emissions, would not show large differences between countries. At least one could have expected this for the EU15. This hypothesis is not supported by our analysis, as we find large variations with respect to allocated EUAs and verified emissions across countries and sectors.

As indicated in Table 1, in the years 2005-2007 EU allowances for 2,090 million tons CO_2 were allocated on average per year, but only 2,040 million tons of emissions were verified. The market was long with 70 million tons[4] CO_2 on average, corresponding to 3.4% of the allocated allowances. The overall net long position is the balance of a 12.1% gross long position, the relative amount of allowances allocated to installations above their verified emissions, and an 8.7% gross short position, the relative amount of allowances below their verified emissions.

At this stage, a first caveat for the interpretation of these numbers is appropriate. We deliberately do not use the terms "over-" or "under-allocation" since this might suggest faulty allocations by the authorities responsible for the Allocation Plans. It is conceivable that the observed allocation discrepancies - the difference between allocated EUAs and the verified emissions - result from abatement efforts. The extent to which this is plausible will be discussed later.

[4] Due to the fact that there are installations for which either only an allocation or only verified emissions are available, the overall net position (70 m tons) is not the difference between the columns "Allocation" (2,090 m tons) and "Verified emissions" 2,040 m tons).

Table 1: Short and long positions by countries in the first trading period 2005-2007

	Allocation				Verified emissions				Gross short position			
	2005 [tCO2]	2006 [tCO2]	2007 [tCO2]	Ø 05/07 [tCO2]	2005 [tCO2]	2006 [tCO2]	2007 [tCO2]	Ø 05/07 [tCO2]	2005 [tCO2]	2006 [tCO2]	2007 [tCO2]	Ø 05/07 [tCO2]
European Union	2,095,376,624	2,063,666,631	2,076,423,157	2,090,441,489	2,004,113,434	2,020,210,440	2,039,155,116	2,040,485,813	170,261,340	205,704,732	218,649,733	182,108,875
Austria	32,412,654	32,649,366	32,659,659	32,570,462	33,372,841	32,380,809	31,640,652	32,467,891	3,311,430	3,259,849	4,135,621	3,252,328
Belgium	58,311,087	59,952,177	60,428,821	59,612,292	55,355,164	54,763,317	52,795,333	54,355,377	9,987,450	7,958,096	7,148,792	8,032,974
Cyprus	5,471,353	5,612,379	5,899,493	5,661,075	5,078,877	5,259,273	5,396,164	5,244,771	408,077	426,139	424,618	418,599
Czech Republic	96,910,587	96,919,971	96,919,971	96,919,971	82,454,636	83,610,792	87,875,973	84,808,331	100,713	884,387	3,829,249	731,232
Denmark	37,303,720	27,907,569	27,902,895	31,038,061	26,475,718	34,199,589	29,373,856	30,422,860	125,549	8,321,084	5,405,196	3,259,832
Estonia	16,747,054	18,199,834	21,343,525	18,763,471	12,621,824	12,109,281	15,327,118	13,378,815	14,832	55,799	178,667	39,451
Finland	44,657,504	44,610,082	44,620,371	44,626,690	33,099,525	44,584,230	42,354,272	39,955,630	435,443	3,485,138	2,797,788	789,462
France	150,393,692	149,930,229	149,775,970	150,087,525	131,257,908	123,421,073	126,583,986	129,632,240	4,220,340	3,090,611	3,036,012	2,685,696
Germany	494,988,690	496,226,656	497,296,562	496,938,938	474,196,580	477,489,068	483,821,110	478,594,318	20,650,662	23,114,163	28,374,997	20,966,142
Greece	71,162,432	71,162,432	71,162,432	71,162,432	71,267,752	69,965,151	72,713,355	71,367,886	3,381,154	3,258,868	5,045,359	3,570,958
Hungary	30,236,166	30,236,166	30,236,166	30,236,166	26,027,659	25,841,751	26,550,859	26,348,700	1,105,683	1,102,628	1,378,463	1,108,068
Ireland	19,236,747	19,237,593	19,240,229	19,238,190	22,397,678	21,700,826	21,246,120	21,943,846	4,200,654	4,266,214	3,960,297	4,093,264
Italy	215,816,416	204,340,593	203,255,077	207,804,029	225,239,643	227,378,441	226,257,913	230,039,613	28,223,866	38,229,816	33,216,527	31,356,645
Latvia	4,070,078	4,058,197	4,035,018	4,054,431	2,854,424	2,940,685	2,849,210	2,926,586	21,988	128,267	142,641	85,354
Lithuania	13,503,454	10,579,740	10,318,307	11,468,350	6,603,869	6,516,911	5,998,744	6,373,175	7,046	175,785	179,130	6,631
Luxembourg	3,229,321	3,229,321	3,229,321	3,229,321	2,603,349	2,712,972	2,567,231	2,627,851	0	6,898	14,700	3,318
Netherlands	86,452,491	86,387,889	86,476,714	86,439,031	80,351,292	76,667,072	79,783,885	78,934,083	6,151,089	5,807,072	8,042,220	6,233,242
Poland	237,532,330	237,544,330	237,542,720	237,543,793	203,149,576	209,686,465	209,602,041	207,788,888	2,084,435	3,442,949	5,692,480	2,291,289
Portugal	36,898,516	36,908,808	36,908,808	36,905,377	36,425,933	33,083,879	31,185,733	33,609,454	1,771,813	1,329,970	625,139	651,302
Slovakia	30,470,677	30,486,877	30,486,829	30,481,461	24,556,729	25,543,243	24,516,834	25,120,184	46,789	604,750	158,834	85,078
Slovenia	9,138,064	8,691,991	8,245,914	8,691,990	8,720,550	8,842,182	9,048,634	8,877,012	137,055	433,524	1,072,876	458,465
Spain	172,120,299	160,305,535	159,716,691	167,220,748	183,242,858	176,132,482	186,077,445	184,548,495	34,468,620	36,512,206	48,650,670	38,477,073
Sweden	22,281,227	22,483,602	22,846,480	22,537,108	19,381,661	19,880,729	15,348,253	19,440,693	3,560,407	3,535,717	3,233,272	3,274,104
UK	206,032,065	206,005,294	215,875,184	217,210,576	237,377,388	245,500,219	250,240,395	251,679,117	45,846,245	56,274,802	51,906,185	50,238,367

	Gross long position				Netposition				Netposition			
	2005 [tCO2]	2006 [tCO2]	2007 [tCO2]	Ø 05/07 [tCO2]	2005 [tCO2]	2006 [tCO2]	2007 [tCO2]	Ø 05/07 [tCO2]	2005 [%]	2006 [%]	2007 [%]	Ø 05/07 [%]
European Union	266,174,434	261,972,718	265,971,896	252,643,954	95,909,989	56,267,721	47,166,591	70,595,268	4.6	2.7	2.3	3.4
Austria	2,351,243	3,525,706	5,151,928	3,359,585	-960,187	265,857	1,016,307	107,257	-3.0	0.8	3.1	0.3
Belgium	12,943,373	13,145,014	13,878,456	13,305,012	2,955,923	5,189,811	6,729,664	5,272,038	5.1	8.7	11.1	8.8
Cyprus	800,553	779,245	927,947	834,903	392,476	353,106	503,329	416,304	7.2	6.3	8.5	7.4
Czech Republic	14,621,924	14,329,092	13,112,851	13,159,676	14,521,211	13,444,705	9,283,602	12,428,444	15.0	13.9	9.6	12.8
Denmark	10,960,607	2,037,403	2,736,898	3,887,569	10,835,058	-6,283,681	-2,659,987	627,736	29.0	-22.5	-9.5	2.0
Estonia	4,135,473	6,215,040	6,248,975	5,494,033	4,120,641	6,159,241	6,070,308	5,454,582	24.6	33.8	28.4	29.1
Finland	12,019,234	3,587,500	5,147,226	5,461,101	11,583,791	102,362	2,349,548	4,671,640	25.9	0.2	5.3	10.5
France	23,356,313	29,612,164	30,027,557	26,928,978	19,135,784	26,521,553	26,991,545	24,243,282	12.7	17.7	18.0	16.2
Germany	46,158,377	47,889,003	44,983,110	44,040,203	25,507,715	24,774,840	16,608,113	23,074,061	5.2	5.0	3.3	4.6
Greece	3,240,328	5,093,176	4,347,896	3,918,351	-140,826	1,834,308	-697,463	347,393	-0.2	2.6	-1.0	0.5
Hungary	5,387,489	5,608,611	4,951,267	5,281,690	4,281,806	4,502,881	3,569,822	4,173,622	14.2	14.9	11.8	13.8
Ireland	1,070,636	1,575,133	2,153,387	1,651,348	-3,130,018	-2,691,081	-1,806,910	-2,441,916	-16.3	-14.0	-9.4	-12.7
Italy	18,664,109	18,561,922	20,275,127	17,497,041	-9,559,757	-19,667,894	-12,941,400	-13,859,604	-4.4	-9.6	-6.4	-6.7
Latvia	1,239,488	1,260,895	1,419,775	1,280,324	1,217,500	1,132,628	1,277,134	1,209,549	29.9	27.9	31.7	29.8
Lithuania	6,906,631	4,282,241	4,578,940	5,143,098	6,899,585	4,106,456	4,399,810	5,136,467	51.1	38.8	42.6	44.8
Luxembourg	625,972	523,247	676,790	604,788	625,972	516,349	662,090	601,470	19.4	16.0	20.5	18.6
Netherlands	12,252,288	15,551,267	14,762,016	13,754,972	6,101,199	9,744,195	6,719,796	7,521,730	7.1	11.3	7.8	8.7
Poland	36,678,769	31,645,961	33,244,754	32,443,187	34,591,418	28,203,012	27,397,475	30,151,898	14.6	11.9	11.5	12.7
Portugal	2,244,396	5,216,082	6,452,971	4,047,256	472,583	3,886,112	5,827,832	3,395,954	1.3	10.5	15.8	9.2
Slovakia	5,285,697	5,544,464	6,146,450	5,474,418	5,238,908	4,939,714	5,981,404	5,389,340	17.2	16.2	19.6	17.7
Slovenia	571,198	327,941	313,033	318,328	434,143	-105,583	-759,843	-140,138	4.8	-1.2	-9.2	-1.6
Spain	23,700,095	23,397,996	23,745,292	22,670,225	-10,768,525	-13,114,210	-24,905,378	-15,806,848	-6.3	-8.2	-15.6	-9.5
Sweden	6,459,319	6,012,420	4,039,230	6,369,564	2,898,912	2,476,647	805,958	3,095,460	13.0	11.0	3.5	13.7
UK	14,500,922	16,251,195	16,650,020	15,718,305	-31,345,323	-40,023,607	-35,256,165	-34,474,452	-15.2	-19.4	-16.3	-15.9

* Netposition in % of allocated allowances

Source: CITL; WIFO calculations

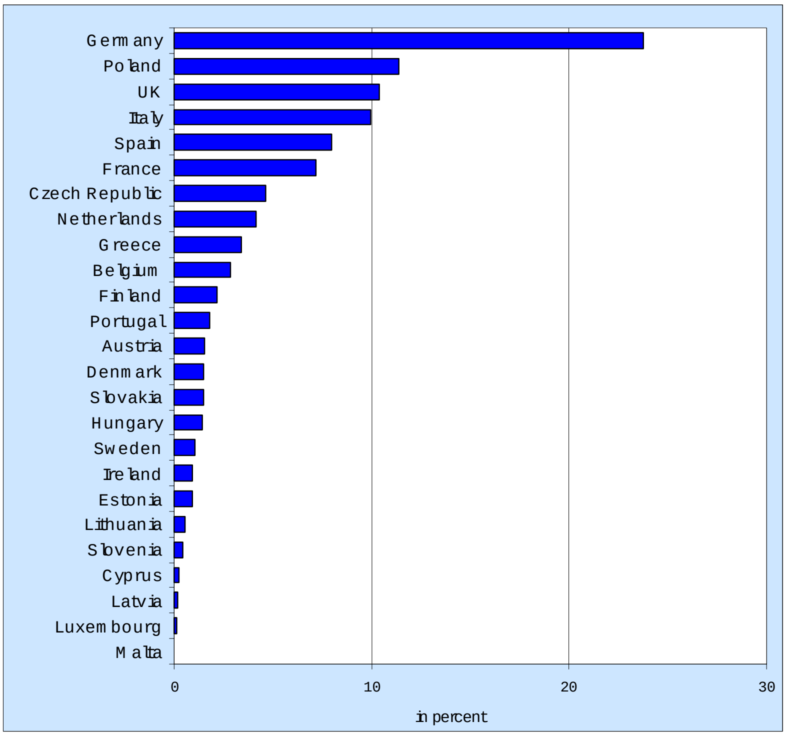
The Member States Evidence

Table 1 in addition presents a summary of the allocation discrepancies by Member States. Differences as to the size of the Member States and their emissions intensities are depicted in Figure 2, which ranks the Member States according to their average share in total emission allowances over the three years 2005-2007. An outstanding position with a share of 24% of total allocated allowances accrues to Germany, which together with Poland, Italy and the UK accounts for more than half of the emissions covered by the EU ETS.

As indicated in Table 1 and Figure 3, only five out of the 24 countries were in a short position up to 34.5 million tons (United Kingdom). The remaining 19 countries were long up to 30.2 million tons (Poland). A similar ranking according to the relative allocation discrepancy, the percentage of net long or net short positions relative to the amount of allowances, is depicted in Figure 4. It shows that all new Member States with the exception of Slovenia allocated more allowances to their installations than needed. Out of the five largest emitters, Germany and Poland exhibit a net long position and the UK, Italy and Spain show a net short position. Between 2005 and 2007 a major change can be observed for Denmark with a net long position of 29% in 2005 compared to a net short position of 23% and 9.5% in 2006 and 2007 respectively. This is likely a result of the degressive allocation procedure (see above). Changes from a net short position to a net long position can be found in Austria. The opposite is true for Slovenia over the three year period. According to Convery et al. (2008) and Trotignon and Delbosc (2008) these differences in long and short positions between countries led to a significant cross-border trade of allowances implying a transfer of allowances from countries with a long position to countries with a short position.

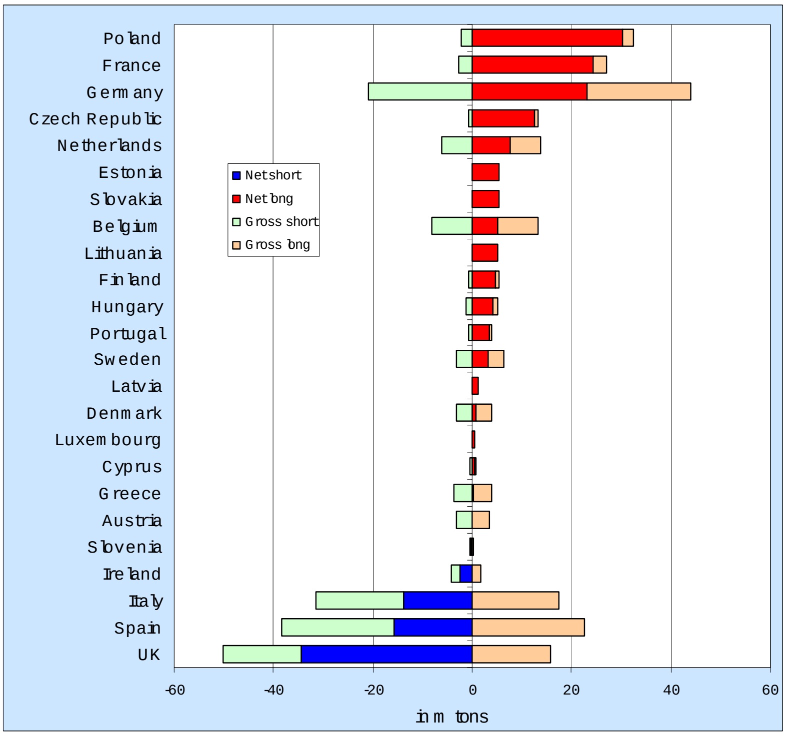
Figure 3 and Figure 4 also illustrate the extent to which the net long or the net short position is influenced by the gross long and gross short positions of the countries. The net short positions in countries like Italy and Spain stem from the balance of roughly equal-sized gross long and short positions at the installation level. For countries like Denmark the balance of the gross long and short positions results in a small overall net long position.

Figure 2: Country's share in total EU ETS allowances (average 2005 - 2007)



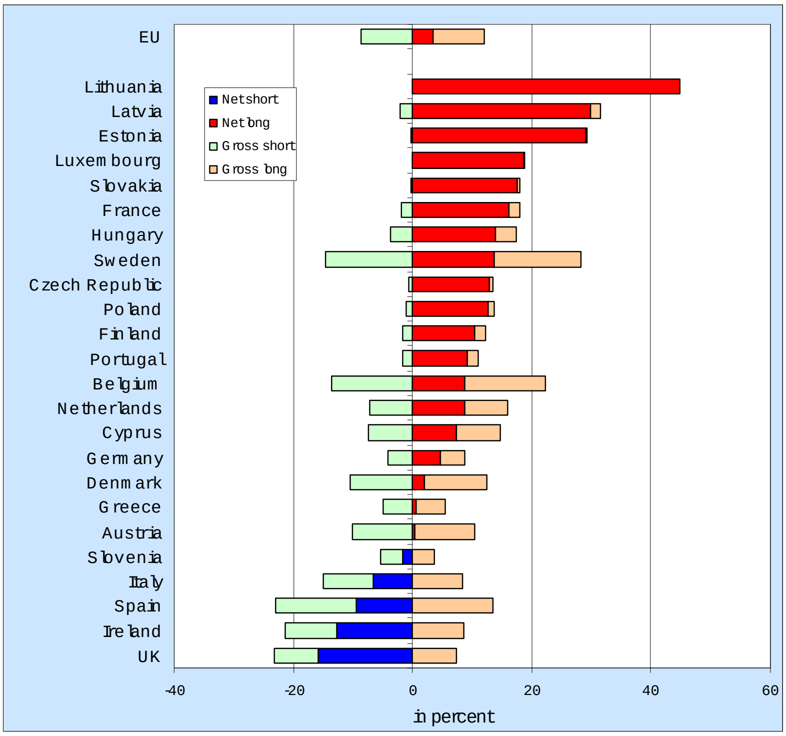
Source: CITL; WIFO calculations

Figure 3: Absolute short and long positions by countries in million tons (average 2005 - 2007)



Source: CITL; WIFO calculations

Figure 4: Relative short and long positions by countries in percent (average 2005 - 2007)



Source: CITL; WIFO calculations

Evidence presented so far suggests that National Allocation Plans created substantial inequalities as to the allocation positions between Member States on country aggregates, but also within Member States between individual installations.

For the three years of the first trading period the Member States can be combined according to the observed allocation positions into the following groups:

- EU-15 countries that exhibit sectors both with net long and net short positions, such as Austria, Belgium, Finland, Greece, Ireland, Italy, Spain and the UK.
- EU-15 countries that show a pronounced net short position in the heat and power sector but are generally long in all other sectors, as the Netherlands and Sweden.
- EU-15 countries with net long positions in their sectors, as Denmark, Portugal and Luxemburg. Germany and France show a slight short position in one sector only.
- New Member States that are long in all sectors, as Cyprus, Estonia, Poland, Latvia and the Czech Republic.
- New Member States that have a long position in total but are short at least in a few sectors, as Hungary, Slovakia, Lithuania.

The sectoral evidence

While we would expect rather small allocation discrepancies on the country level, this would not necessarily hold true for the sectoral level since Criterion 11 of Annex III of Directive 2003/87/EC states that the Member States' National Allocation Plans "…may contain information on the manner in which the existence of competition from countries or entities outside the Union will be taken into account".

Kolshus and Torvanger (2005), e.g., show sectoral differences in the generosity of allocation motivated by competitiveness considerations. As to the effects of differentiated allocations it is common to distinguish between

- sectors not exposed to international competition (power and heat), and
- sectors exposed to international competition (refineries, iron and steel, cement, glass, lime, ceramics, pulp and paper and others).

The overall evidence for the sectoral breakdown of allocation positions shows a rather pronounced long position for all sectors except for power and heat, as indicated in Table 2 and Figure 5. An obvious explanation is the strong exposure of the energy and emission intensive sectors to international competition which might have induced generous allocations to these sectors. Kettner et al. (2008) and Ellerman and Buchner (2006) conclude that most member states explicitly allocated the power sector fewer allowances relative to the expected demand than the other sectors because of concerns about competitiveness and a belief that the abatement potential was larger in the power sector than in the other sectors. Based on an analysis of the second allocation plans Convery et al. (2008) conclude that a short position of the power and heat sector can also be expected for the second trading phase. The reason for the short position of the power and heat sector may also be linked to the observation that wholesale electricity prices reflect the fluctuations of prices for EUAs because of the ability to pass on additional costs to consumers due to market power.

Table 2: Short and long positions by sectors in the first trading period 2005-2007

	Allocation				Verified emissions			
	2005 [tCO2]	2006 [tCO2]	2007 [tCO2]	Ø 05/07 [tCO2]	2005 [tCO2]	2006 [tCO2]	2007 [tCO2]	Ø 05/07 [tCO2]
EU	2,095,376,624	2,063,666,631	2,076,423,157	2,090,441,489	2,004,113,434	2,020,210,440	2,039,155,116	2,040,485,813
Cement and Lime	187,049,893	185,501,718	189,206,949	189,635,904	172,445,989	177,158,651	185,831,522	180,643,327
Iron and Steel	194,820,273	194,296,534	194,498,493	194,552,194	157,688,119	163,889,742	160,657,214	161,928,497
Power and Heat	1,066,072,609	1,038,759,081	1,034,339,747	1,046,929,692	1,101,018,186	1,103,315,725	1,105,017,308	1,104,175,059
Pulp and Paper	42,071,081	42,140,981	42,191,347	42,142,600	33,773,907	33,670,747	32,443,694	33,485,835
Refineries	149,729,517	148,460,463	147,284,348	148,737,574	139,496,119	138,342,381	138,347,058	138,728,519
Ceramics	18,728,615	18,694,830	18,648,317	18,693,574	15,522,386	15,677,967	13,950,975	15,669,532
Glass	21,952,136	21,994,615	21,968,698	21,979,119	19,678,084	19,440,791	19,182,586	19,499,848
Other*	414,952,500	413,818,409	428,285,258	427,770,832	364,490,644	368,714,436	383,724,759	386,355,196

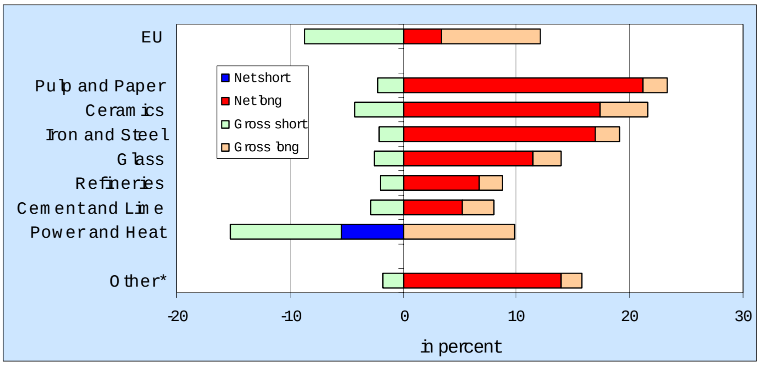
	Gross short position				Gross long position			
	2005 [tCO2]	2006 [tCO2]	2007 [tCO2]	Ø 05/07 [tCO2]	2005 [tCO2]	2006 [tCO2]	2007 [tCO2]	Ø 05/07 [tCO2]
EU	170,261,340	205,704,732	218,649,733	182,108,875	266,174,434	261,972,718	265,971,896	252,643,954
Cement and Lime	5,045,180	6,110,958	9,536,638	5,390,343	19,649,084	15,178,477	13,483,837	15,170,271
Iron and Steel	3,154,508	5,327,456	5,900,982	4,180,047	40,594,671	36,016,548	33,380,890	37,104,589
Power and Heat	150,179,320	178,968,146	183,800,219	159,836,294	115,241,695	114,632,732	111,492,908	103,185,537
Pulp and Paper	892,101	1,263,406	1,182,673	932,043	9,113,683	9,756,390	10,947,909	9,834,128
Refineries	2,727,622	3,166,366	5,010,051	2,970,275	12,961,020	13,284,448	13,947,341	12,979,329
Ceramics	688,921	943,279	1,294,581	789,988	3,936,637	4,066,902	4,313,858	4,045,379
Glass	471,197	605,089	747,716	547,238	2,727,159	3,126,079	3,451,356	3,069,525
Other*	7,102,491	9,320,032	11,176,873	7,462,648	61,950,485	65,911,142	74,953,797	67,255,197

	Net position				Net position			
	2005 [tCO2]	2006 [tCO2]	2007 [tCO2]	Ø 05/07 [tCO2]	2005 [%]	2006 [%]	2007 [%]	Ø 05/07 [%]
EU	95,909,989	56,267,721	47,166,591	70,595,268	4.6	2.7	2.3	3.4
Cement and Lime	14,603,904	9,070,094	3,935,233	9,794,507	7.8	4.9	2.1	5.2
Iron and Steel	37,437,247	30,685,990	27,476,926	32,924,542	19.2	15.8	14.1	16.9
Power and Heat	-34,937,625	-64,335,414	-72,307,311	-56,650,757	-3.3	-6.2	-7.0	-5.4
Pulp and Paper	8,221,582	8,492,984	9,765,236	8,902,086	19.5	20.2	23.1	21.1
Refineries	10,233,398	10,118,082	8,937,290	10,009,054	6.8	6.8	6.1	6.7
Ceramics	3,247,716	3,123,623	3,019,277	3,255,391	17.3	16.7	16.2	17.4
Glass	2,255,962	2,520,990	2,703,750	2,522,287	10.3	11.5	12.3	11.5
Other*	54,847,805	56,591,372	63,636,190	59,838,160	13.2	13.7	14.9	14.0

*Net position in % of allocated allowances

Source: CITL; WIFO calculations

Figure 5: Short and long positions by sectors (average 2005 - 2007)



Source: CITL; WIFO calculations

4.3 Distribution of installations and allocations

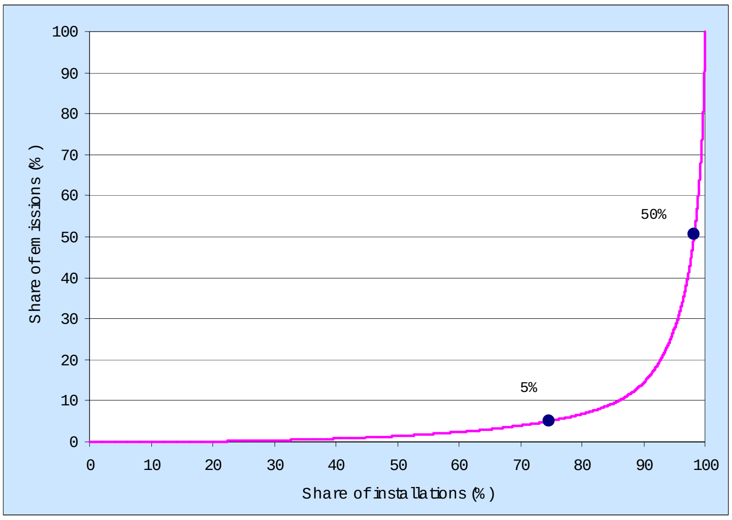
Distribution of the size of installations

An outstanding characteristic of the EU ETS is the inclusion of a large number of small installations. Figure 6 ranks almost 9,900, installations for which a complete data set for all three trading years is available, according to their verified emissions and reveals meaningful insights about the pronounced inequality of the size of installations included in the EU ETS in the first trading period 2005-2007:

- The smallest three quarters of all installations (7,397 installations) represent only 5.1% of the total verified emissions.
- The biggest 1.8% of all installations (177 installations) account, however, for 50% of the emissions.
- The biggest 500 installations (5%) emit 72.8% of all emissions.
- The 1,000 biggest installations (10.1% of all installations) are responsible for 85.8% of the EU ETS emissions.

This extreme inequality in the size distribution of installations suggests a need to differentiate between large and small installations in the framework of the EU ETS. Currently, small installations complain about excessive transaction costs for monitoring, reporting of emissions and the registry account. In addition, the large number of small installations requires a lot of administrative capacities. This burden was especially noticeable in the implementation phase of the emissions trading scheme but might be reduced after a learning phase or once initial problems are solved. Big installations, on the other hand, often express concern about unequal treatment in the allocation procedures of different Member States.

Figure 6: Distribution of size of installations with respect to verified emissions (average 2005 - 2007)

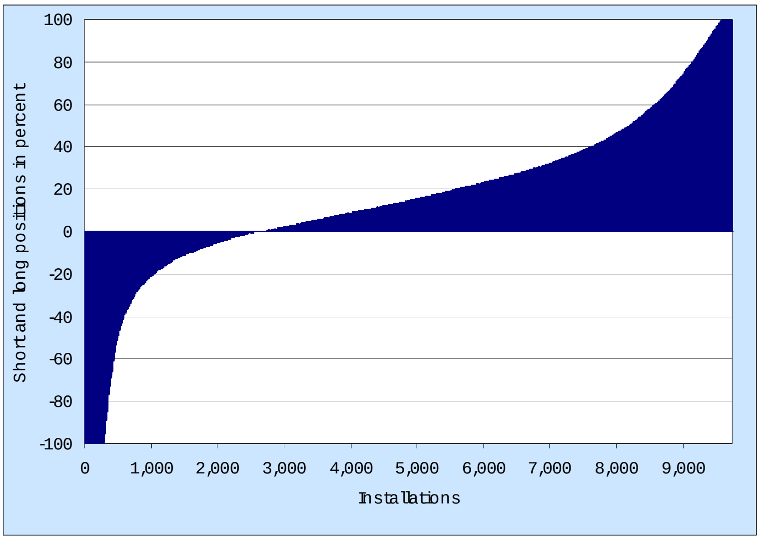


Source: CITL; WIFO calculations

Distribution of allocation discrepancies

The surprisingly wide dispersion of allocation discrepancies, i.e. the difference between allocated allowances and verified emissions, was not anticipated when implementing the pilot phase of the EU ETS. Obviously these discrepancies reflect the actions of the allocation authorities as well as abatement activities by the installations. Figure 7 indicates that out of the approximately 9,900 installations analyzed, 2,583 (25%) were short on average over the three years and the remaining installations were long. The tails in this figure with 100% long positions refer to installations for which zero emissions were verified. With respect to short positions 100% refers to installations with verified emissions at least twice the amount of the allocation.

Figure 7: Distribution of allocation discrepancies of installations (average 2005 - 2007)



Source: CITL; WIFO calculations

4.4 Evidence on the CITL data analysis

The data analysis performed on the allocated and verified emissions for the first trading period (2005-2007) suggests a number of conclusions.

A first set of conclusions deals with the discrepancy between allocated allowances and verified emissions. Obviously, in the three trading years the system was in an aggregate long position with 3.4% more emission allowances available than actually needed. When it first became known in May 2006 that the market was long, the spot prices for EUAs plummeted. The average long position for 2005-2007 for the EU total is the balance between a 12.1% long and an 8.7% short position of the total market. Out of the 9,900 installations reported up to June 2008 only 2,583 were short. The observed allocation differences vary, however, between Member States and sectors. Out of the 24 Member States included in the analysis only 5 countries were short in the range of 1.6% (Slovenia) and 15.9% (UK) but the remaining 19 countries were long up to 44.8% (Lithuania). Looking at sectors, only power and heat was short with 5.4%.

A second set of conclusions refers to the pronounced inequality in the distribution of the size of installations when ordered according to their emissions. The smallest three quarters of all installations represent only about 5% of all emissions whereas the biggest 1.8% of all installations account for half of the emissions. The 1,000 biggest installations, or one tenth of all installations, cover 85.8% of the EU ETS emissions.

The responsibility of Member States for allocating emission allowances to sectors and installations in the National Allocation Plans creates inherent incentives to allow for generous allocations. Reasons for the results obtained for the first trading period regarding differences in allocations might be incomplete information of authorities concerning the allocations of other Member States and the impact of industry lobbying groups.

5 Lessons learnt from the EU ETS pilot phase – suggestions for future trading periods

In the light of the pronounced long positions in many countries and sectors the Commission played a much stronger role in the allocation process and the setting of national caps for the second period (Convery et al. 2008). An even stronger exertion of influence is planned for future trading periods (EC, 2008b). There was a lack of consistency in the first trading period with regard to allocation methodologies between Member States leading to the results we showed in chapter 4. Still, when interpreting the currently available data, it is important to keep in mind that there might be other reasons for long or short positions of installations than generous or very stringent allocations by authorities. For example, long or short positions can reflect an unexpected rise or fall in production, abnormal weather conditions, specific situations in the availability of raw materials and fuels, or changes in production processes.

Installations subject to the ETS

One requirement for future trading periods is the harmonization of the definition of combustion installations that was not clear in the first period. Variations in the definition of what installations are subject to the EU ETS lead to inconsistencies and market distortions between Member States in the first trading period. For example, two different interpretations of combustion installations were applied across countries: A narrow one that includes the production of electricity, heat or steam for the purpose of energy production and a broad one that includes the production of electricity, heat and steam in general (CEPS, 2005a).

As was shown in chapter 4 there are a lot of very small installations in the ETS. In the first trading period the belonging to a sector decided whether an installation was subject to the EU ETS or not; there was no general lower limit (only the 20 MW limit for combustion installations) with respect to installation size (e.g. emissions) but these small installations faced very high transaction costs compared to their emission reduction potential (CEPS, 2005a). According to CEPS (2005a) an emission threshold of e.g. 10,000 tons of CO_2 per year would reduce the total number of installations in the ETS by almost a third but total emissions only by one percent (see also Kettner et al., 2008 and chapter 4 of this study). In its proposal for amending the Emissions Trading Directive the Commission opts for a combined size limit. The new proposal foresees that installations with an installed thermal capacity of between 20 and 25 MW emitting less than 10,000 tons of CO_2 per year can be excluded from the EU ETS if other emissions reduction measures are applied at these installations (EC, 2008a).

The allocation method

Grandfathering will still be the main method to allocate allowances to the installations in the current second trading period; benchmarking has increased in the second trading period, mainly in the power sector (Convery et al. 2008).

CEPS (2005b) see short-term allocation periods – like 2005-2007 and 2008-2012 for the first two periods – , grandfathering with continued change of the base year (updating) and inconsistencies between Member States in the allocation process as major threats to the ETS's efficiency and effectiveness.

Auctioning could overcome the problem of differing allocations for industries in the various countries (CEPS, 2005a). The amount of auctioned allowances will be higher in the current second trading period but will still be below the maximum allowed level (10% of total allocated allowances) and the Commission opts for full auctioning in the power sector from 2013 on to reduce windfall profits of electricity producers and further increase incentives to invest in low carbon power generation technologies (EC 2008a, EC 2008b, Convery et al. 2008).

As was shown above CO_2 prices were quite volatile in the first trading period. This is partly due to the fact that banking between trading periods was not allowed and thus "…reduced the decision horizon significantly" (Convery et al., 2008). One way to increase long-term incentives for the market players to reduce their CO_2 emissions would be the possibility to bank allowances for future periods (Convery et al., 2008).). This is also proposed in the proposal for the amended Directive on greenhouse gas emissions trading (EC, 2008a).

Evidence on abatement

As was shown in chapter 4 the market for allowances was long on aggregate in the first three years of the EU ETS meaning that there were more allowances allocated to installations than CO_2 emissions reported in this period. First attempts of analyzing the extent of abatement activities induced by the EU ETS were made by Ellerman and Buchner (2006) coming to the conclusion that there was modest abatement in the year 2005 compared to business-as-usual. In general the following abatement options are available to installations (Kettner et al., 2008):

- Reducing production if the marginal costs for additional emission allowances are not covered by marginal revenues.
- A fuel shift if this option is technically feasible and the fuel with lower carbon content creates lower marginal costs than the marginal costs for emission allowances.
- Improved operating of the existing equipment if this involves lower costs than buying additional emission allowances.
- Finally, investments that change processes, e.g. by switching to combined heat and power generation, and improve factor productivity in general. Such decisions will hardly be justified only by the price for emission allowances alone.

Looking at this spectrum of abatement options it is rather unlikely that the EU ETS has already created incentives for a significant volume of abatement investments in the first trading years. Given the low carbon prices it is also extremely unlikely that industries with a large CO_2 cost component, such as cement and lime, have reduced their production levels because of the stringency of allowance allocation. In some installations the option for a fuel shift as well as biomass co-firing may have been used. Most probably the only reduction option that was widely used was the improved operation of existing equipment. The reduction potential of this option is, however, rather limited.

Extension of the ETS

In 2008 Norway, Liechtenstein and Iceland joined the ETS. According to Convery et al. (2008) the integration of further emissions trading systems would however be more difficult to achieve.

The issue of carbon leakage

A long-term impact of the EU ETS could be the relocation of carbon intensive industries to regions without CO_2 regulation (COMETR 2007, Kohlhaas 2003). This effect is known as carbon leakage. Most work on this issue (Demailly et al. 2007, Reinaud 2005, McKinsey &Company, Ecofys 2006) concludes that the threat of carbon leakage is minor in total and limited to some industrial sectors like semi-finished steel, clinker, lime, pulp and some chemicals (Neuhoff et al., 2007). Proposals to cope with carbon leakage include sectoral CO_2 reduction agreements, border tax adjustments and continued full free allocation of CO_2 allowances (Neuhoff et al., 2007).

The European Commission acknowledges that "certain energy-intensive sectors and subsectors in the Community subject to international competition could be exposed to the risk of carbon leakage" (EC, 2008a). The Commission will identify potentially threatened sectors by 2010 in a consultation process and submit a report on this issue. Identified industries could get up to 100% of allowances free of charge or border tax adjustments. The latter option would first have to be checked with respect to the compatibility with WTO agreements (EC, 2008a).

6 Potential impacts of National Allocation Plans on competitiveness

The EU ETS was chosen as an instrument of climate policy to achieve the environmental target of reducing CO_2 in an efficient way. Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community emphasizes the avoidance of distortions in competition as a requirement in the allocation procedures of individual Member States and the European Union as a whole. The trading of emission allowances sets a market price for CO_2. According to economic theory (Perman et al., 2003) the emerging price ensures that the cheapest options for emission reductions are implemented first. Companies invest in emission reduction activities as long as the CO_2 price is above their cheapest option of carbon abatement; as soon as the CO_2 price is below their cheapest abatement option it is more cost efficient for them to purchase CO_2 allowances.

The two crucial elements of emissions trading are the emerging market price for CO_2 that can be incorporated into the companies' future decisions and the capping of emission allowances that ensures that the environmental target is met. From a macroeconomic point of view the environmental target is met in the most efficient way.

Within the economy, however, there will be winners and losers. Energy intensive industries will be confronted with higher input costs (COMETR, 2007) as the costs for carbon based energy include the price for CO_2. This is an intended effect of the EU ETS and is meant to serve as an incentive for companies to move away from carbon intensive structures.

The main reason for introducing the EU ETS was to stabilize and reduce CO_2 emissions from European industries to help meeting Europe's targets agreed upon in the Kyoto Protocol. This main target of tackling an environmental problem was however accompanied by considerations of how to regulate CO_2 emissions in a way that minimizes adverse impacts on industries. Environmental regulation can have negative impacts on regulated industries in the short to medium term via higher costs that come from the requirement to comply with the provisions of the regulation (Jenkins, 1998). However, Porter and van der Linde (1995) show that environmental regulation can have positive impacts on regulated industries in the longer term by profiting from first mover advantages. This is also an argument that should be taken into consideration when discussing the effects of the EU ETS as the European Union plays the role of a first mover in this field and other countries or regions may follow in capping their industries' CO_2 emissions.

Potential impacts on industries subject to environmental regulation like the EU ETS that also affect their competitive position can have two reasons:

- All firms in a market are regulated, but firms face different stringency of regulation
- Not all firms in a market are regulated, thus there are firms that are not subject to environmental regulation

Both factors play a role when looking at the EU ETS.

As could be seen in chapter 4 there are differences between countries and sectors in implementing the EU ETS. In some countries or sectors large amounts of excess allowances are available whereas other countries or sectors are in need of allowances. As was also shown in chapter 4 we can detect these kinds of differences within sectors as well. Thus, installations subject to the EU ETS were facing different degrees of stringency of regulation. It has to be added that barriers to trade are low in the EU thus potentially exacerbating the negative competitiveness effects because of different implementation of the EU ETS across countries (Carbon Trust, 2004, CEPS, 2005a). Companies in a country with less stringent regulation have a competitive advantage over companies in countries with a stricter regulation.

At the moment only industries in the European Union are subject to CO_2 regulation. As many products of the regulated industries are not only traded within the EU and firms face competition from outside the EU, there might be negative impacts on the competitiveness of European industries compared to non-EU industries.

How can competitiveness be affected?

Most of the studies dealing with potential effects of the EU ETS on competitiveness are based on an ex-ante perspective. Reinaud (2005) states "…Industrial competitiveness is a controversial and multi-faceted notion. It depends on a number of factors including primary factor and other input costs, the availability of a skilled labor force, company's ability to compete on quality as well as cost and to generate product innovations". Convery et al. (2008) quote the OECD definition of competitiveness, which is "the ability to produce high-quality, differentiated products at the lowest cost possible to sustain market shares and profitability". The studies dealing with the effects on European industries' competitiveness look at the changes in input costs caused by the EU ETS. Competitiveness can be defined as the ability to keep a certain level of profitability or market share (Walker, 2006).

As soon as there is a market price for CO_2 input costs for industries using fossil fuels in their production rise. Thus, there is broad consensus that the introduction of the EU ETS is likely to increase industries' costs. Costs rise either because companies invest in carbon abatement activities (e.g. fuel switch, technological changes) or because companies have to purchase emission allowances in excess of their allocation (Reinaud, 2005). In addition to these direct effects of the EU ETS indirect cost increases can occur when electricity prices rise (Demailly et al. 2007, McKinsey &Company, Ecofys 2006) as a result of passing through cost increases in electricity production to consumer prices. The effects of this rise in production costs on competitiveness depend on a number of factors determining the structure of the examined industry as energy intensity or competition within the market.

Competitiveness on a country level can also be affected by the introduction of the EU ETS via carbon leakage – the relocation of carbon or energy intensive industries to countries with no CO_2 regulation (Convery et al. 2003, Demailly, Quirion 2006). The idea is that future investments in these industries are more likely to happen in those third countries resulting in lower employment and growth rates in the countries subject to CO_2 reduction requirements. It is important to realize that carbon leakage would not only reduce growth and employment in the EU but also undermine the environmental effectiveness of the EU ETS. As Klepper and Peterson (2004) state it is important to keep in mind that "…any competitiveness effects are not a result of the ETS but of the emission restrictions implied by the Kyoto target. The ETS is indeed intended to lower the negative effects of reaching this target compared to pure unilateral action".

Potential impacts of the allocation method

There are various possibilities of how to allocate the CO_2 allowances in a cap and trade scheme to installations with the following two extremes:

- Grandfathering: Allowances are allocated for free based on the past emissions of the installations
- Auctioning: Installations have to buy the required amount of allowances in an auction

When based on the same emission cap both options ensure that the same reduction in CO_2 emissions is attained. However, giving allowances away for free is a potential source of excess profits for industries, whereas auctioning minimizes this effect. Also grandfathering can have unintended effects on the behavior of regulated industries (see below). Thus, the differences between these two options are not the environmental effectiveness but linked to distributional issues and consideration about incentives.

Continued high emissions after the implementation of an emissions trading scheme are possibly an unintended consequence of grandfathering of allowances. As long as the allocation of CO_2 allowances depends on past emissions there is no real incentive for industries to reduce emissions. (Neuhoff et al., 2007). Giving allowances away for free to industries is a potential source of excess profits for the industries but does not necessarily lead to windfall profits[1] (Convery et al. 2008, Demailly, Quirion 2007). It is the extent to which industries can pass through higher costs to prices that determines the change in their profitability. Evidence so far suggests that there is some pass through but it varies considerably across countries and sectors, with the electricity sector getting the highest windfall profits (Convery et al, 2008, Neuhoff et al., 2007) because of the pricing in of allowance costs to consumer prices. Grandfathering based on historical emissions in the electricity sector has also the potential of strengthening the market power of the incumbents and undermine competition (CEPS, 2005a), at least when new entrants are treated differently (e.g. do not get the same share of emissions for free) than incumbents. Neuhoff et al. (2007) suggest that for future trading periods grandfathering should play a minor role in allocation and there should be more auctioning. This would reduce some of the main uncertainties in the market, creating less volatile prices, probably reduce administrative costs associated with the EU ETS and increase its political credibility.

For the future trading scheme the Commission proposes that auctioning should be the standard allocation method with the power sector facing full auctioning from 2013 on and the other sectors starting with auctioning of 20% and a gradual increase until 2020 (EC, 2008a). There might be exceptions to this rule for sectors facing the threat of carbon leakage.

[1] Windfall profits are excess profits. In the case of the EU ETS they occur if producers are given allowances for free but are able to include the opportunity cost of allowances into consumer prices

Which industries are affected by the introduction of the EU ETS?

The Carbon Trust (2004) lists the main factors potentially influencing the competitiveness of European industries when looking at the introduction of emissions trading:

1. Energy intensity and carbon intensity: Sectors covered and not covered by the EU ETS will face rising energy costs if they do nothing to reduce their energy use. Energy and carbon intensive sectors will be more heavily exposed to rising energy prices.
2. Pass through of cost increases. This depends on three factors:
    - The price elasticity of demand. Sectors with a relatively high elasticity of demand will face stronger reductions in demand when they raise the product's price.
    - The competition within the market. Competition limits the extent to which prices can be raised as a reaction to increased input costs.
    - The geography of the sector's market. Companies outside the EU will not experience reduced competitiveness because of the EU ETS. This factor is seen as the one most influencing the competitiveness of European industries. As an additional factor related to this aspect the study addresses the distortions that can be created by different approaches of the Member States with respect to the stringency of the National Allocation Plans. This leads to a situation where sectors in different EU countries are exposed to negative effects of the EU ETS to a different extent.
3. Opportunity to abate carbon. The potentials for cheap abatement activities like energy savings differ between sectors.

Table 3 identifies sectors potentially exposed to competitiveness effects due to the EU ETS according to the above mentioned factors. There are more sectors subject to the EU ETS, but this table focuses on the sectors that are mainly discussed in the existing literature on possible competitiveness effects of the EU ETS:

Table 3: Sectors affected by the EU ETS

Sector	**Energy intensity**	**Price elasticity of demand**	**Competition within the market**	**Geography of the market**	**Opportunity to abate carbon**	**Comments**
Electricity	high	Inelastic	no	local	high	Emits large proportion of EU ETS emissions
Cement	high	Inelastic	yes	local	limited	No significant long distance trade on road
Paper	high	Elastic	yes	global	high	Mainly trade within Europe
Steel manufacture	high	Elastic	yes	global	limited	Differentiated markets
Aluminum	high (electricity)	Elastic	yes	global	n/a	Not in the EU ETS but high dependency on electricity

Source: Carbon Trust (2004)

All sectors in this table can be labeled as being energy intensive. It is also worth noting that many sectors in the EU ETS are exposed to direct effects (use of fossil fuels) and indirect effects (use of electricity) like the pulp and paper sector. Some studies that assess the competitiveness impacts of the EU ETS also include aluminum – that is not included in the scheme – as a sector with high energy intensity (use of electricity) to show indirect effects of the EU ETS. (McKinsey &Company, Ecofys 2006, Carbon Trust 2004).

Table 4 shows estimates of the price elasticity of demand in the selected sectors as used in an IEA information paper (Reinaud, 2005).

Table 4: Price elasticities in European industries

Industry	**Price elasticity**
Electricity	-0.1 – 0.3
Cement	-0.27
Pulp and paper	-1.88
Steel	-1.56
Aluminum	-0.86

Source: Reinaud (2005)

Demand in the power market is generally seen as being quite inelastic (closer to zero) whereas other sectors experience a more elastic demand. Sectors like pulp and paper and steel will be more exposed to demand reductions when raising their product prices (Carbon Trust 2004, Reinaud 2005).

The competition within the market and the geography of the market are related issues. There is competition in all markets except the power market. However, for cement competition is limited to close distances, whereas some steel products and aluminum are traded on fully global markets.

It is important to emphasize that all sectors have potentials to abate carbon by further increasing energy efficiency in their production processes. Another abatement option is the decarbonization of the used energy mix. In this respect the opportunity to abate carbon is generally seen to be high in the electricity sector as electricity can be generated with a wide variety of technologies and fuels (CEPS, 2005b). The pulp and paper sector also has quite high potentials for abating carbon by using renewables in energy supply and own generation of electricity. The cement production has potentials for abating fuel based CO_2 emissions. However, a high share of CO_2 emissions in the cement sector are process related resulting from processing the raw material and thus cannot be avoided. Of the sectors analyzed the steel sector - if producing with the primary or blast oxygen furnace (BOF) process - has the smallest potential of reducing CO_2 emissions by changing the fuel mix as this technology relies heavily on the use of coke in the production process.

Coming back to Table 3 we check what industries are potentially most exposed to adverse effects of the EU ETS. In Table 5 a “plus” indicates a possible adverse effect according to this dimension.

Table 5: Sectors affected by the EU ETS

Sector	Energy intensity	Price elasticity of demand	Competition within the market	Geography of the market	Opportunity to abate carbon
Electricity	+				
Cement	+		+		+
Paper	+	+	+	+	
Steel manufacture	+	+	+	+	+
Aluminum	+ (electricity)	+	+	+	+

The only two sectors that are affected negatively according to all five factors are steel (basic oxygen furnace) and aluminum. One can also see that cement as well as pulp and paper are also potentially affected in some dimensions.

In order to assess effects on competitiveness on a country level, within the EU and with respect to companies outside the EU, the cement sector (the issue of carbon leakage) is chosen to illustrate these effects. The European cement sector although, dominated by a small number of companies, has many installations and companies all over Europe and also trades with countries outside the EU, although trade relations are mainly determined by distance.

In the electricity sector there seems to be no danger of adverse effects from EU ETS as rising costs can be passed through to prices and there are many opportunities to abate carbon. Because of this second feature the electricity sector is interesting for an analysis of the effects of the EU ETS, as according to theory most of the early carbon abatement should happen in this sector. This is why the electricity sector is chosen for a deeper analysis of the effects of the EU ETS in chapter 8 of this study.

Many studies (Carbon Trust 2004, Demailly et al. 2007, McKinsey &Company, Ecofys 2006) come to the conclusion that the effects of the EU ETS on the international competitiveness of European companies will be negligible even for energy-intensive industries, if the scheme is properly implemented. Some sectors will even gain from the introduction of the EU ETS. These results are based on the assumptions of the ability to pass through costs to prices as well as a continued high share of free allocation. These results are valid for sector aggregates. There might be different effects on the company level. However, a weak or inconsistent implementation of the EU ETS between countries poses a high threat to competitiveness (Carbon Trust, 2004). As was shown in chapter 4 and Kettner et al. (2008) both factors played a role in the first trading period of the EU ETS. There was an overall long position, meaning an excess supply of CO_2 allowances with large differences between countries and sectors. Convery et al.

(2008) conclude that there is no empirical evidence in the EU for a correlation between carbon prices and competitiveness of European industries. This conclusion, however, is a result of the overall long position in the allowance market leading to low or almost zero carbon prices complemented by relatively high commodity prices during the first trading period. Only the aluminum sector is expected to experience clearly negative effects on competitiveness even though not being subject to the EU ETS.

Apart from these short-term impacts long-term effects - mainly future investment decisions of regulated industries - of the EU ETS are also of major interest. Sustained high carbon prices can be one factor triggering investment decisions towards less carbon intensive structures. The two most important factors with respect to these long-term decisions are persistent sufficiently high carbon prices.

What can be done to reduce competitiveness effects on the regulated industries?

As long as there is no CO_2 regulation comparable to the EU ETS in other regions of the world carbon leakage could undermine the environmental effectiveness and the competitive position of European energy-intensive industries. Thus, accompanying measures to avoid competitive distortions could be considered in the EU (EC, 2008a, 2008b). There are two groups of measures to reduce the negative competitiveness effects because of the EU ETS (CEPS, 2005b):

- Alleviation measures
- Compensation measures

Alleviation measures change the incentive structure of the scheme and the functioning of the market. They include the recycling of auctioning revenues to the sectors, limiting the CO_2 allowances price (e.g. by allowing a higher inflow of JI/CDM credits to the market) and allocation based on a benchmark system.

Compensation measures include tax breaks, reduction of burdens, government subsidies and the redistribution of "windfall taxes".

The following chapters of the report contain the two case studies analyzing the electricity sector and the cement sector. The analysis starts with a literature overview on competitiveness issues in the electricity sector. This chapter is followed by an empirical analysis of the structure of the electricity sector and possible evidence on effects of the EU ETS. After that the chapters on competitiveness issues in the cement sector and empirical evidence on the effects of the EU ETS in this sector follow.

7 Competitiveness issues in the power sector

As stated in chapter 6 and shown in chapter 4 the electricity sector is the largest emitter in the EU ETS and has many opportunities to abate carbon. According to theory most of the early carbon abatement should happen in this sector. This is why the electricity sector is of particular interest to analyze effects of the first trading phase of the EU ETS. We will start with considerations about possible effects of the EU ETS on the electricity sector and present empirical evidence on some of these issues in the next chapter.

The electricity sector is a key sector within the EU ETS. It emits more than 50% of CO_2 emissions covered in the trading scheme. This results in a high market share of the electricity sector in emissions trading. The electricity sector is expected to remain the biggest single CO_2-emitting sector until 2030 (Reinaud, 2003).

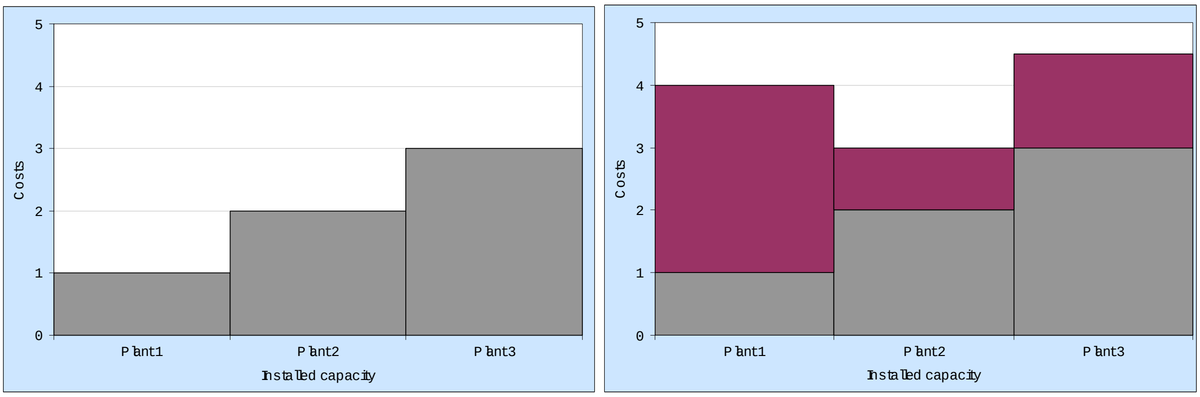
As in other sectors the introduction of the EU ETS will result in higher variable production costs for many generators as CO_2 costs are incorporated in the costs of fossil fuels. Some of the abatement opportunities in the electricity sector like fuel switching are available in the short term. The electricity sector is not only exposed to direct effects of emissions trading but also a source of indirect effects when electricity prices rise as a result of passing through cost increases in the electricity sector to prices. It has to be noted that both effects are intended and should serve as incentives for the transition to energy efficient and less carbon intensive technologies.

Short term impacts

The production of electricity can be carried out using a variety of technologies and fuels. With the introduction of the EU ETS and a resulting price for carbon, fuels and technologies that emit more carbon are assumed to lose competitiveness in comparison to fuels and technologies with lower carbon content. This effect could for example render gas fired power plants more competitive in comparison to coal fired power plants (Reinaud, 2003) and result in a fuel switch from coal to gas and lignite to coal (Reinaud, 2007, CEPS, 2005b). According to McKinsey & Company and Ecofys (2006) the EU ETS is expected to mainly affect the balance between hard coal and gas in electricity generation. However, a fuel switch can also be motivated by changing relative prices for fossil fuels. As oil prices (and with it gas prices) increase coal can become more competitive. If the rise in oil prices is higher than the CO_2 price, this effect could even completely offset the fuel switch effects of the EU ETS.

A short term effect of the EU ETS (as long as CO_2 prices are positive) is the possible change in the merit order of the electricity supply curve (Sijm et al, 2006, Reinaud, 2003). Figure 8 shows the change in the merit order of electricity supply due to higher carbon costs. The left diagram illustrates the situation before the introduction of the EU ETS. Installed capacity includes three technologies that have different costs in power generation. The price is set by the marginal (most expensive) plant that is run to meet electricity demand. The cheaper plants receive excess profits with plant 1 receiving the highest profits. The right diagram shows the situation after the introduction of the EU ETS. Generation costs for all fossil fuel based technologies rise. However, they rise to a different extent depending on the carbon content of the fuel. Now the profits for plant 2 are highest. This is due to the lower carbon content of the fuel used in plant 2 compared to plant 1, implying a lower rise in production costs. This shows that depending on the price of CO_2 the EU ETS could trigger changes in the merit order of electricity supply, for example making less carbon intensive natural gas more competitive in comparison to more carbon intensive coal.

Figure 8: Merit order of electricity supply



Source: Own illustration based on Sijm et al. (2006)

Changes in power prices (when CO_2 costs are passed through to power prices) trigger indirect effects of the EU ETS resulting in competitiveness effects for electricity consuming industries. According to Reinaud (2003) the effects of the EU ETS on power prices will both depend on the price setting behavior in the power sector and on the allocation method.

As the elasticity of demand for electricity is very low in the short run and competition is quite low economic theory would suggest a full pass through of CO_2 costs to power prices. However, the extent to which this happens depends also on regulatory pricing mechanisms and the allocation method for the next trading period. If the allocation of CO_2 allowances in a period depends on the CO_2 emissions of the past, there is an incentive to maintain high CO_2 emissions in the present to get higher allocation in the future (Reinaud, 2003). Power companies earned large profits in the first trading phase. Apart from the effects of the EU ETS described above and grandfathering there are a number of other reasons for this; for example high gas and oil prices increased profits of nuclear and hydropower (Convery et al. 2008). This is why the Commission opts for full auctioning of allowances in the post-Kyoto phase of the ETS. It is however important that even full auctioning of allowances can not avoid windfall profits of non-carbon fuel electricity generators like nuclear and hydropower.

Long term impacts

Investment decisions in the electricity sector may be altered by the future design of the EU ETS, although the EU ETS reduced certainty in its early phase. The change in competitiveness of certain technologies plays an important role for new investments in the power sector. For example, continued grandfathering of emissions allowances based on past emissions could reduce the incentive to invest in low carbon power generation technologies (Reinaud, 2003).

Concluding, electricity generation is regarded as the sector benefiting most from the introduction of the EU ETS. Existing hydro and nuclear plants will have the highest increase in profits as a result of the pass through of higher costs to prices.

As stated in Chapter 6 the elasticity of demand is rather low at least in the short run and international competition does not play an important role. This implies that it is easier for this sector to pass through cost increases to end-user prices. According to Carbon Trust (2004) the electricity sector would only need to pass through a low proportion of costs increases due to the introduction of the EU ETS to prices to maintain its pre-ETS profits.

8 Empirical analysis of the structure of electricity generation in the EU 27

What follows is an empirical analysis of the structure of the electricity sector. The intention is to identify long-term developments in the sector in order to show how demand and production as well as supply structures have changed over time. Special attention is put on significant observable changes in the structure of the electricity sector since the introduction of the EU ETS (2005-2007). From this we try to find some implications for the effects of the EU ETS.

Data for the following analysis of electricity generation is taken from the IEA energy balances, editions 2007 (time series until 2005) and 2008. Edition 2008 contains electricity data until the year 2007[2]. At the finalization of the report edition 2008 was only available for those EU 27 countries that are members of the OECD (19 countries, among them the EU 15). For these countries the analysis comprises the years 2006 and 2007. EU 27 aggregates contain only data until 2005. The EU 15 aggregates contain data until 2007. GDP[3] data is taken from the indicators publication of the IEA energy balances editions 2007 and 2008.

Economic growth and energy demand

We start with an analysis of how economic growth (GDP) and energy and electricity consumption are related. We do this by computing GDP elasticities with respect to total energy consumption and with respect to total electricity consumption. This gives us indications about structural differences in energy consumption between countries and shows which countries are closer to decoupling economic growth from total energy and electricity consumption, an important factor that could contribute to achieving energy efficiency and CO_2 reduction targets.

The following formulas are used for computing the elasticities:

$$\varepsilon_{f,q} = \frac{\overline{\overline{\%\ f}}}{\overline{\overline{\%\ q}}} \text{ and } \varepsilon_{fe,q} = \frac{\overline{\overline{\%\ fe}}}{\overline{\overline{\%\ q}}}$$

where $\overline{\overline{\%\ f}}$, $\overline{\overline{\%\ fe}}$ and $\overline{\overline{\%\ q}}$ are the exponentially smoothed rates of change of total energy consumption, total electricity consumption and GDP.

For a small number of countries (see table 6) it was not possible to compute GDP elasticities due to data restrictions.

[2] From “Energy Balances for OECD countries – Documentation for Beyond 2020 Files”: “In order to further improve the effectiveness of this publication, the IEA has decided to include supply estimates for “year-1” (i.e. for 2007). For the most part, the 2007 data are based on “mini questionnaires” received from national administrations of OECD countries as well as on monthly oil questionnaires. The 2007 data are considered as best estimates and are subject to revision in future editions.”

[3] GDP in billion 2000 US$ using purchasing power parities (PPPs)

Table 6: GDP elasticities of total final energy consumption and total electricity consumption

	GDP elasticity total final energy consumption				GDP elasticity total electricity consumption			
	1995	2000	2005	2006	1995	2000	2005	2006
Austria	0.6	0.5	1.2	0.7	0.8	0.7	1.0	0.9
Belgium	2.1	0.8	0.2	-0.2	1.8	1.0	0.5	0.7
Bulgaria	-	-	-	-	-	-	-	-
Cyprus	1.1	0.7	0.5	-	0.6	1.4	1.7	-
Czech Republic	-	-	-	-	-	-	-	-
Denmark	0.6	-0.2	0.4	0.4	0.5	0.3	0.5	0.5
Estonia	-	-	-	-	-	-	-	-
Finland	0.2	0.2	0.1	0.5	0.6	0.6	0.3	0.7
France	0.5	0.4	0.3	0.1	1.3	0.8	1.1	0.9
Germany	-0.1	-0.2	0.6	0.6	0.0	0.6	1.3	0.7
Greece	1.2	0.8	0.5	0.6	1.5	1.4	0.8	0.8
Hungary	0.0	0.0	0.7	0.5	0.3	0.2	0.3	0.4
Ireland	0.3	0.6	0.6	0.7	0.8	0.7	0.7	0.8
Italy	0.8	0.5	2.5	1.2	1.5	1.4	2.6	2.0
Latvia	-0.7	-0.6	0.3	-	0.1	0.1	0.6	-
Lithuania	-0.3	-1.0	0.3	-	0.0	-0.4	0.6	-
Luxembourg	-0.2	0.5	1.0	0.6	1.3	0.5	0.4	0.6
Malta	-	-	-	-	-	-	-	-
Netherlands	0.5	0.4	1.0	0.0	1.0	0.8	1.0	0.8
Poland	-0.1	-0.5	0.2	0.5	0.3	0.3	0.2	0.4
Portugal	1.6	1.3	1.3	0.1	2.4	1.6	3.2	3.1
Romania	-	-	-	-	-	-	-	-
Slovakia	0.2	0.1	0.2	0.0	0.6	0.1	0.0	0.2
Slovenia	0.9	0.5	0.6	-	0.5	0.5	0.8	-
Spain	1.9	1.2	1.1	0.6	1.5	1.4	1.5	1.3
Sweden	0.1	-0.1	-0.2	-0.2	0.2	0.2	0.1	0.1
United Kingdom	0.3	0.3	0.2	-0.1	0.7	0.6	0.5	0.3

Source: IEA; own calculations

As can be seen in Table 6 only three countries (Belgium, Sweden, UK) have decoupled economic growth from energy demand; Sweden has had a negative GDP elasticity with respect to total energy consumption already since 2000. It is also worth noting that the elasticities show no clear pattern over the years. In some countries the elasticities rise, in some they decline. However, positive elasticities in most cases show that the majority of countries has not yet decoupled economic growth from energy and electricity consumption. This observation has two implications for the EU ETS: First, as long as the GDP elasticity of electricity consumption is not decoupled from economic growth (i.e. positive), reaching CO_2 reduction targets in the short run will be more difficult (note that the electricity sector has a high share in total CO_2 emissions); second, positive CO_2 prices could help decrease the GDP elasticity of electricity consumption in the medium-term, if they are passed through to consumers causing higher electricity prices. This in turn could lead to lower energy demand and thus the EU ETS could serve as a driver to increase energy efficiency. For country specific diagrams on GDP elasticities see Appendix 1.

The structure of electricity supply in the EU 27

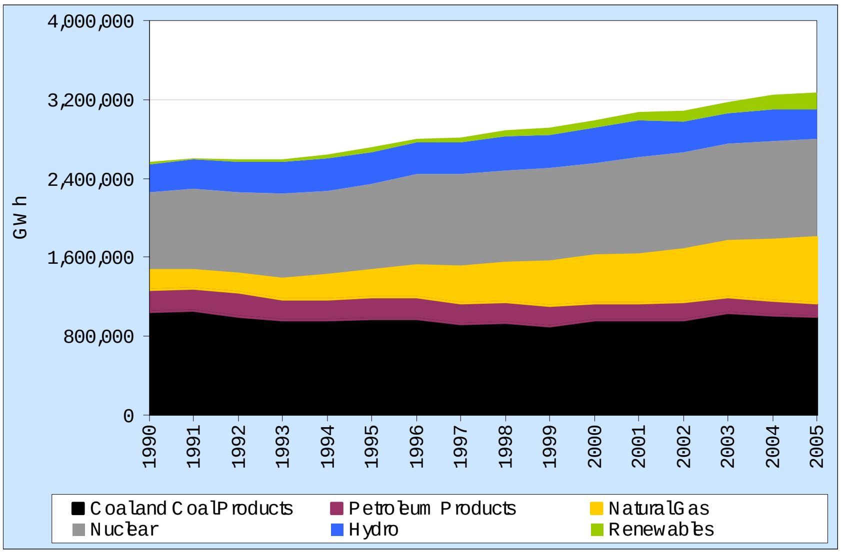
To assess changes in the composition of electricity generation which also determines emissions total electricity production is disaggregated into the following energy categories:

- Coal and coal products
- Petroleum products

- Natural gas
- Nuclear
- Hydro
- Renewables
- Others (all other energy sources)

Electricity generation in the EU 27 amounted to 3,274,118 GWh in the year 2005. From 1990 to 2005 it increased by 28%.

Figure 9: Total electricity production, EU 27, 1990-2005



Source: IEA; Own calculations

As can be seen from Figure 9 coal and nuclear energy are the dominant energy sources in European electricity generation. The shares of nuclear, hydro and petroleum products were decreasing; the share of natural gas was increasing strongest from a share of 7% in 1990 to 20% in 2005. Also, renewables showed an increase in share but still account for only 5% in Europe's electricity output. For country specific diagrams see Appendix 1.

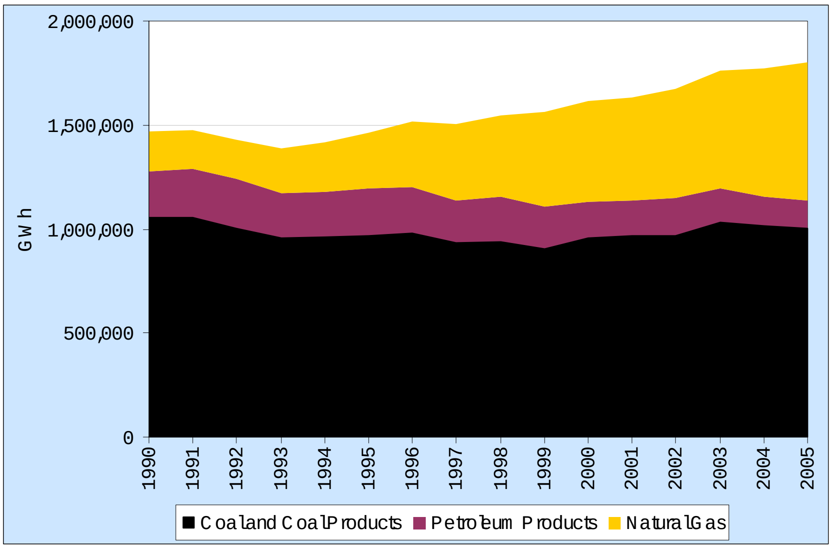
For a deeper analysis in this report we assess effects of the EU ETS in the years 2005 to 2007 on electricity production with respect to the following questions:

- Has there been a shift in shares of total production within the group of fossil fuels (e.g. a shift to less carbon intensive fossil fuels)?
- Are there observable changes in the way additional demand for electricity is met?

Shifts within the group of fossil fuels

In a first step we assess whether there was a change in the shares of fossil fuels in the respective electricity production, which would be translated into different emission paths.

Figure 10: Electricity production from fossils, EU 27, 1990-2005



Source: IEA; own calculations

Electricity from fossil fuels accounted for 55% of total electricity production in the year 2005 in the EU 27. This is equivalent to 1,803,054 GWh. The shares of the fuels within the group of fossils changed quite considerably in the years 1990 to 2005 with a decreasing share of coal and petroleum and a strongly increasing share of natural gas. Still, coal is the dominant fossil fuel in electricity production of the EU 27 with a share of 56%.

Table 7: Shares in electricity production from fossils, EU 27, 1990-2005

	1980	1985	1990	1995	2000	2005
Coal and coal products	-	-	72%	66%	59%	56%
Petroleum products	-	-	15%	15%	11%	8%
Natural gas	-	-	13%	18%	30%	37%

Source: IEA; own calculations

For the EU 15 data on electricity production until 2007 is already available for this report (see introductory remarks to this chapter). Table 8 shows that compared to the EU 27, coal has a lower share in electricity production (48%) whereas the importance of natural gas in electricity production is higher (45% compared to 37%). When looking at the three years of the first trading period of the EU ETS (2005-2007) we can see that the trend of a decreasing share of coal and an increasing share of natural gas has continued in the years 2005 to 2007. However, there was no stronger fuel switch (coal to natural gas) than in the years before. Therefore, it seems that the EU ETS did not cause an additional fuel switch. This is not very surprising when keeping in mind that CO_2 prices for most of the first trading period were low or even close to zero (see chapter 3) and a clearly positive CO_2 price would be necessary to change the merit order of electricity supply. Another influence on the shares of coal and natural gas and petroleum products are oil prices. Rising oil prices have an increasing influence on natural gas prices as well and by this render coal relatively cheaper. For country specific evidence on this issue see Appendix 1.

Table 8: Shares in electricity production from fossils, EU 15, 1980-2007

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	60%	71%	69%	62%	53%	49%	49%	48%
Petroleum products	30%	18%	18%	18%	13%	9%	8%	7%
Natural gas	11%	11%	13%	20%	34%	42%	43%	45%

Additional demand

As long as electricity consumption rises an important question is by what energy sources this additional electricity consumption is met as this also determines future CO_2 emissions from electricity production. We start with the observation that total electricity supply (SS) in a country can be met by the following sources:

- Domestic production from fossils (FO)
- Domestic production from nuclear (NU)
- Domestic production from hydro (HY)
- Domestic production from renewables (RE)
- Net imports (M)

We use the IEA energy balances to obtain the above mentioned 5 components of electricity supply. In a next step we take the absolute changes of all components in each year and get the following identity:

$$ss_t = fo_t + nu_t + hy_t + re_t + m_t$$

where the small letters indicate absolute changes in each component.

We then compute the correlation coefficients between changes in each of the components and the other components. By this we can get evidence on how additional supply is met and what sources of supply are substitutes and what sources of supply are complements. We compute correlations for two periods (1980-1993, 1994-2005/2007) and time dependent correlation time series from 1980-2005/2007. By this we get evidence on how correlations are changing over time.

For the correlation coefficients the following formula is applied where in the usual way the covariance of the two components is divided by the product of the standard deviations:

$$cor(x,y) = \frac{\sum\left(x_i - \bar{x}\right)\times\left(y_i - \bar{y}\right)}{\sqrt{\sum\left(x_i - \bar{x}\right)^2}\times\sqrt{\sum\left(y_i - \bar{y}\right)^2}}$$

The time dependent correlation coefficient time series are attained by the following formula:

$$cor(x,y) = \frac{\overline{\overline{xy_t}} - \overline{\overline{x_t}}\,\overline{\overline{y_t}}}{\sqrt{\overline{\overline{x_t^2}} - \overline{\overline{x_t}}^2} \times \sqrt{\overline{\overline{y_t^2}} - \overline{\overline{y_t}}^2}}$$

where the symbol $\overline{\overline{\ }}$ marks the exponentially smoothed value for each year.

Note that net imports are not available for the EU 27. For the EU 27 we apply the same approach but replace supply by domestic production, thus leaving net imports aside. The EU 27 electricity market cannot be seen as a closed system as there is considerable trade with countries outside the EU (e.g. Norway and Ukraine). Also, aggregate EU 27 data are available only from 1990 on, thus no correlation coefficients are computed for the period 1980-1993.

Looking at the correlations between the components of total supply in the periods 1980-1993 and 1994-2006 one can identify the main complements and substitutes. Red bold numbers indicate strong correlations over 0.5 and -0.5.

Table 9 shows the correlation components of electricity supply. The aggregate EU 27 data reveal only one significant relationship, a positive correlation between total electricity production and fossil fuels. This result indicates that additional electricity production in the EU 27 is still met mainly by fossil fuels with accompanying emissions.

Table 10 shows the shares of energy sources in total electricity production to indicate which energy sources and thus correlation coefficients play an important role in electricity production.

Table 9: Correlations components of electricity supply, 1994-2005, EU 27

		Total production	Fossils	Nuclear	Hydro	Renewables	Net imports
Total production	1980-1993	-	-	-	-	-	-
	1994-2005	1.00	0.59	0.47	0.49	-0.06	-
Fossils	1980-1993		-	-	-	-	-
	1994-2005		1.00	-0.03	-0.23	-0.05	-
Nuclear	1980-1993			-	-	-	-
	1994-2005			1.00	0.10	-0.34	-
Hydro	1980-1993				-	-	-
	1994-2005				1.00	-0.13	-
Renewables	1980-1993					-	-
	1994-2005					1.00	-
Net imports	1980-1993						-
	1994-2005						-

Source: IEA; own calculations

Table 10: Shares of energy sources in total electricity production, 1990-2005, EU 27

	1980	1985	1990	1995	2000	2005
Fossils	-	-	57%	54%	54%	55%
Nuclear	-	-	31%	32%	32%	30%
Hydro	-	-	11%	12%	12%	9%
Renewables	-	-	1%	1%	3%	5%

Source: IEA; own calculations

As will be shown in the remainder of the chapter, the only significant correlation in all countries is the one between total supply (production corrected by net imports) and fossil fuels. This is also the relationship that is of most interest when analysing the effects of the EU ETS. A decreasing correlation between supply and fossil fuels would imply that they play a decreasing role in meeting additional electricity supply.

Table 11 (1980-2007) and Table 12 (2000-2007) show time dependent correlation coefficients between total electricity supply and electricity production from fossil fuels. These time series thus reveal how the relationship between these two components changes over time. Table 11shows the correlation coefficients in five year steps from 1980 to 2005 and the years 2006 and 2007; Table 12 shows the short-term development of the correlation coefficients from 2000 to 2007. The results depicted in Table 11and Table 12 are complemented with details on country specific correlation coefficients in Appendix 1.

The tables highlight that in most countries the correlation between total supply and fossil fuels is positive but decreasing. This would indicate that additional electricity demand is increasingly met by other energy sources than fossils. Still, the high correlations show the continued importance of fossil fuels in electricity production in the European Union.

Table 11: Time dependent correlation coefficients between total electricity supply and electricity production from fossils, 1980-2007

	1980	1985	1990	1995	2000	2005	2006	2007
Austria	0.86	0.80	0.70	0.71	0.68	0.72	0.44	0.41
Belgium	-0.22	-0.18	0.40	0.50	0.50	0.33	0.24	0.12
Bulgaria	0.91	0.87	0.61	0.73	0.62	0.56	-	-
Cyprus	1.00	1.00	1.00	1.00	1.00	1.00	-	-
Czech Republic	-0.26	-0.37	0.12	0.49	0.51	0.44	0.43	0.34
Denmark	0.44	0.62	0.62	0.58	0.84	0.76	0.79	0.82
Estonia	-	-	1.00	0.99	0.99	0.98	-	-
Finland	0.50	0.59	0.51	0.56	0.06	0.65	0.77	0.79
France	-0.34	-0.21	-0.33	0.20	0.28	0.11	0.20	0.18
Germany	0.77	0.44	0.16	0.42	0.60	0.43	0.42	0.36
Greece	0.70	0.53	0.72	0.67	0.85	0.72	0.73	0.87
Hungary	-0.28	-0.17	0.08	-0.48	-0.14	-0.02	0.03	0.08
Ireland	0.99	0.96	0.92	0.92	0.94	0.57	0.69	0.78
Italy	0.08	0.05	0.51	0.57	0.67	0.63	0.62	0.62
Latvia	-	-	1.00	0.95	0.93	0.91	-	-
Lithuania	-	-	1.00	0.89	0.88	0.88	-	-
Luxembourg	0.95	0.91	0.76	0.11	0.07	0.03	0.00	0.04
Malta	1.00	1.00	1.00	1.00	1.00	1.00	-	-
Netherlands	0.83	0.76	0.51	0.59	0.50	0.52	0.56	0.33
Poland	0.98	0.96	0.94	0.94	0.93	0.89	0.90	0.72
Portugal	-0.10	-0.25	0.29	0.49	0.44	0.23	0.33	0.37
Romania	0.14	0.17	0.84	0.81	0.79	0.71	-	-
Slovakia	0.81	0.68	0.57	0.65	0.52	0.54	0.48	0.52
Slovenia	-	-	1.00	0.97	0.94	0.92	-	-
Spain	-0.08	-0.21	0.12	0.32	0.54	0.55	0.55	0.50
Sweden	0.35	0.49	0.19	-0.16	-0.07	-0.18	-0.20	-0.20
United Kingdom	0.93	0.96	0.83	0.77	0.78	0.71	0.65	0.47

Source: IEA; own calculations

Table 12: yearly time dependent correlation coefficients between total electricity supply and electricity production from fossils, 2000-2007

	2000	2001	2002	2003	2004	2005	2006	2007
Austria	0.68	0.75	0.73	0.77	0.74	0.72	0.44	0.41
Belgium	0.50	0.55	0.46	0.42	0.42	0.33	0.24	0.12
Bulgaria	0.62	0.59	0.56	0.58	0.58	0.56	-	-
Cyprus	1.00	1.00	1.00	1.00	1.00	1.00	-	-
Czech Republic	0.51	0.47	0.49	0.48	0.46	0.44	0.43	0.34
Denmark	0.84	0.84	0.82	0.76	0.76	0.76	0.79	0.82
Estonia	0.99	0.99	0.99	0.98	0.98	0.98	-	-
Finland	0.06	0.12	0.13	0.15	0.18	0.65	0.77	0.79
France	0.28	0.28	0.12	0.20	0.20	0.11	0.20	0.18
Germany	0.60	0.61	0.61	0.50	0.47	0.43	0.42	0.36
Greece	0.85	0.80	0.81	0.72	0.72	0.72	0.73	0.87
Hungary	-0.14	-0.08	-0.08	-0.07	0.00	-0.02	0.03	0.08
Ireland	0.94	0.88	0.68	0.68	0.65	0.57	0.69	0.78
Italy	0.67	0.65	0.64	0.66	0.68	0.63	0.62	0.62
Latvia	0.93	0.93	0.93	0.92	0.91	0.91	-	-
Lithuania	0.88	0.88	0.88	0.88	0.88	0.88	-	-
Luxembourg	0.07	-0.03	-0.07	-0.09	-0.04	0.03	0.00	0.04
Malta	1.00	1.00	1.00	1.00	1.00	1.00	-	-
Netherlands	0.50	0.48	0.45	0.46	0.49	0.52	0.56	0.33
Poland	0.93	0.93	0.93	0.91	0.89	0.89	0.90	0.72
Portugal	0.44	0.40	0.31	0.20	0.23	0.23	0.33	0.37
Romania	0.79	0.80	0.80	0.80	0.72	0.71	-	-
Slovakia	0.52	0.52	0.52	0.53	0.53	0.54	0.48	0.52
Slovenia	0.94	0.93	0.93	0.93	0.92	0.92	-	-
Spain	0.54	0.48	0.50	0.38	0.49	0.55	0.55	0.50
Sweden	-0.07	-0.02	-0.10	-0.20	-0.18	-0.18	-0.20	-0.20
United Kingdom	0.78	0.78	0.76	0.73	0.73	0.71	0.65	0.47

Source: IEA; own calculations

For time dependent correlation coefficients between total electricity supply and the other components of electricity supply (nuclear, hydro, renewables, net imports) see Appendix 2. Appendix 2 shows that nuclear is in most countries positively correlated with total supply although most correlations are weak (under 0.5). Only in two countries (Lithuania and Slovenia) correlations are over 0.5. This means that only in these countries nuclear still contributes significantly to additional electricity supply. The correlation between supply and hydro shows no clear pattern for the EU 27 countries. Like nuclear also renewables are positively correlated with total supply in most countries. However, it has to be noted that the time dependent correlation coefficients for supply and renewables in most countries show a quite fluctuating development over the years. The correlation of supply with net imports identifies net exporters (negative correlation coefficient) and net importers (positive correlation coefficient).

The analysis of the electricity sector reveals that Europe is still heavily relying on fossil fuels in electricity production (55% in 2005) but the extent to which additional supply is met by fossil fuels is decreasing. A high carbon content in electricity production and positive GDP elasticities with respect to electricity consumption in all countries imply that not all CO_2 reduction potentials in this sectors were used yet. A properly designed and implemented EU ETS can be one instrument to deploy these potentials.

9 Competitiveness issues in the cement industry

The second case study in this report analyses available data on the cement industry. The cement industry was chosen for a case study because we want to try getting evidence on potential carbon leakage and data on exports and imports was available for the cement industry.

The cement industry is a highly energy intensive industry that to a large extent uses carbon intensive fuels (Reinaud, 2005). This and the relatively low product prices compared to energy costs imply that low carbon costs are already a significant part of total production costs. If the pass through of CO_2 costs to consumer prices is not possible the industry is threatened by carbon leakage (the relocation of production capacities to regions without CO_2 regulation). In the empirical part on the cement industry we will assess developments of production and consumption of cement and clinker since 1998.

The clinker making process is responsible for all direct emissions in the cement industry. The two CO_2 emission sources in the clinker making process are fossil fuels and the raw material that emits CO_2 in the calcinating process. An important feature of these process-related emissions is that they can hardly be reduced as they depend on the carbon content of the raw material that serves as the basis of cement. The cement industry is also an important source of indirect emissions when clinker is ground to powder by electric mills. This powder is then complemented with additives to obtain cement.

The price of cement is relatively low compared to the inland transportation costs. This implies that cement is usually only exposed to short distance international competition, as transportation costs over long distances over land are too high to be economical. However, it can be transported over long distances at sea at reasonable costs (Reinaud, 2005). The cement industry can be described as a market with mostly geographically limited international competition as noted in chapter 6. Thus, the danger of carbon leakage because of introduction of the EU ETS is higher in countries at the borders of the EU - especially in countries with or close to seaports.

Due to the high carbon intensity of the production process and the low product price the cement industry is expected to have the highest increases in direct costs due to the introduction of the EU ETS. Besides, the cement industry that uses a significant amount of electricity is also exposed to indirect effects of the EU ETS due to increasing power prices (Reinaud, 2005). Overall, the cement industry is expected to face high increases in marginal costs as a result of the introduction of the EU ETS. However, the sector would need to increase prices only by a small proportion to maintain its pre-ETS profits (Carbon Trust, 2004). A higher pass through of cost increases to prices is most likely to be possible in countries that do not lie at the borders of the EU or close to seaports (McKinsey &Company, Ecofys 2006). Walker (2006) presents first evidence on the pass through of costs to cement prices for the year 2005 and comes to the conclusion that it was much lower than predicted by all models and that cement producers did not earn significant windfall profits as a result of the EU ETS. With respect to leakage concerns - the change of imports and exports to non-EU regions - Convery et al. (2008) find that relative energy costs in the cement industry play a very secondary role compared to available production capacities for selected EU countries. This implies that available capacities are used for production regardless of energy prices. Still, clinker production is one sub-sector that is potentially threatened by carbon leakage (Neuhoff et al., 2007). These observations lead to the conclusion that although the competitiveness effects of the EU ETS on existing installations is expected to be minor, there is the threat of carbon leakage for additional capacities – when new investments for meeting the EU's clinker demand are made outside of the borders of the EU.

10 Empirical evidence on cement and clinker consumption and production

This chapter combines available data (1998-2006) on production, exports and imports of cement and clinker to get hints on developments in the industry.

The cement industry can reduce specific direct CO_2 emissions via two channels:

- A reduction in the use of fossil fuels
- A reduction of the clinker factor – the clinker content of cement

Two questions will be addressed in the following data analysis:

- Is there a difference between domestic production and domestic consumption of cement and clinker in the European cement industry? This gives us hints about production capacities. If consumption exceeds production over a longer time horizon either new capacities have to be built in Europe or imports from outside the EU 27 have to be increased (carbon leakage).
- Is the European cement industry reducing the clinker factor? One option for reducing CO_2 emissions (process related and fuel based) is the reduction of the clinker factor that is defined as domestic clinker consumption divided by domestic cement production. In short the clinker factor can also be defined as the clinker content in domestic cement production.

10.1 Cement consumption and production

Data for domestic cement consumption and production from 1998 to 2006 were supplied by CEMBUREAU, the representative organization of the cement industry in Europe. Cement exports and imports were also available from this source.

Table 13 shows cement consumption in the EU 27. As can be seen there was an overall increase in cement consumption by 26% from 1998 to 2006. In the EU 15 Spain and Italy account for almost half of the total cement consumption. The new Member States (EU 16:27) increased their cement consumption twice as much as the EU 15 in the period 1998 to 2006. Thus, most of the increase in cement consumption was due to higher cement demand in the new Member States. It is important to note that cement demand is heavily influenced by the business cycle and growth prospects of the construction industry. Thus, economic growth and expanding construction activities have a direct effect on cement demand.

Table 13: Cement consumption in kilotons, EU 27, 1998-2006

	1998	1999	2000	2001	2002	2003	2004	2005	2006	% 1998-2006
EU 15	176,950	186,162	192,106	190,356	193,465	197,410	204,275	206,560	217,398	22.86
EU 16:27	30,243	31,331	32,365	29,541	30,821	32,107	34,815	37,653	43,390	43.47
EU 27	207,193	217,493	224,471	219,897	224,286	229,517	239,090	244,213	260,788	25.87

Source: CEMBUREAU; own calculations

In the same period (1998-2006) cement production in the EU 27 increased by 21% as can be seen from Table 14. This implies cement consumption increased stronger than cement production.

Table 14: Cement production in kilotons, EU 27, 1998-2006

	1998	1999	2000	2001	2002	2003	2004	2005	2006	% 1998-2006
EU 15	181,373	189,996	193,764	193,602	193,467	198,489	205,972	210,092	221,565	22.16
EU 16:27	36,782	36,636	36,588	32,886	32,392	33,365	34,915	38,367	43,454	18.14
EU 27	218,155	226,632	230,352	226,488	225,859	231,854	240,887	248,459	265,019	21.48

Source: CEMBUREAU; own calculations

If this trend continues in the future there may be two options to meet rising cement demand:

- Increasing domestic production capacities
- Increasing imports (carbon leakage)

In the analysis of short and long positions in the first trading phase of the EU ETS in chapter 4 of this report the cement sector was aggregated with the lime sector. The analyzed sector cement and lime showed a long position of 5.2% in the average of 2005-2007. However, this long position was decreasing over the years. This decreasing long position suggests that production increased over the three years of the EU ETS.

Excess demand in the European cement market will at least in the short to medium run be driving prices up, potentially increasing the cement industry's profits and offsetting potential negative impacts caused by the EU ETS.

Table 15 shows the difference between domestic production and domestic consumption of cement in the EU 27. A positive number thus indicates a net exporter of cement, a negative number a net importer of cement. As can be seen, cement production in the EU 27 aggregate is higher than consumption. However, consumption is increasing stronger than cement production; in 2006 the EU 27 was a net exporter of cement.

Table 15: Excess supply cement, EU 27, 1998-2006

	1998	1999	2000	2001	2002	2003	2004	2005	2006
Austria	-1,044	-857	-719	-632	-716	-650	-644	-588	-627
Belgium	1,303	1,308	1,385	1,432	1,465	1,092	974	793	1,514
Denmark	496	389	393	507	435	431	554	473	315
Finland	-252	-270	-281	-284	-376	-409	-372	-372	-350
France	-282	-684	-913	-822	-1,290	-1,023	-974	-1,238	-1,824
Germany	-1,536	-965	-368	939	2,088	2,777	2,734	4,113	4,710
Greece	5,813	5,204	5,457	5,284	3,640	3,484	4,408	5,076	4,048
Ireland	-429	-479	-535	285	240	430	523	487	281
Italy	1,389	1,152	587	335	147	-49	-313	352	934
Luxembourg	201	243	218	188	176	170	244	222	228
The Netherlands	-2,500	-2,455	-2,670	-2,370	-2,315	-2,710	-2,850	-2,880	-2,795
Portugal	-286	-428	-767	-1,168	-1,041	-683	-357	-297	505
Spain	1,459	1,155	-324	-1,539	-1,703	-1,476	-1,407	-1,163	-1,848
Sweden	775	717	1,117	1,020	1,071	854	861	815	819
United Kingdom	-684	-188	-908	54	-1,815	-1,164	-1,668	-2,239	-1,714
Czech Rep.	688	471	434	-64	-437	-506	-642	-451	-590
Cyprus	281	222	453	312	235	342	83	213	157
Estonia	82	168	83	143	141	132	195	216	187
Hungary	-72	-163	-211	-83	-332	-436	-750	-803	-565
Latvia	135	45	-32	-35	-71	-51	-157	-205	-313
Lithuania	284	195	144	105	99	1	60	31	56
Malta	-248	-224	-252	-261	-276	-273	-280	-334	-393
Poland	1,828	1,282	736	782	14	-121	-66	104	109
Slovak Rep	1,213	1,325	1,267	1,304	1,273	1,214	1,121	1,087	1,252
Slovenia	112	27	15	60	18	31	-74	-237	-139
Bulgaria	-303	225	459	237	46	-47	136	461	20
Romania	2,539	1,732	1,127	845	861	972	474	632	283
EU 15	4,423	3,842	1,672	3,229	6	1,074	1,713	3,554	4,196
EU 16-27	6,539	5,305	4,223	3,345	1,571	1,258	100	714	64
EU 27	10,962	9,147	5,895	6,574	1,577	2,332	1,813	4,268	4,260

Source: CEMBUREAU; own calculations

10.2 Clinker consumption and production

As mentioned above, all direct CO_2 emissions in cement production result from the clinker production process via the use of fossil fuels and process related CO_2 emissions from the raw material. To understand changes in CO_2 emissions in this sector one has to concentrate on changes in the clinker production process.

Data for clinker production from 1990 to 2006 is taken from the countries' submissions to the UNFCCC in the CRF (common reporting format) format (excel sheet "Table2(I).A-Gs1"). This sheet includes countries' data on process emissions in the cement sector and activity data (countries can chose to submit either domestic clinker production or domestic cement production). Denmark's and Poland's data contains cement and not clinker as activity data for the cement sector. In three countries (Belgium, Estonia, Latvia) it is not clear whether cement or clinker production is submitted. All these countries are excluded from the following analysis. Data for Malta and Cyprus are not available. Clinker exports and imports from 1998 to 2006 were supplied by CEMBUREAU, the representative organization of the cement industry in Europe.

As can be seen from Table 16 clinker consumption increased by 16% only compared to an increase of 25% in cement consumption. This can have two reasons. The share of imported clinker in cement consumption could have been increased or the clinker factor could have been decreased.

Table 16: Clinker consumption in kilotons, EU 27, 1998-2006

	1998	1999	2000	2001	2002	2003	2004	2005	2006	% 1998-2006
EU 15 countries	140,841	146,077	149,103	147,714	148,644	151,335	157,731	159,575	163,757	16.27
EU 16:27 countries	16,797	16,882	15,864	15,758	14,882	15,006	16,676	17,782	19,781	17.77
EU 27 countries	157,637	162,959	164,966	163,472	163,526	166,341	174,407	177,357	183,538	16.43

Source: CEMBUREAU; own calculations

Table 17 shows clinker production from 1998 to 2006. In this period production increased by 9% compared to a 21% increase in cement production.

Table 17: Clinker production in kilotons, EU 27, 1998-2006

	1998	1999	2000	2001	2002	2003	2004	2005	2006	% 1998-2006
EU 15 countries	139,491	142,375	144,748	142,365	142,265	145,125	149,694	149,884	151,758	8.79
EU 16:27 conutries	18,218	17,857	17,018	16,775	16,067	15,878	17,619	18,390	19,995	9.75
EU 27 countries	157,709	160,232	161,765	159,140	158,332	161,003	167,313	168,274	171,753	8.91

Source: UNFCCC; own calculations

The higher increases in cement consumption and production as compared to the increases in clinker consumption and production can have two reasons. The share of imported clinker in cement consumption could have increased and/or the clinker factor could have decreased.

Table 18 shows the difference between domestic production and domestic consumption of clinker in the EU 27 countries. As above, a positive number indicates that production exceeds consumption; a negative number indicates that consumption exceeds production. In contrast to cement clinker consumption exceeds clinker production in the EU 27. The net imports to the EU 27 were increasing over the past 9 years. Note that some of the countries potentially exposed to carbon leakage like Spain and Italy exhibit the highest net imports. As one reaction to this situation some European cement companies invest into new clinker production capacities in North Africa (Walker, 2006) that could supply Italy and Spain with additional clinker. Still it is not clear whether high growth rates in the construction sector (i.e. high growth rates in clinker consumption) can be sustained especially in Spain in the future years.

Table 18: Excess supply clinker, EU 27, 1998-2006

	1998	1999	2000	2001	2002	2003	2004	2005	2006
Austria	-434	-310	-299	-253	-256	-365	-386	-497	-358
Finland	-82	-137	-140	-97	-6	-66	-27	-17	-102
Frankreich	954	658	307	554	321	459	323	176	-14
Germany	-583	-252	-111	290	-31	522	497	483	448
Greece	715	457	933	627	393	1,038	555	585	443
Ireland	-135	-140	0	0	0	0	-215	-249	-451
Italy	47	-128	-452	-901	-1,694	-2,245	-2,713	-2,822	-2,811
Luxembourg	406	468	441	374	416	332	392	343	342
Netherlands	-765	-895	-840	-830	-770	-495	-750	-750	-608
Portugal	-1,127	-1,093	-1,443	-976	-17	693	833	1,157	1,148
Spain	-587	-2,299	-2,696	-3,920	-4,608	-5,883	-6,259	-7,830	-9,587
Sweden	-9	-61	-1	0	0	0	0	13	0
United Kingdom	250	30	-54	-217	-127	-200	-287	-283	-449
Czech Republic	429	439	341	214	70	-32	-76	-87	-84
Hungary	0	0	7	-70	125	39	92	18	-65
Lithuania	19	2	0	0	0	0	-22	0	0
Slovakia	0	-12	0	-11	0	-7	-27	-51	-15
Slovenia	0	-3	-151	-21	-15	-87	-62	60	9
Bulgaria	564	280	286	398	432	599	369	159	-293
Romania	98	242	627	504	573	360	669	470	610
Total	-240	-2,754	-3,245	-4,335	-5,194	-5,338	-7,094	-9,122	-11,837

Source: UNFCCC, CEMBUREAU; own calculations

10.3 **Clinker factor**

Clinker and cement data can be combined to assess changes in the composition of cement i.e. the content of clinker in cement. This so called clinker factor is defined as domestic clinker consumption divided by domestic cement production. Apart from product quality requirements a reduction in the clinker factor and thus a reduction of specific CO_2 emissions in the cement sector can be motivated by ETS related reasons. Reducing the clinker factor can thus be seen as a technological option for reducing CO_2 emissions.

Table 19 shows the development of the clinker factor in EU 27 countries from 1998 to 2006. From 1998 to 2005 no major changes in the clinker factor are visible but in 2006 the clinker factor of European cement production decreased considerably from 0.8 to 0.77. This reduction in the clinker factor is one of the expected reactions of the cement sector to the EU ETS.

Table 19: Clinker factor of EU 27 countries

	1998	1999	2000	2001	2002	2003	2004	2005	2006
EU 27 countries	0.81	0.80	0.80	0.82	0.82	0.81	0.82	0.80	0.77

Source: UNFCCC, CEMBUREAU; own calculations

Summarizing, the EU 27 is a net exporter of cement and a net importer of clinker. Thus, domestic clinker production is below domestic clinker consumption. There are two options for meeting additional clinker demand in the future: new domestic capacities can be built in Europe or imports from outside the EU 27 have to be increased, which would lead to carbon leakage – the relocation of production capacities to regions with no CO_2 regulation.

After not fluctuating much in the years 1998 to 2005, the clinker factor decreased considerably from 2005 to 2006. This reduction of the clinker content in domestic cement production is one of the CO_2 abatement options that were expected to be caused by the EU ETS.

11 Summary and conclusions

The EU Emissions Trading System (EU ETS), which has been in operation since January 2005, represents in several respects a unique experiment: it is the first international implementation of an innovative policy instrument; it is a test ground for the even bigger emissions trading market starting in 2008 under the Kyoto Protocol; and it challenges research on issues ranging from investigating the inherent incentives that drive the allocation of emission allowances (EUAs) to analyzing the economic impact on countries, sectors and individual installations.

This report contributes to the analyses of the first trading period 2005-2007 with respect to the following aspects: We analyzed the CITL data to get evidence on short and long positions of sectors and countries and the size distribution of installations. After general considerations about competitiveness effects of the EU ETS we presented two case studies on the electricity sector and the cement sector that identified structural developments in these sectors based on available data.

The data analysis regarding the allocated allowances and verified emissions for the first trading period (2005-2007) and the analyses on the electricity and cement sector suggest a number of conclusions. In the first trading period the EU ETS was in an overall long position implying very low or even close to zero carbon prices. As a positive carbon price is one of the main prerequisites for the system to render the intended effects (lower carbon emissions by less carbon intensity and more energy efficiency), this long position posed a serious threat to the effectiveness of the scheme. The average long position for 2005-2007 for the EU total is the balance between a 12.1% long and an 8.7% short position of the total emissions. The majority of single installations were long and only 2,583 out of 9,900 were short. The allocation differences also vary between Member States and sectors. Out of the 24 Member States included in the analysis only 5 countries were short in the range of 1.6% (Slovenia) and 15.9% (UK) but the remaining 19 countries were long up to 44.8% (Lithuania). Looking at sectors, only power and heat was short with 5.4%. Another feature of the EU ETS is the pronounced inequality in the distribution of the size of installations when ranked according to their emissions. The biggest 1.8% of all installations account for half of the emissions. These results suggest that a harmonization of allocation methods and a revision of the size limits of installations subject to the EU ETS is urgently needed in order to avoid distortions caused by different approaches of Member States.

When looking at competitiveness effects of the EU ETS it is important to differentiate between sectors. Some sectors might be affected to a larger extent by the introduction of the EU ETS than others. The exposure to these effects depends respectively on the energy intensity, the price elasticity of demand, competition within the market, the geography of the market and the opportunities to abate carbon. Each sector has to be checked against these criteria. In this report we chose two sectors as case studies - electricity and cement. For these sectors we analyzed possible effects of the EU ETS. The results of available studies are complemented with further empirical analysis for these sectors.

Electricity generation is the sector with the highest share of CO_2 emissions in total regulated emissions in the ETS. Electricity generation in the EU 27 is dominated by fossil fuels, 55% of electricity production is based on fossil fuels and coal is the dominant fossil fuel in electricity production. The data show that only three countries (Belgium, Sweden, UK) have decoupled economic growth from energy demand and none with respect to electricity demand. These two facts – a high carbon intensity in European electricity production and a positive GDP elasticity with respect to electricity consumption - imply that if no further measures are taken we can expect a continued growth of CO_2 emissions from electricity production. Due to the overall long position in the EU ETS and the very low CO_2 prices for most of the period 2005-2007 combined with increasing oil prices the EU ETS did not give an incentive to switch fuels from coal to natural gas in electricity production as could be seen from the analysis of the structure of the electricity sector in Europe. An interesting observation is the fact that, although additional electricity supply in most EU 27 countries is still met mainly by fossil fuels, this takes place to a decreasing extent. This decreasing role of fossil fuels in meeting electricity supply points to a diversification of energy sources in electricity production - a trend that could be enforced by an Emissions Trading Scheme delivering positive carbon prices.

The cement sector – a highly energy intensive industry that to a large extent uses carbon intensive fuels – experiences a stronger increase in consumption than in production. High excess demand in the European cement market will at least in the short to medium run be driving prices up, potentially increasing the cement industry's profits thus offsetting potential negative impacts triggered by the EU ETS. The clinker making process that is responsible for all direct emissions in the cement sector exhibits a higher domestic consumption than domestic production in the EU 27. In addition, some of the countries potentially exposed to carbon leakage like Spain and Italy are the largest net importers of clinker. Whether leakage will be an issue in the next years in these countries depends very much on the future growth rates of their economies and their construction sectors. One sign of potential carbon leakage in the cement sector might be the fact that European cement corporations are already building clinker production capacities in North Africa that could supply Italy and Spain with clinker.

The clinker factor, i.e. the content of clinker in cement, can be one measure for the cement industry to reduce specific CO_2 emissions in cement production. From 1998 to 2005 no major changes in the clinker factor are visible but in 2006 the clinker factor of European cement production decreased considerably – an effect that would have been expected as a consequence of the EU ETS.

From the empirical analysis of the sectors electricity and cement it seems that the EU ETS so far did not generate large incentives to enforce the long-term developments in these sectors. This has to be seen in the context of low or close to zero CO_2 prices in the first trading period and emphasizes the importance of adjustments in the design of the ETS that are envisaged for the post-Kyoto trading periods, predominantly measures that reduce the volatility of carbon prices and administrative costs and increase planning security for the industries included in the cap-and-trade scheme.

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Appendix 1: Country specific evidence in the electricity sector

What follows is a country by country fact sheets including four analyses:

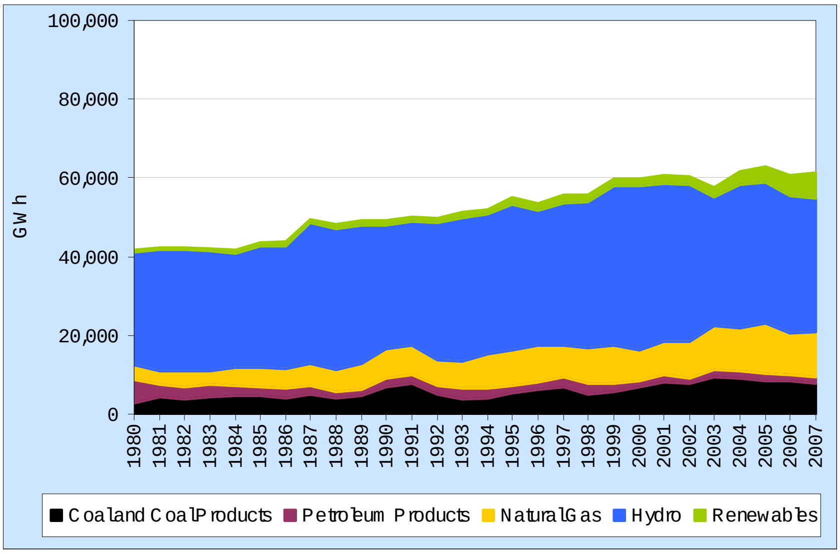
- The composition of total domestic electricity production from 1980/1990-2005/2007
- The GDP elasticities with respect to total final energy consumption and final electricity consumption from 1990-2005/2006. For some countries elasticities could only be computed from 1995, for some countries no elasticities could be computed due to data restrictions.
- The composition of electricity generation from fossils from 1980/1990-2005/2007.
- The composition of total electricity supply from 1980/1990-2005/2007.
- The correlations between the components of total electricity supply in the periods 1980-1993 and 1994-2005/2007.

Austria

The share of hydro in electricity production in the year 2007 was high (55%). The remaining electricity production comes from fossils and renewables.

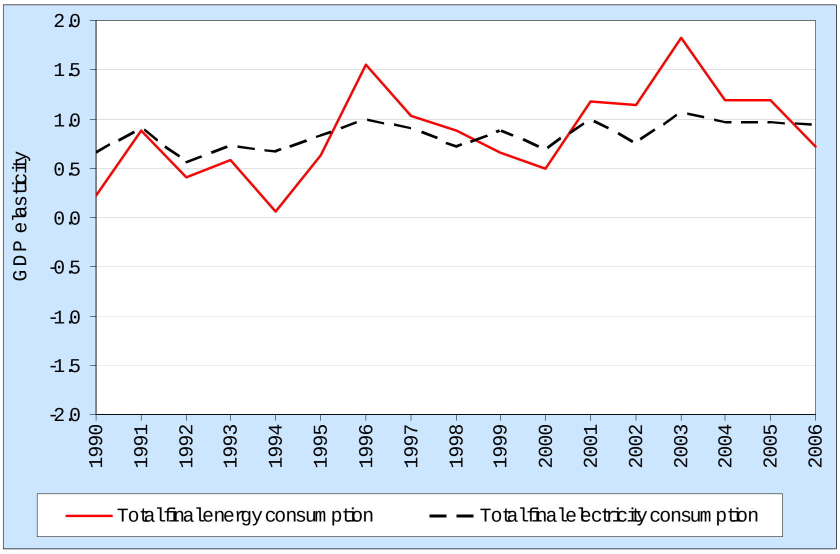
The GDP elasticities both with respect to total energy consumption and total electricity consumption show a slightly increasing trend since 1990.

Figure 11: Structure of total electricity output, Austria



Source: IEA; own calculations

Figure 12: GDP elasticities final energy and electricity consumption, Austria



Source: IEA; own calculations

Natural gas showed an increasing importance over the last decades and was the main fossil fuel used in electricity production with a share of 56% in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply are the decreasing importance of fossils in meeting additional electricity supply– mirrored by an increasing importance of imports and the clear substitutional relationships between hydro and the two components fossils and net imports.

Table 20: Shares in electricity production from fossils, Austria

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	23%	40%	42%	32%	42%	37%	40%	37%
Petroleum products	46%	18%	11%	13%	10%	7%	8%	7%
Natural gas	30%	42%	46%	55%	48%	56%	52%	56%

Source: IEA; own calculations

Table 21: Shares in electricity supply, Austria

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	33%	28%	34%	31%	28%	35%	31%	31%
Nuclear	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	76%	74%	65%	70%	72%	55%	52%	50%
Renewables	1%	2%	2%	4%	3%	6%	8%	9%
Net imports	-11%	-4%	-1%	-5%	-2%	4%	10%	10%

Table 22: Correlations components of electricity supply, 1980-1993 and 1994-2007, Austria

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.75	-	-0.43	-0.19	0.27
	1994-2007	1.00	0.36	-	-0.33	0.06	0.46
Fossils	1980-1993		1.00	-	-0.59	-0.29	0.11
	1994-2007		1.00	-	-0.62	-0.27	0.21
Nuclear	1980-1993			-	-	-	-
	1994-2007			-	-	-	-
Hydro	1980-1993				1.00	-0.43	-0.83
	1994-2007				1.00	-0.03	-0.85
Renewables	1980-1993					1.00	0.66
	1994-2007					1.00	0.03
Net imports	1980-1993						1.00
	1994-2007						1.00

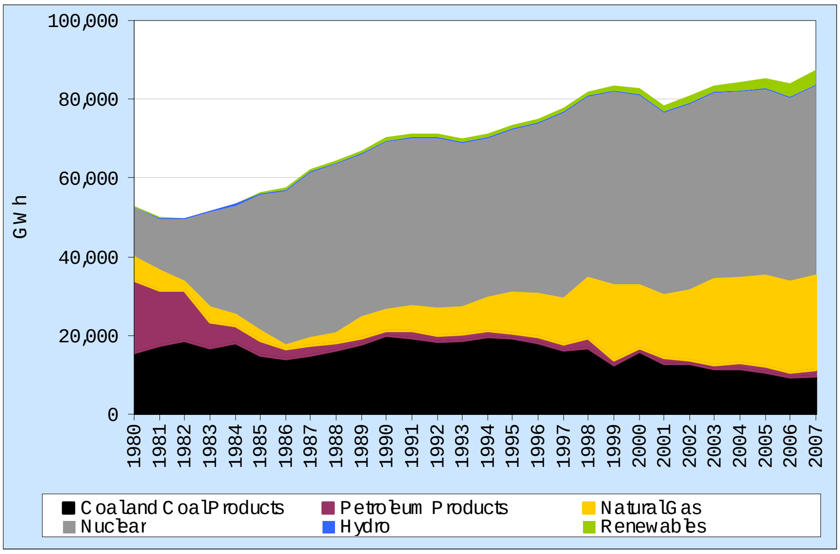
Source: IEA; own calculations

Belgium

The share of nuclear in electricity production in the year 2007 was high (55%). The remaining electricity production comes mainly from fossils and to a limited extent from hydro and renewables.

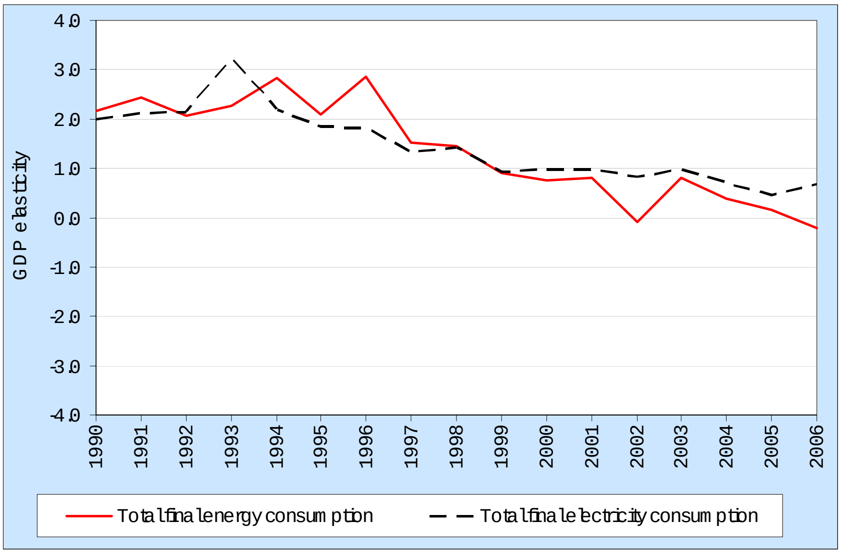
The GDP elasticities both with respect to total energy consumption and total electricity consumption show a significantly decreasing trend since 1990.

Figure 13: Structure of total electricity output, Belgium



Source: IEA; own calculations

Figure 14: GDP elasticities final energy and electricity consumption, Belgium



Source: IEA; own calculations

Natural gas showed a strongly increasing development over the last decades and is the main fossil fuel used in electricity production with a share of 68% in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply are the decreasing importance of renewables in meeting additional electricity supply and the substitutional relationships between fossils and nuclear and fossils and net imports.

Table 23: Shares in electricity production from fossils, Belgium

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	39%	71%	75%	63%	49%	30%	27%	27%
Petroleum products	46%	18%	5%	4%	2%	5%	4%	4%
Natural gas	15%	11%	20%	33%	49%	65%	68%	68%

Source: IEA; own calculations

Table 24: Shares in electricity supply, Belgium

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	79%	37%	40%	40%	38%	38%	36%	37%
Nuclear	25%	62%	64%	53%	55%	52%	49%	51%
Hydro	1%	1%	0%	0%	1%	0%	0%	0%
Renewables	1%	1%	1%	1%	2%	3%	4%	4%
Net imports	-5%	0%	-6%	5%	5%	7%	11%	7%

Table 25: Correlations components of electricity supply, 1980-1993 and 1994-2007, Belgium

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.37	0.07	-0.12	0.56	-0.16
	1994-2007	1.00	0.23	-0.33	0.61	-0.04	0.45
Fossils	1980-1993		1.00	-0.78	-0.19	0.23	-0.16
	1994-2007		1.00	-0.28	0.09	-0.31	-0.53
Nuclear	1980-1993			1.00	0.07	0.00	-0.39
	1994-2007			1.00	-0.33	-0.37	-0.56
Hydro	1980-1993				1.00	0.03	0.10
	1994-2007				1.00	0.21	0.36
Renewables	1980-1993					1.00	-0.10
	1994-2007					1.00	0.38
Net imports	1980-1993						1.00
	1994-2007						1.00

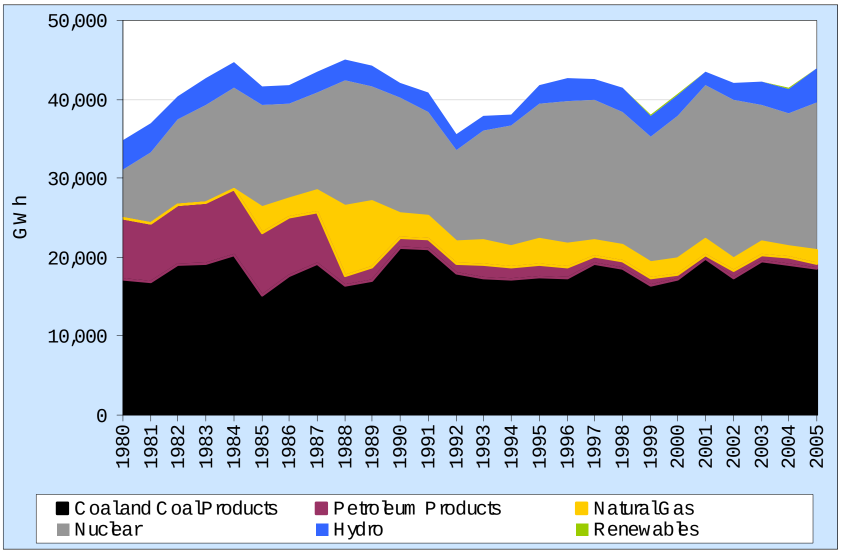
Source: IEA; own calculations

Bulgaria

Nuclear and coal are the main energy sources in electricity production with shares of 42% each in the year 2005. The remaining electricity production comes from other fossils, hydro and to a very limited extent renewables.

It was not possible to compute GDP elasticities due to data restrictions.

Figure 15: Structure of total electricity output, Bulgaria



Source: IEA; own calculations

As stated above coal is the main fossil fuel in electricity production and showed even an increasing trend since 1980. Natural gas in comparison to that decreased its share in electricity production.

The most interesting features when looking at the correlation coefficients of total electricity supply are the decreasing importance of fossils and nuclear in meeting additional electricity supply and the substitutional relationships between nuclear and net imports.

Table 26: Shares in electricity production from fossils, Bulgaria

	1980	1985	1990	1995	2000	2005
Coal and coal products	69%	58%	83%	79%	87%	89%
Petroleum products	31%	30%	5%	6%	3%	3%
Natural gas	0%	12%	12%	14%	10%	8%

Source: IEA; own calculations

Table 27: Shares in electricity supply, Bulgaria

	1980	1985	1990	1995	2000	2005
Fossils	65%	57%	56%	53%	55%	58%
Nuclear	16%	29%	32%	41%	50%	51%
Hydro	10%	5%	4%	6%	7%	12%
Renewables	0%	0%	0%	0%	0%	0%
Net imports	10%	9%	8%	0%	-13%	-21%

Table 28: Correlations components of electricity supply, 1980-1993 and 1994-2005, Bulgaria

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.70	0.58	0.28	-	0.00
	1994-2005	1.00	0.42	0.40	0.45	-0.40	0.13
Fossils	1980-1993		1.00	-0.03	0.42	-	-0.26
	1994-2005		1.00	-0.05	-0.07	-0.76	-0.43
Nuclear	1980-1993			1.00	-0.10	-	-0.24
	1994-2005			1.00	-0.08	-0.40	-0.50
Hydro	1980-1993				1.00	-	-0.36
	1994-2005				1.00	0.06	0.25
Renewables	1980-1993					-	-
	1994-2005					1.00	0.68
Net imports	1980-1993						1.00
	1994-2005						1.00

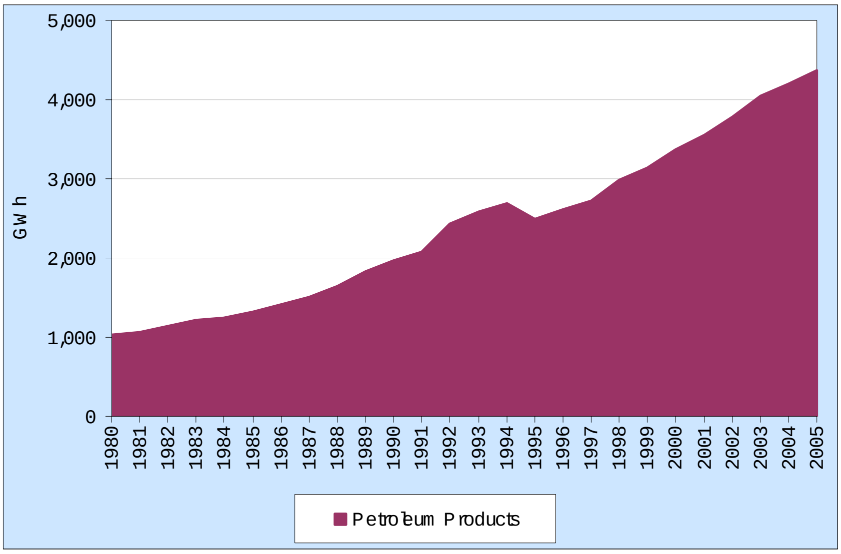
Source: IEA; own calculations

Cyprus

Only petroleum products are used in electricity production.

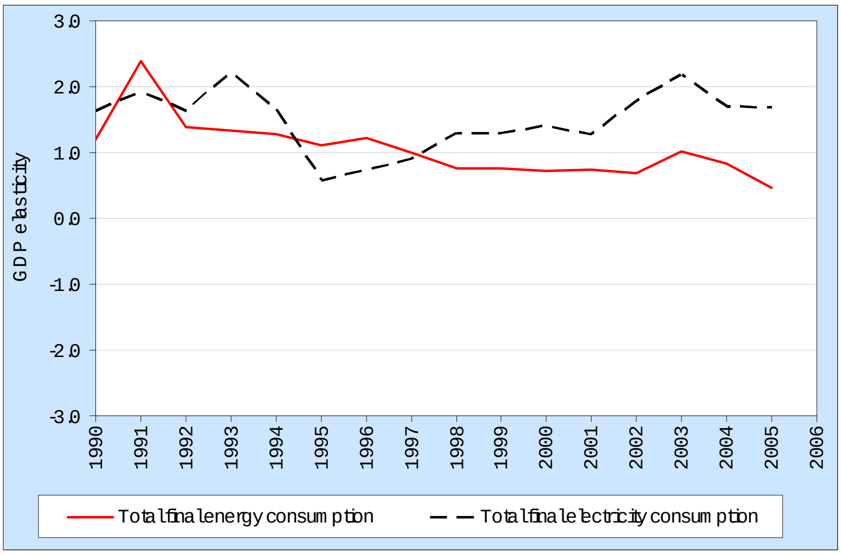
The GDP elasticity with respect to total energy consumption showed a slightly decreasing trend since 1990, the GDP elasticity with respect to total electricity consumption an increasing trend.

Figure 16: Structure of total electricity output, Cyprus



Source: IEA; own calculations

Figure 17: GDP elasticities final energy and electricity consumption, Cyprus



Source: IEA; own calculations

Only petroleum products are used in electricity production.

As fossils are the only energy source in electricity production the correlation coefficient between supply and fossils is one.

Table 29: Shares in electricity production from fossils, Cyprus

	1980	1985	1990	1995	2000	2005
Coal and coal products	0%	0%	0%	0%	0%	0%
Petroleum products	100%	100%	100%	100%	100%	100%
Natural gas	0%	0%	0%	0%	0%	0%

Source: IEA; own calculations

Table 30: Shares in electricity supply, Cyprus

	1980	1985	1990	1995	2000	2005
Fossils	100%	100%	100%	100%	100%	100%
Nuclear	0%	0%	0%	0%	0%	0%
Hydro	0%	0%	0%	0%	0%	0%
Renewables	0%	0%	0%	0%	0%	0%
Net imports	0%	0%	0%	0%	0%	0%

Table 31: Correlations components of electricity supply, 1980-1993 and 1994-2005, Cyprus

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	1.00	-	-	-	-
	1994-2005	1.00	1.00	-	-	-	-
Fossils	1980-1993		1.00	-	-	-	-
	1994-2005		1.00	-	-	-	-
Nuclear	1980-1993			-	-	-	-
	1994-2005			-	-	-	-
Hydro	1980-1993				-	-	-
	1994-2005				-	-	-
Renewables	1980-1993					-	-
	1994-2005					-	-
Net imports	1980-1993						-
	1994-2005						-

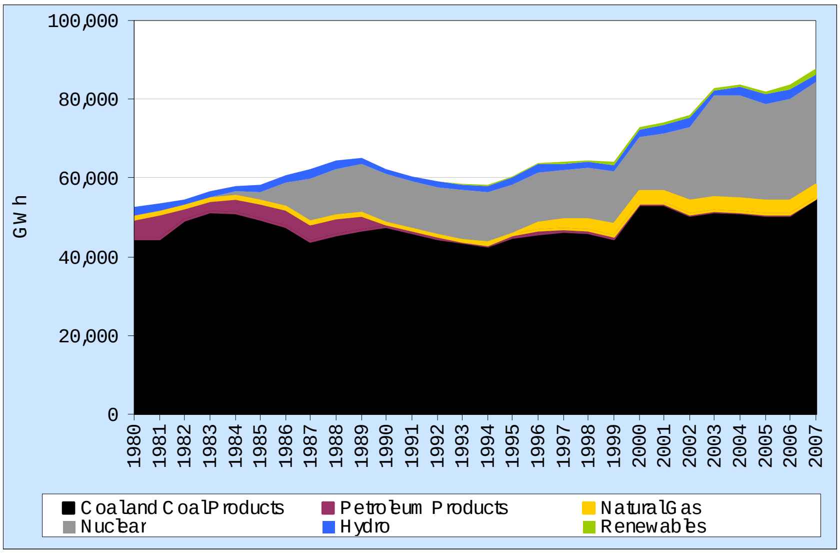
Source: IEA; own calculations

Czech Republic

The share of nuclear and coal in electricity production in the year 2007 were high (30% and 62%). The remaining electricity production comes from natural gas and to a limited extent from hydro and renewables.

It was not possible to compute GDP elasticities due to data restrictions.

Figure 18: Structure of total electricity output, Czech Republic



Source: IEA; own calculations

Coal is the dominant source from fossil fuels and even increased its share in electricity production since 1980. Natural gas showed a strongly increasing development over the last decades but has still only a share of 5% in electricity production.

The most interesting features when looking at the correlation coefficients of total electricity supply are the changing correlation between nuclear and hydro over the years and the substitutional relationships between fossils and net imports.

Table 32: Shares in electricity production from fossils, Czech Republic

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	89%	92%	98%	98%	94%	93%	93%	94%
Petroleum products	10%	7%	1%	1%	1%	1%	0%	0%
Natural gas	1%	1%	1%	1%	6%	6%	6%	5%

Source: IEA; own calculations

Table 33: Shares in electricity supply, Czech Republic

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	98%	94%	79%	75%	90%	78%	76%	81%
Nuclear	0%	4%	20%	20%	22%	36%	37%	37%
Hydro	5%	3%	2%	3%	3%	3%	4%	3%
Renewables	0%	0%	0%	1%	1%	1%	1%	2%
Net imports	-3%	-1%	-1%	1%	-16%	-18%	-18%	-23%

Table 34: Correlations components of electricity supply, 1980-1993 and 1994-2007, Czech Republic

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.27	0.47	0.16	0.00	0.37
	1994-2007	1.00	0.41	0.06	0.10	-0.42	0.05
Fossils	1980-1993		1.00	-0.50	-0.55	-0.12	-0.32
	1994-2007		1.00	-0.19	-0.24	-0.17	-0.65
Nuclear	1980-1993			1.00	0.55	-0.10	0.00
	1994-2007			1.00	-0.54	-0.47	-0.48
Hydro	1980-1993				1.00	0.03	0.07
	1994-2007				1.00	0.17	0.58
Renewables	1980-1993					1.00	0.24
	1994-2007					1.00	0.26
Net imports	1980-1993						1.00
	1994-2007						1.00

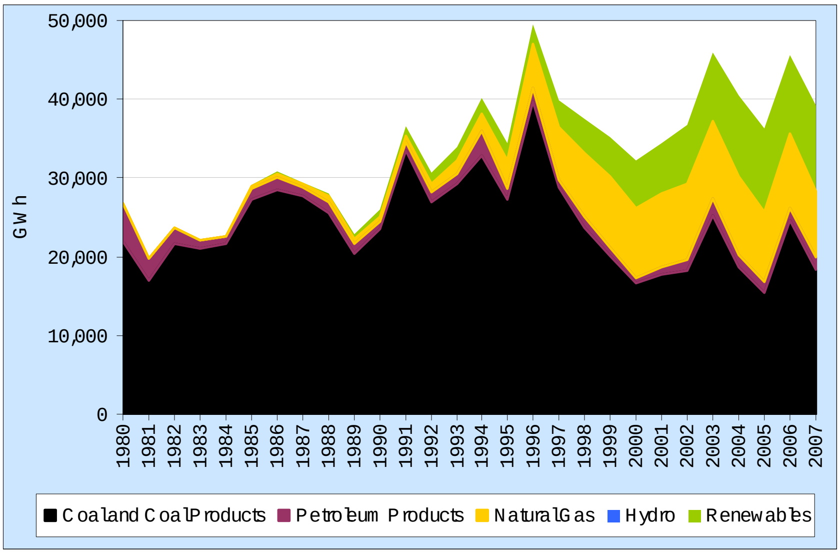
Source: IEA; own calculations

Denmark

The share of coal in electricity production in the year 2007 was high (47%). The remaining electricity production mainly comes from natural gas and renewables.

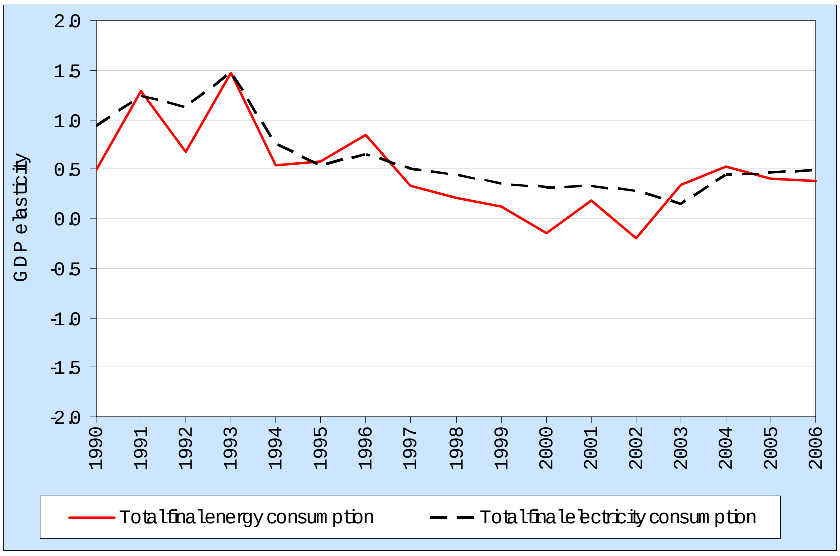
The GDP elasticities both with respect to total energy consumption and total electricity consumption showed a decreasing trend from 1990 until 2002 then increased slightly and stabilized since then at an around 0,5.

Figure 19: Structure of total electricity output, Denmark



Source: IEA; own calculations

Figure 20: GDP elasticities final energy and electricity consumption, Denmark



Source: IEA; own calculations

Even though the share of coal decreased significantly since 1980 it is still the dominant source from fossil fuels. Natural gas showed a strong increase over the last decades and had share of 30% in electricity production in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply is the highly positive correlation between supply and fossils and the strongly substitutional relationship between supply and net imports and fossils and net imports.

Table 35: Shares in electricity production from fossils, Denmark

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	82%	94%	94%	84%	64%	60%	69%	65%
Petroleum products	18%	5%	3%	4%	3%	5%	5%	5%
Natural gas	0%	1%	3%	11%	34%	34%	26%	30%

Source: IEA; own calculations

Table 36: Shares in electricity supply, Denmark

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	105%	98%	76%	90%	71%	68%	92%	74%
Nuclear	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	0%	0%	0%	0%	0%	0%	0%	0%
Renewables	0%	0%	2%	6%	17%	28%	26%	28%
Net imports	-5%	2%	21%	-2%	2%	4%	-18%	-2%

Table 37: Correlations components of electricity supply, 1980-1993 and 1994-2007, Denmark

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.73	-	-0.22	-0.13	-0.65
	1994-2007	1.00	0.84	-	-0.63	-0.48	-0.85
Fossils	1980-1993		1.00	-	-0.02	0.02	-0.99
	1994-2007		1.00	-	-0.51	-0.45	-1.00
Nuclear	1980-1993			-	-	-	-
	1994-2007			-	-	-	-
Hydro	1980-1993				1.00	-0.02	-0.01
	1994-2007				1.00	0.11	0.52
Renewables	1980-1993					1.00	-0.06
	1994-2007					1.00	0.45
Net imports	1980-1993						1.00
	1994-2007						1.00

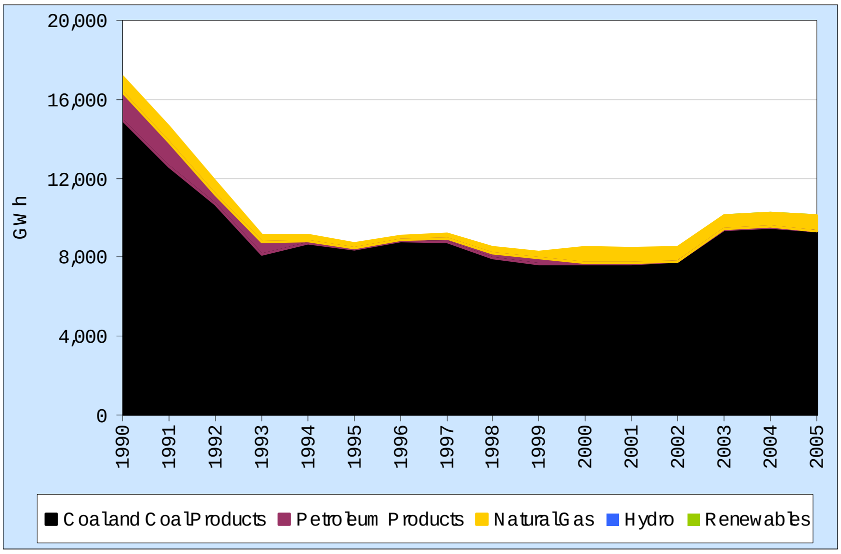
Source: IEA; own calculations

Estonia

The share of coal in electricity production in the year 2005 was very high (91%). The remaining electricity production comes from natural gas and petroleum products and very small amounts of hydro and renewables.

It was not possible to compute GDP elasticities due to data restrictions.

Figure 21: Structure of total electricity output, Estonia



Source: IEA; own calculations

Coal was the dominant fuel in electricity production in the past and had a share of 92% in electricity production from fossils in 2005. Natural gas had a share of 8%.

The most interesting features when looking at the correlation coefficients of total electricity supply is the positive correlation between supply and fossils and the strong substitutional relationship between fossils and net imports.

Table 38: Shares in electricity production from fossils, Estonia

	1980	1985	1990	1995	2000	2005
Coal and coal products	-	-	87%	96%	90%	92%
Petroleum products	-	-	8%	1%	1%	0%
Natural gas	-	-	5%	2%	9%	8%

Source: IEA; own calculations

Table 39: Shares in electricity supply, Estonia

	1980	1985	1990	1995	2000	2005
Fossils	-	-	169%	109%	112%	117%
Nuclear	-	-	0%	0%	0%	0%
Hydro	-	-	0%	0%	0%	0%
Renewables	-	-	0%	0%	0%	1%
Net imports	-	-	-69%	-10%	-12%	-19%

Table 40: Correlations components of electricity supply, 1980-1993 and 1994-2005, Estonia

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	-	-	-	-	-	-
	1994-2005	1.00	0.58	-	0.52	-0.04	-0.15
Fossils	1980-1993		-	-	-	-	-
	1994-2005		1.00	-	0.56	-0.16	-0.89
Nuclear	1980-1993			-	-	-	-
	1994-2005			-	-	-	-
Hydro	1980-1993				-	-	-
	1994-2005				1.00	-0.10	-0.39
Renewables	1980-1993					-	-
	1994-2005					1.00	0.14
Net imports	1980-1993						-
	1994-2005						1.00

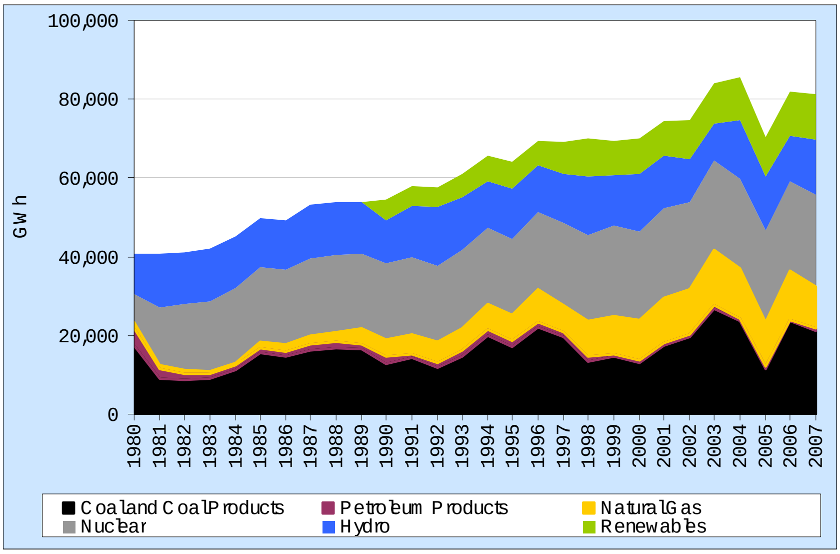
Source: IEA; own calculations

Finland

The allocation of energy sources in electricity production except petroleum products is very balanced with coal (26%) and nuclear (29%) showing the highest shares.

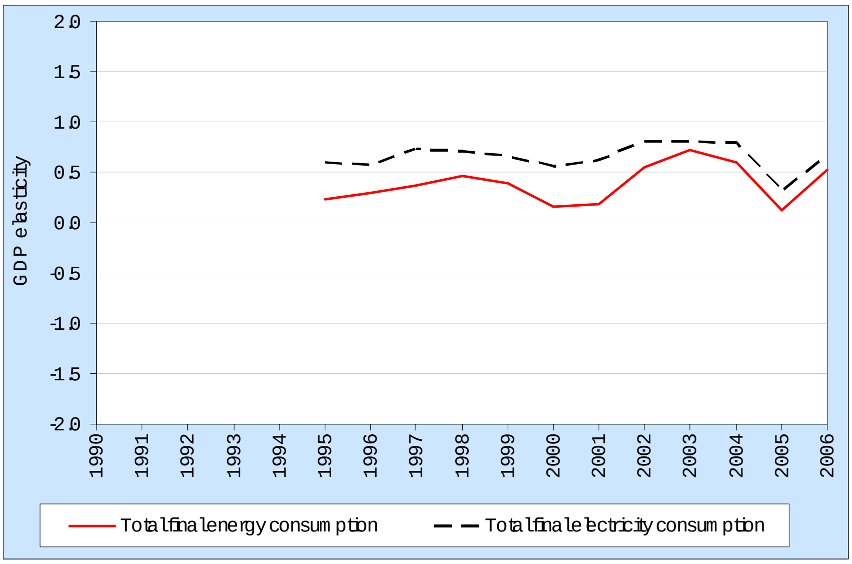
The GDP elasticities both with respect to total energy consumption and total electricity consumption are quite stable since 1995 between zero and one.

Figure 22: Structure of total electricity output, Finland



Source: IEA; own calculations

Figure 23: GDP elasticities final energy and electricity consumption, Finland



Source: IEA; own calculations

Even though the share of coal decreased since 1980 it is still the dominant source from fossil fuels and increased again in 2006 and 2007. Natural gas showed a strong increase over the last decades and had share of 33% in electricity production in 2007 with strong decreases in 2006 and 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply is the positive correlation between supply and fossils but also between supply and renewables and the substitutional relationships between fossils and nuclear, fossils and hydro and fossils and net imports.

Table 41: Shares in electricity production from fossils, Finland

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	74%	85%	67%	68%	55%	50%	65%	66%
Petroleum products	19%	7%	9%	6%	3%	2%	1%	1%
Natural gas	7%	8%	24%	26%	42%	48%	34%	33%

Source: IEA; own calculations

Table 42: Shares in electricity supply, Finland

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	56%	34%	29%	35%	29%	27%	39%	34%
Nuclear	17%	35%	30%	27%	27%	27%	24%	25%
Hydro	24%	23%	17%	18%	18%	16%	12%	15%
Renewables	0%	0%	8%	9%	11%	11%	12%	12%
Net imports	3%	9%	16%	12%	15%	19%	12%	13%

Table 43: Correlations components of electricity supply, 1980-1993 and 1994-2007, Finland

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.46	-0.15	-0.32	0.10	0.19
	1994-2007	1.00	0.69	-0.16	-0.18	0.72	-0.62
Fossils	1980-1993		1.00	-0.79	-0.55	-0.15	-0.34
	1994-2007		1.00	-0.35	-0.51	0.12	-0.90
Nuclear	1980-1993			1.00	0.53	-0.12	0.05
	1994-2007			1.00	0.08	-0.04	0.30
Hydro	1980-1993				1.00	-0.51	-0.21
	1994-2007				1.00	0.15	0.13
Renewables	1980-1993					1.00	0.22
	1994-2007					1.00	-0.13
Net imports	1980-1993						1.00
	1994-2007						1.00

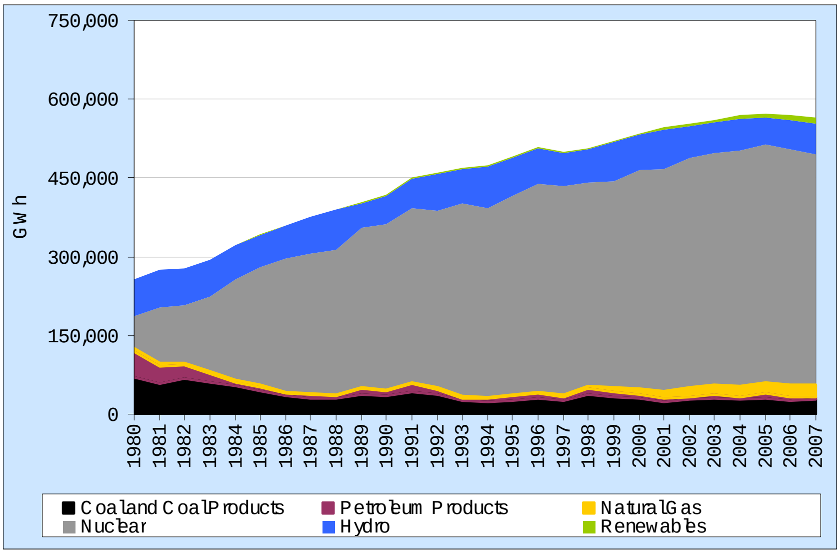
Source: IEA; own calculations

France

The share of nuclear in electricity production in the year 2007 was very high (78%). The remaining electricity production mainly comes from hydro and to a limited extent from fossils.

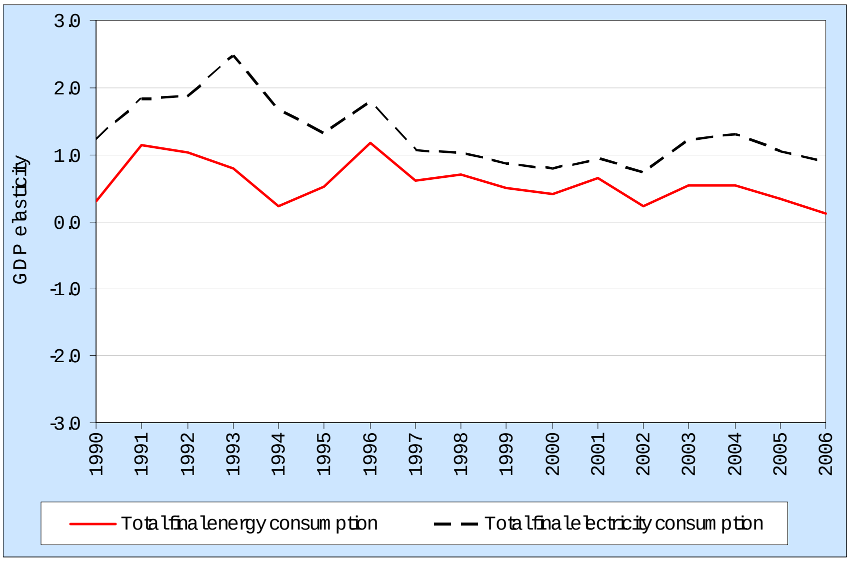
The GDP elasticities with respect to total energy consumption and total electricity consumption showed a decreasing trend since 1996. The elasticity with respect to total energy consumption almost reached zero - a decoupling of economic growth and energy consumption.

Figure 24: Structure of total electricity output, France



Source: IEA; own calculations

Figure 25: GDP elasticities final energy and electricity consumption, France



Source: IEA; own calculations

Coal and natural gas are the dominant sources from fossils with a decreasing trend for coal and a strongly increasing trend for natural gas. The share of petroleum products decreased significantly over the last decades.

The most interesting features when looking at the correlation coefficients of total electricity supply are the substitutional relationships between nuclear and the other components.

Table 44: Shares in electricity production from fossils, France

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	56%	82%	75%	70%	62%	50%	47%	49%
Petroleum products	38%	13%	18%	20%	15%	13%	13%	11%
Natural gas	6%	6%	6%	10%	23%	37%	40%	40%

Source: IEA; own calculations

Table 45: Shares in electricity supply, France

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	48%	17%	13%	9%	11%	12%	11%	11%
Nuclear	24%	70%	84%	90%	89%	88%	89%	87%
Hydro	27%	19%	14%	17%	14%	10%	11%	11%
Renewables	0%	0%	1%	1%	1%	1%	2%	2%
Net imports	1%	-7%	-12%	-17%	-15%	-12%	-13%	-11%

Table 46: Correlations components of electricity supply, 1980-1993 and 1994-2007, France

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.22	0.22	0.10	0.06	0.03
	1994-2007	1.00	0.46	0.36	-0.06	-0.45	0.35
Fossils	1980-1993		1.00	-0.55	-0.34	0.53	0.23
	1994-2007		1.00	0.02	-0.52	-0.23	0.28
Nuclear	1980-1993			1.00	-0.40	-0.16	-0.53
	1994-2007			1.00	-0.56	-0.31	-0.56
Hydro	1980-1993				1.00	-0.39	0.10
	1994-2007				1.00	0.02	0.12
Renewables	1980-1993					1.00	0.03
	1994-2007					1.00	0.07
Net imports	1980-1993						1.00
	1994-2007						1.00

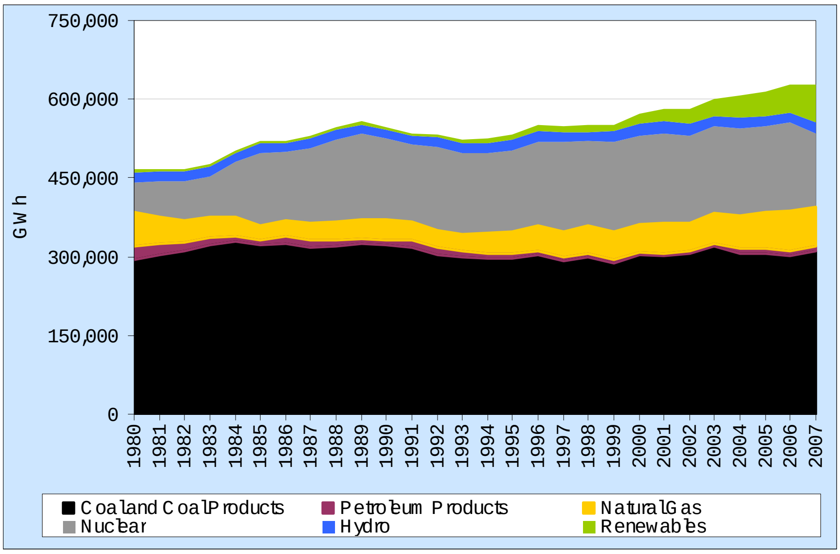
Source: IEA; own calculations

Germany

The share of coal in electricity production in the year 2007 was high (49%). The remaining electricity production mainly comes from nuclear but also natural gas and to an increasing extent from renewables.

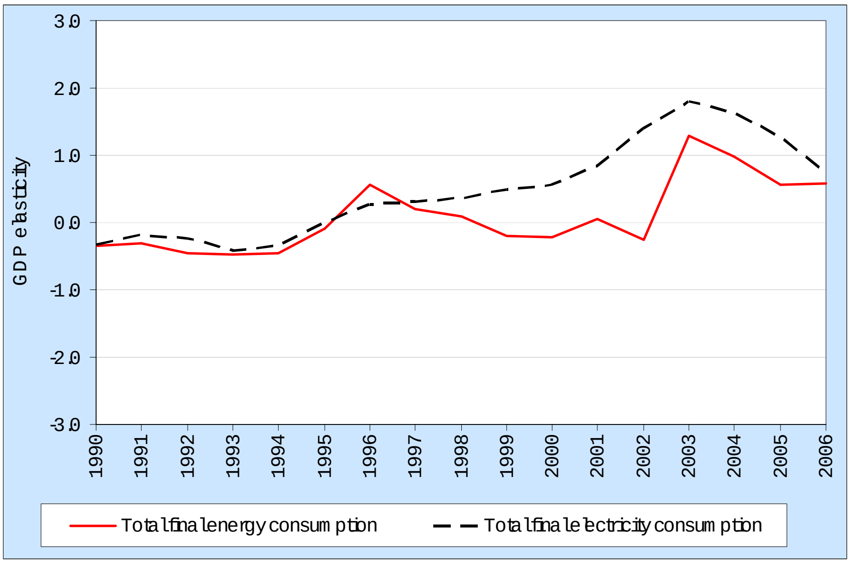
The GDP elasticities both with respect to total energy consumption and total electricity consumption showed a slightly increasing trend from 1990 until 2003 and are decreasing trend since then.

Figure 26: Structure of total electricity output, Germany



Source: IEA; own calculations

Figure 27: GDP elasticities final energy and electricity consumption, Germany



Source: IEA; own calculations

The shares of coal and natural gas in electricity production showed no clear development from 1980 until 2007. Coal was the dominant fossil source in electricity production with a share of 79% in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply is the decreasing positive correlation between supply and nuclear and the increasing substitutional relationship between nuclear and renewables.

Table 47: Shares in electricity production from fossils, Germany

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	76%	90%	86%	85%	84%	79%	78%	79%
Petroleum products	7%	3%	3%	3%	1%	3%	2%	2%
Natural gas	17%	8%	11%	12%	15%	18%	20%	19%

Source: IEA; own calculations

Table 48: Shares in electricity supply, Germany

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	82%	69%	68%	65%	63%	63%	63%	64%
Nuclear	12%	27%	28%	28%	29%	27%	27%	23%
Hydro	4%	3%	3%	4%	4%	3%	3%	3%
Renewables	1%	1%	1%	2%	3%	7%	9%	12%
Net imports	2%	0%	0%	1%	1%	-1%	-3%	-3%

Table 49: Correlations components of electricity supply, 1980-1993 and 1994-2007, Germany

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.27	0.70	-0.01	-0.35	-0.20
	1994-2007	1.00	0.43	0.14	0.39	-0.13	0.09
Fossils	1980-1993		1.00	-0.42	-0.32	-0.22	0.15
	1994-2007		1.00	-0.39	-0.16	0.22	-0.48
Nuclear	1980-1993			1.00	0.04	-0.13	-0.58
	1994-2007			1.00	-0.09	-0.76	-0.22
Hydro	1980-1993				1.00	-0.07	0.14
	1994-2007				1.00	0.03	0.34
Renewables	1980-1993					1.00	-0.13
	1994-2007					1.00	-0.09
Net imports	1980-1993						1.00
	1994-2007						1.00

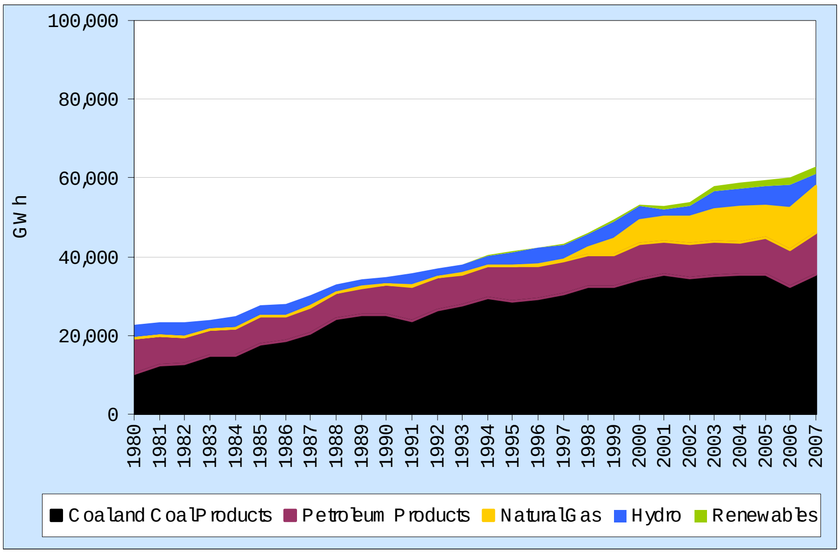
Source: IEA; own calculations

Greece

The share of coal in electricity production in the year 2007 was high (56%). The remaining electricity production mainly comes natural gas and petroleum products and to a limited extent from hydro and renewables.

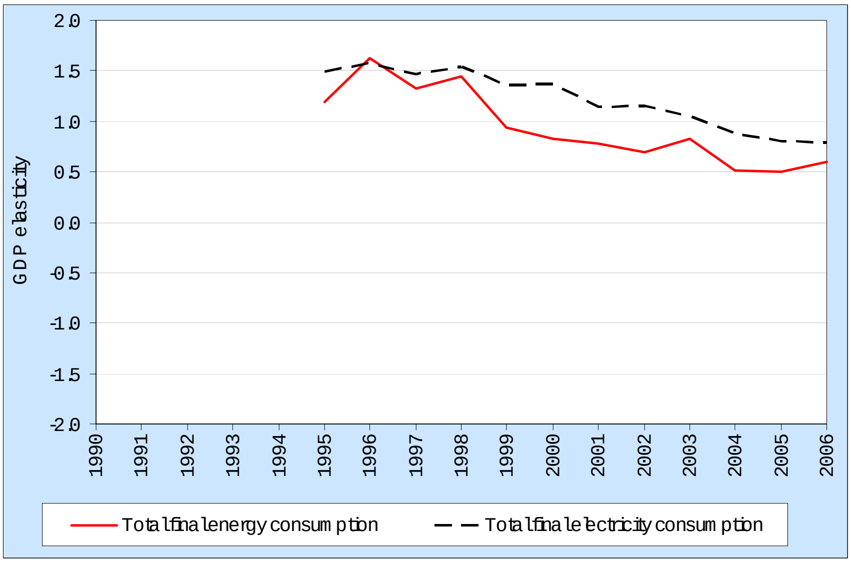
The GDP elasticities both with respect to total energy consumption and total electricity consumption showed a slightly decreasing trend since 1995.

Figure 28: Structure of total electricity output, Greece



Source: IEA; own calculations

Figure 29: GDP elasticities final energy and electricity consumption, Greece



Source: IEA; own calculations

The share of coal in electricity production increased from 1980 to 1995 and then started decreasing. However it is still the main energy source for electricity production. Natural gas showed a strongly increasing trend, whereas petroleum products decreased its share from 47% in 1980 to 18% in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply is the continuously high positive correlation between supply and fossils and the substitutional relationship between fossils and hydro.

Table 50: Shares in electricity production from fossils, Greece

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	53%	71%	76%	76%	70%	67%	61%	61%
Petroleum products	47%	29%	23%	24%	18%	17%	18%	18%
Natural gas	0%	0%	0%	0%	12%	15%	20%	20%

Source: IEA; own calculations

Table 51: Shares in electricity supply, Greece

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	83%	88%	93%	89%	92%	84%	82%	85%
Nuclear	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	15%	10%	5%	8%	7%	8%	9%	4%
Renewables	0%	0%	0%	0%	1%	2%	3%	3%
Net imports	3%	3%	2%	2%	0%	6%	7%	8%

Table 52: Correlations components of electricity supply, 1980-1993 and 1994-2007, Greece

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.70	-	-0.43	0.12	0.02
	1994-2007	1.00	0.89	-	-0.56	0.42	0.00
Fossils	1980-1993		1.00	-	-0.68	0.24	-0.54
	1994-2007		1.00	-	-0.64	0.14	-0.15
Nuclear	1980-1993			-	-	-	-
	1994-2007			-	-	-	-
Hydro	1980-1993				1.00	-0.37	-0.06
	1994-2007				1.00	-0.06	-0.61
Renewables	1980-1993					1.00	-0.04
	1994-2007					1.00	0.08
Net imports	1980-1993						1.00
	1994-2007						1.00

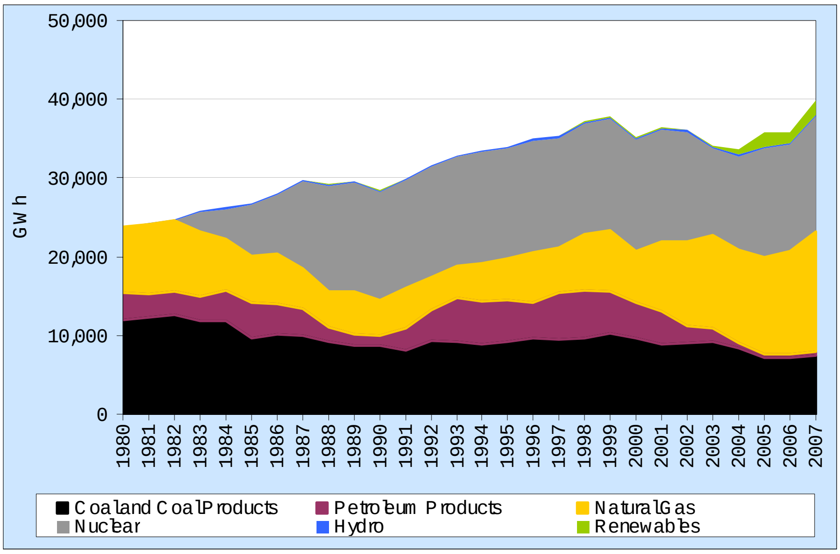
Source: IEA; own calculations

Hungary

Nuclear and natural gas had the highest shares in electricity production in the year 2007 (37% and 38%). The remaining electricity production mainly comes from coal and to a limited extent renewables.

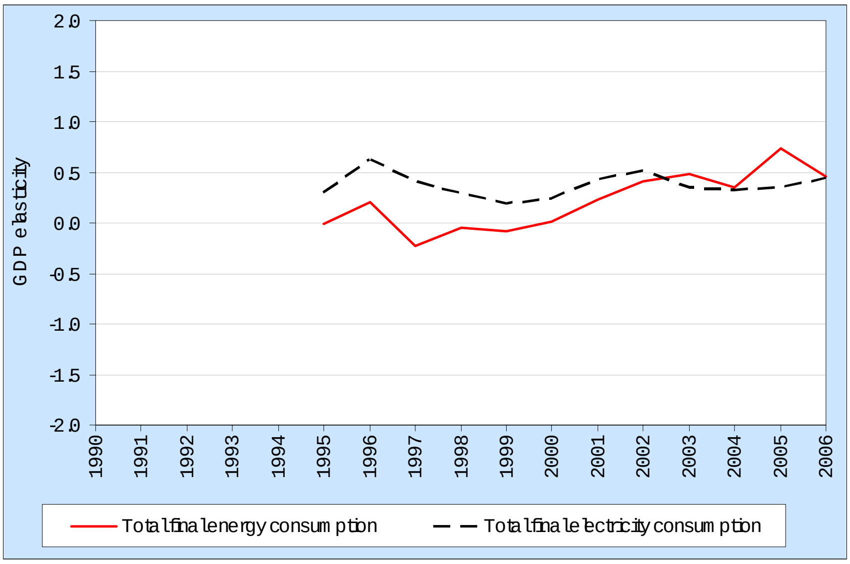
The GDP elasticities both with respect to total energy consumption and total electricity consumption were close to zero in 1995 but showed a slightly increasing trend since then.

Figure 30: Structure of total electricity output, Hungary



Source: IEA; own calculations

Figure 31: GDP elasticities final energy and electricity consumption, Hungary



Source: IEA; own calculations

The share of gas in electricity production almost doubled since 1980. Coal showed a decreasing trend and petroleum products lost their importance in electricity production.

The most interesting features when looking at the correlation coefficients of total electricity supply are the changing correlations between supply and fossils, between supply and nuclear and between supply and net imports. There is a clearly negative correlation between fossils and net imports.

Table 53: Shares in electricity production from fossils, Hungary

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	51%	48%	60%	47%	47%	36%	34%	32%
Petroleum products	14%	23%	9%	27%	21%	2%	3%	2%
Natural gas	35%	30%	31%	26%	32%	62%	63%	65%

Source: IEA; own calculations

Table 54: Shares in electricity supply, Hungary

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	76%	53%	37%	54%	54%	48%	48%	53%
Nuclear	0%	17%	35%	39%	37%	33%	31%	33%
Hydro	0%	0%	0%	0%	0%	0%	0%	0%
Renewables	0%	0%	0%	0%	0%	4%	3%	4%
Net imports	24%	29%	28%	7%	9%	15%	17%	9%

Table 55: Correlations components of electricity supply, 1980-1993 and 1994-2007, Hungary

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	-0.49	0.50	0.18	-0.27	0.84
	1994-2007	1.00	0.60	-0.05	0.13	-0.10	-0.22
Fossils	1980-1993		1.00	-0.79	0.04	0.04	-0.65
	1994-2007		1.00	-0.19	-0.19	-0.29	-0.55
Nuclear	1980-1993			1.00	-0.08	-0.06	0.31
	1994-2007			1.00	0.36	0.56	-0.68
Hydro	1980-1993				1.00	0.09	0.15
	1994-2007				1.00	0.18	-0.10
Renewables	1980-1993					1.00	-0.22
	1994-2007					1.00	-0.38
Net imports	1980-1993						1.00
	1994-2007						1.00

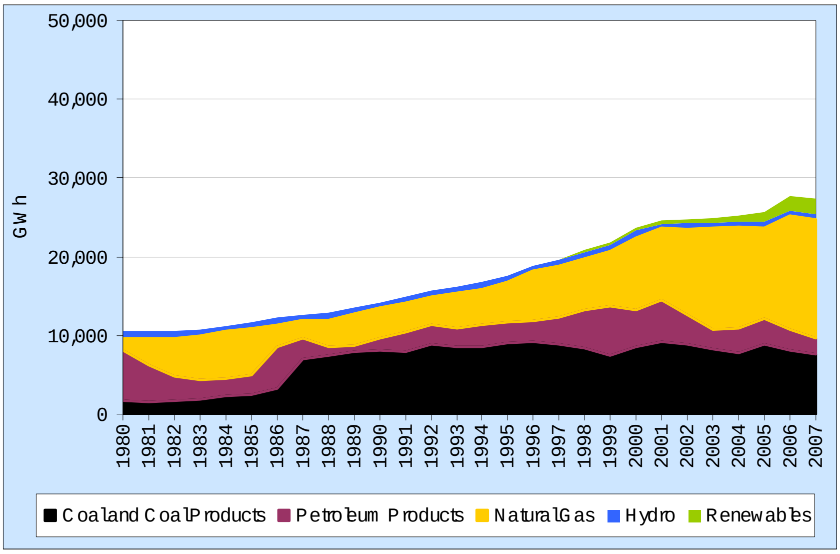
Source: IEA; own calculations

Ireland

The share of natural gas in electricity production was high in 2007 (55%). The remaining electricity production mainly comes from coal and petroleum products (35%) and to a limited extent renewables.

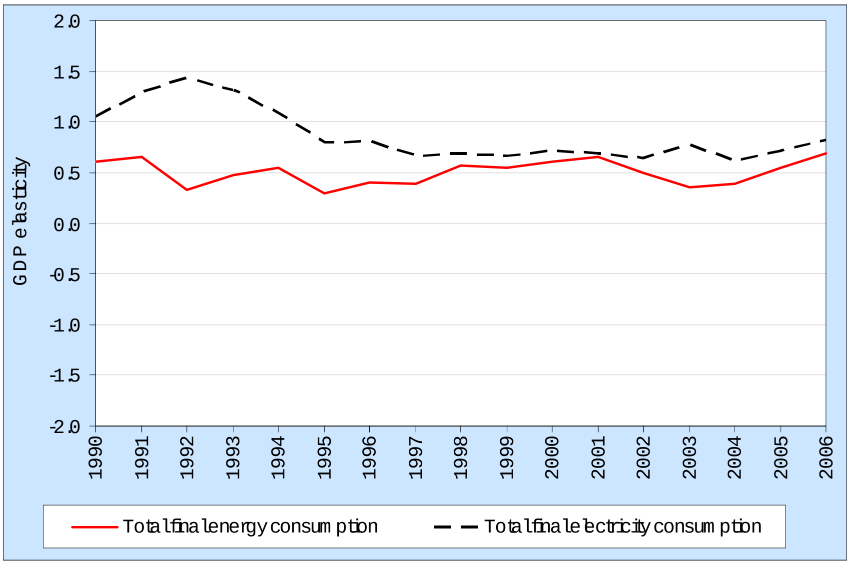
The GDP elasticities both with respect to total energy consumption and total electricity consumption were almost constant from 1990 to 2006.

Figure 32: Structure of total electricity output, Ireland



Source: IEA; own calculations

Figure 33: GDP elasticities final energy and electricity consumption, Ireland



Source: IEA; own calculations

The share of natural gas in electricity production increased considerably from 1980 to 2007. The share of coal increased until 1990 and then decreased. Petroleum products were the dominant fossil energy source in electricity production in 1980 (66%) but decreased its share to 8% in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply is the highly positive correlation between supply and fossils.

Table 56: Shares in electricity production from fossils, Ireland

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	18%	23%	60%	54%	38%	37%	32%	31%
Petroleum products	66%	22%	11%	16%	21%	14%	11%	8%
Natural gas	17%	55%	29%	31%	41%	49%	57%	61%

Source: IEA; own calculations

Table 57: Shares in electricity supply, Ireland

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	92%	93%	95%	96%	95%	86%	86%	86%
Nuclear	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	8%	7%	5%	4%	4%	2%	2%	2%
Renewables	0%	0%	0%	0%	1%	4%	6%	7%
Net imports	0%	0%	0%	0%	0%	7%	6%	5%

Table 58: Correlations components of electricity supply, 1980-1993 and 1994-2007, Ireland

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.92	-	0.08	0.19	-
	1994-2007	1.00	0.74	-	0.30	0.06	0.12
Fossils	1980-1993		1.00	-	-0.31	0.18	-
	1994-2007		1.00	-	-0.12	-0.19	-0.46
Nuclear	1980-1993			-	-	-	-
	1994-2007			-	-	-	-
Hydro	1980-1993				1.00	-0.02	-
	1994-2007				1.00	0.12	0.18
Renewables	1980-1993					1.00	-
	1994-2007					1.00	-0.08
Net imports	1980-1993						-
	1994-2007						1.00

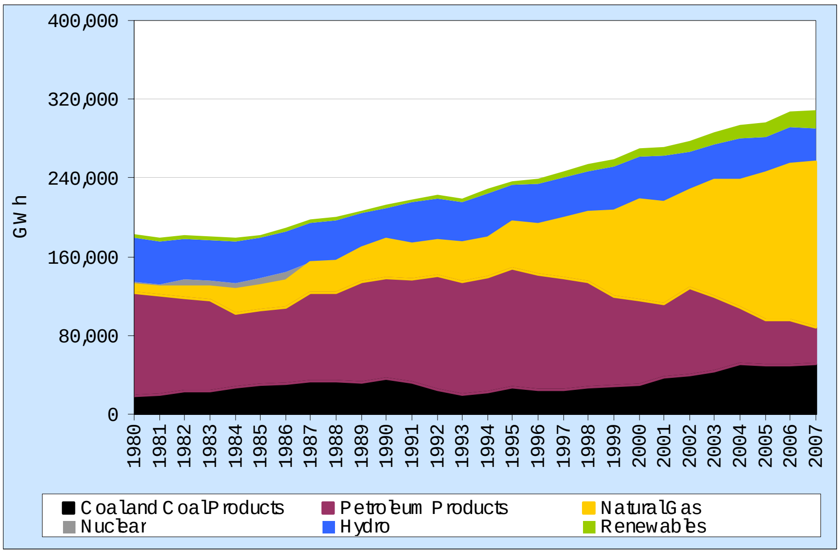
Source: IEA; own calculations

Italy

The share of natural gas in electricity production was high in 2007 (54%). The remaining electricity production mainly comes from coal, petroleum products and hydro.

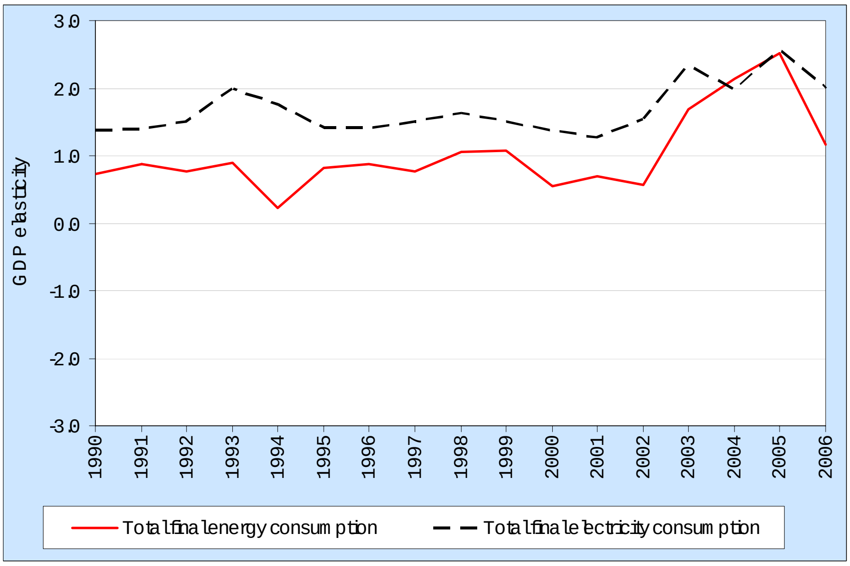
The GDP elasticities both with respect to total energy consumption and total electricity consumption showed a slightly increasing trend since 1990.

Figure 34: Structure of total electricity output, Italy



Source: IEA; own calculations

Figure 35: GDP elasticities final energy and electricity consumption, Italy



Source: IEA; own calculations

The share of natural gas in fossil electricity production increased considerably from 1980 to 2007 (7% to 65%). The share of coal also increased (14% to 20%). Petroleum products were the dominant fossil energy source in electricity production in 1980 (79%) but decreased its share to 15% in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply is the highly positive correlation between supply and fossils and the substitutional relationship between fossils and hydro.

Table 59: Shares in electricity production from fossils, Italy

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	14%	23%	20%	14%	14%	20%	20%	20%
Petroleum products	79%	58%	58%	62%	39%	19%	18%	15%
Natural gas	7%	19%	22%	24%	47%	61%	62%	65%

Source: IEA; own calculations

Table 60: Shares in electricity supply, Italy

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	70%	64%	72%	71%	69%	71%	72%	73%
Nuclear	1%	3%	0%	0%	0%	0%	0%	0%
Hydro	24%	20%	13%	14%	14%	10%	10%	9%
Renewables	2%	2%	1%	2%	3%	4%	5%	5%
Net imports	3%	11%	14%	14%	14%	14%	13%	13%

Table 61: Correlations components of electricity supply, 1980-1993 and 1994-2007, Italy

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.54	-0.47	0.02	0.06	0.35
	1994-2007	1.00	0.67	-	-0.24	-0.26	0.22
Fossils	1980-1993		1.00	-0.64	-0.58	-0.08	-0.28
	1994-2007		1.00	-	-0.76	-0.15	0.04
Nuclear	1980-1993			1.00	0.05	-0.08	-0.07
	1994-2007			-	-	-	-
Hydro	1980-1993				1.00	0.39	0.02
	1994-2007				1.00	-0.10	-0.44
Renewables	1980-1993					1.00	-0.23
	1994-2007					1.00	-0.08
Net imports	1980-1993						1.00
	1994-2007						1.00

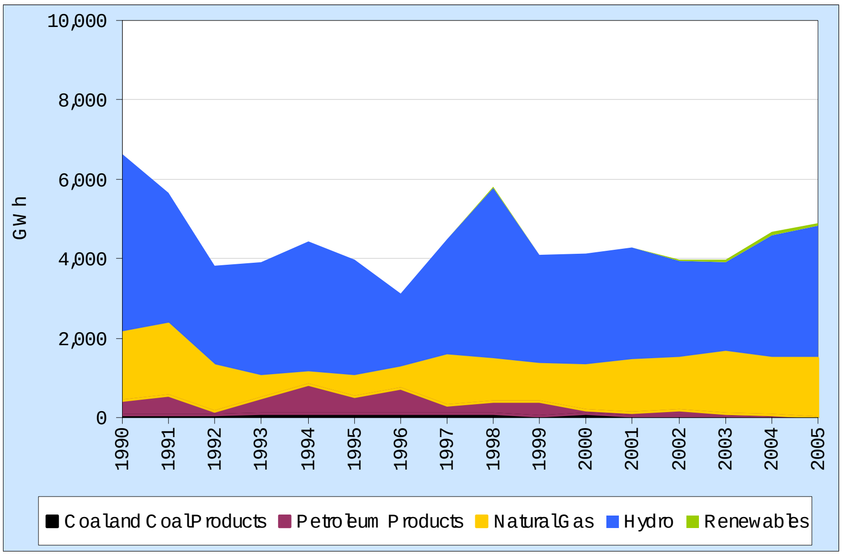
Source: IEA; own calculations

Latvia

The share of hydro in electricity production was high in 2005 (68%). The remaining electricity production mainly comes from natural gas.

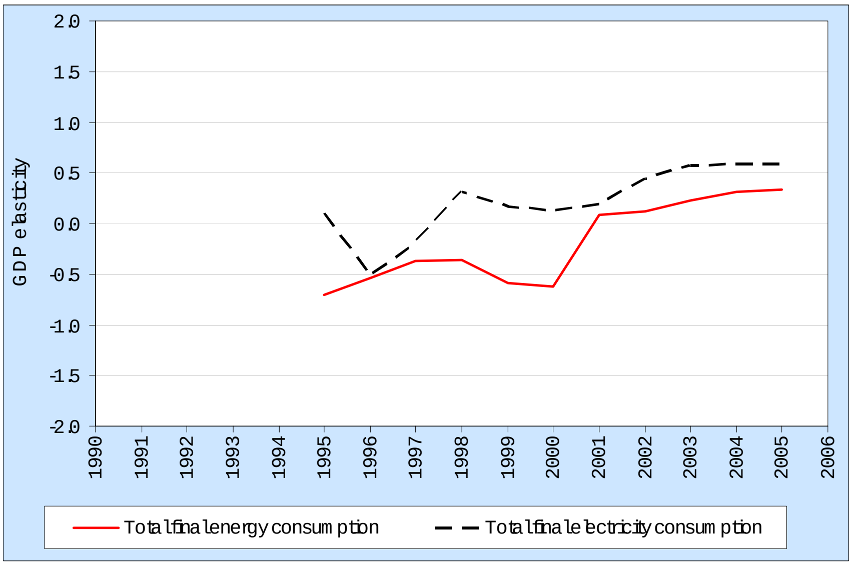
The GDP elasticities both with respect to total energy consumption and total electricity consumption showed an increasing trend since 1995.

Figure 36: Structure of total electricity output, Latvia



Source: IEA; own calculations

Figure 37: GDP elasticities final energy and electricity consumption, Latvia



Source: IEA; own calculations

Natural gas was the only fossil energy source in electricity production in 2005.

The most interesting features when looking at the correlation coefficients of total electricity supply is the positive correlation between supply and renewables and the substitutional relationship between hydro and net imports.

Table 62: Shares in electricity production from fossils, Latvia

	1980	1985	1990	1995	2000	2005
Coal and coal products	-	-	3%	9%	6%	0%
Petroleum products	-	-	17%	40%	7%	0%
Natural gas	-	-	81%	50%	87%	100%

Source: IEA; own calculations

Table 63: Shares in electricity supply, Latvia

	1980	1985	1990	1995	2000	2005
Fossils	-	-	21%	17%	22%	21%
Nuclear	-	-	0%	0%	0%	0%
Hydro	-	-	44%	47%	48%	47%
Renewables	-	-	0%	0%	0%	1%
Net imports	-	-	35%	36%	30%	30%

Table 64: Correlations components of electricity supply, 1980-1993 and 1994-2005, Latvia

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	-	-	-	-	-	-
	1994-2005	1.00	0.29	-	0.15	0.52	0.01
Fossils	1980-1993		-	-	-	-	-
	1994-2005		1.00	-	0.05	0.13	-0.15
Nuclear	1980-1993			-	-	-	-
	1994-2005			-	-	-	-
Hydro	1980-1993				-	-	-
	1994-2005				1.00	-0.05	-0.97
Renewables	1980-1993					-	-
	1994-2005					1.00	0.12
Net imports	1980-1993						-
	1994-2005						1.00

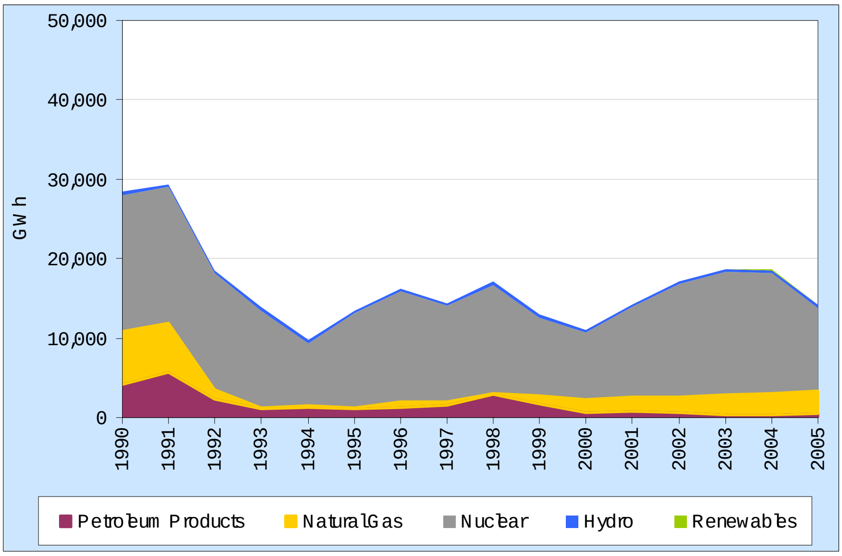
Source: IEA; own calculations

Lithuania

The share of nuclear in electricity production was high in 2005 (72%). The remaining electricity production mainly comes from natural gas.

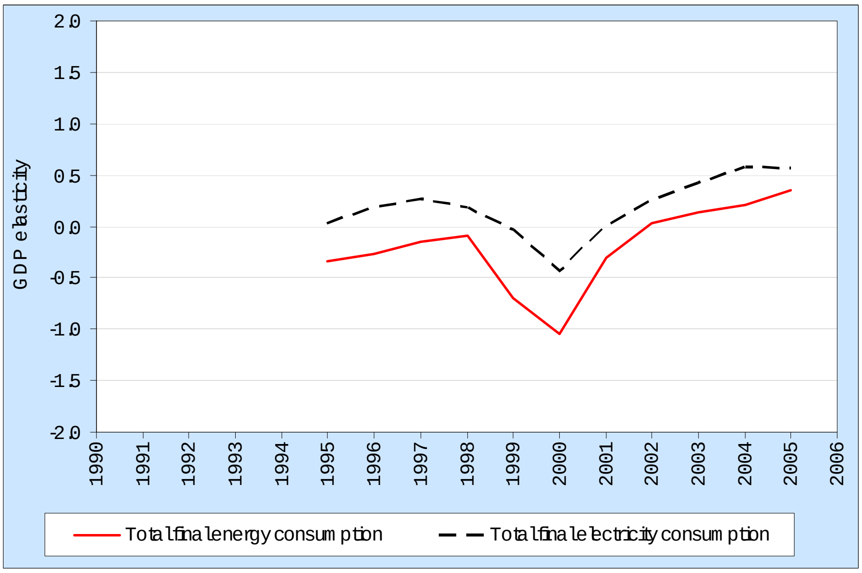
The GDP elasticities both with respect to total energy consumption and total electricity consumption showed a decreasing trend from 1995 to 2000 and an increasing trend since then.

Figure 38: Structure of total electricity output, Lithuania



Source: IEA; own calculations

Figure 39: GDP elasticities final energy and electricity consumption, Lithuania



Source: IEA; own calculations

The share of natural gas in electricity production increased considerably from 1995 to 2007 (18% to 88%). Petroleum products met the remaining electricity production from fossils in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply are the positive correlations between supply and fossils, nuclear and renewables and between fossils and hydro and the substitutional relationship between nuclear and net imports.

Table 65: Shares in electricity production from fossils, Lithuania

	1980	1985	1990	1995	2000	2005
Coal and coal products	-	-	0%	0%	0%	0%
Petroleum products	-	-	38%	82%	29%	12%
Natural gas	-	-	62%	18%	71%	88%

Source: IEA; own calculations

Table 66: Shares in electricity supply, Lithuania

	1980	1985	1990	1995	2000	2005
Fossils	-	-	66%	12%	23%	30%
Nuclear	-	-	104%	109%	86%	90%
Hydro	-	-	3%	3%	3%	4%
Renewables	-	-	0%	0%	0%	0%
Net imports	-	-	-73%	-25%	-14%	-26%

Table 67: Correlations components of electricity supply, 1980-1993 and 1994-2005, Lithuania

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	-	-	-	-	-	-
	1994-2005	1.00	0.54	0.71	0.20	0.59	-0.71
Fossils	1980-1993		-	-	-	-	-
	1994-2005		1.00	0.16	0.62	0.08	-0.25
Nuclear	1980-1993			-	-	-	-
	1994-2005			1.00	-0.23	0.19	-0.99
Hydro	1980-1993				-	-	-
	1994-2005				1.00	-0.05	0.16
Renewables	1980-1993					-	-
	1994-2005					1.00	-0.13
Net imports	1980-1993						-
	1994-2005						1.00

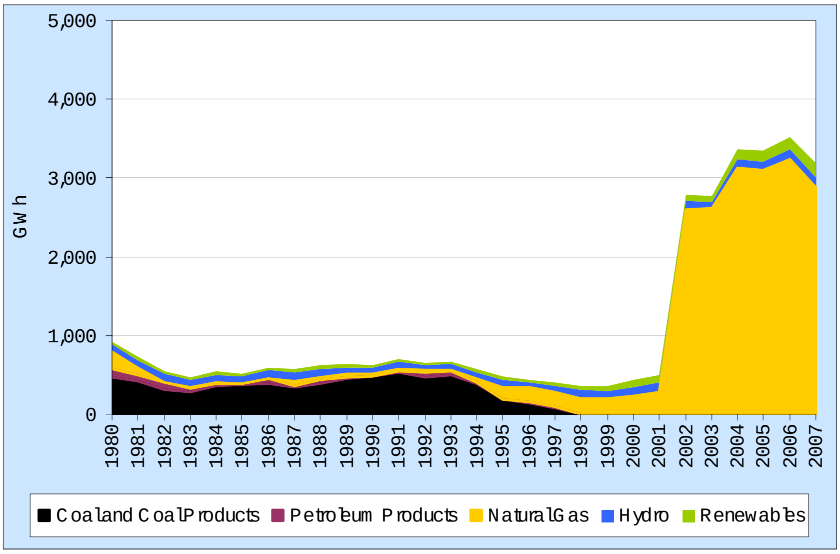
Source: IEA; own calculations

Luxembourg

The share of natural gas in electricity production was high in 2007 (90%). The remaining electricity production comes from hydro and renewables.

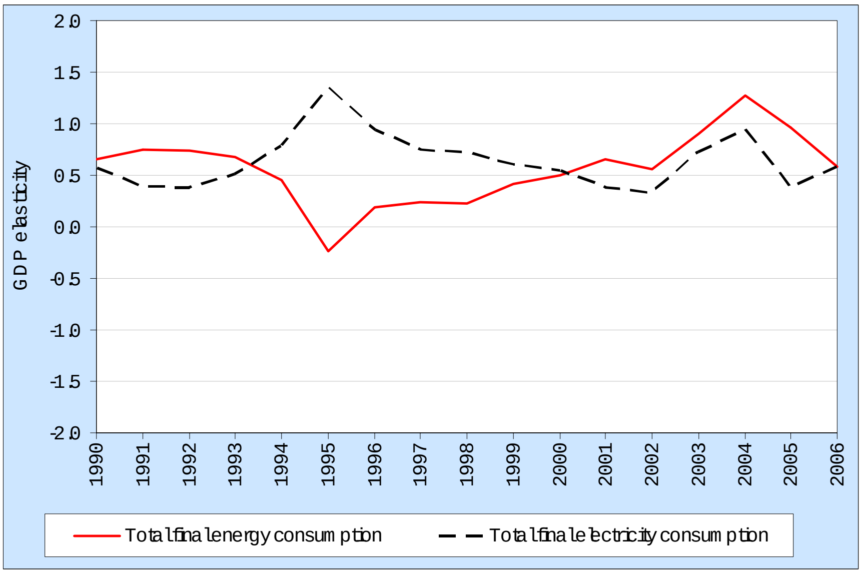
The GDP elasticities both with respect to total energy consumption and total electricity consumption were on the same level in 2007 as in 1990.

Figure 40: Structure of total electricity output, Luxembourg



Source: IEA; own calculations

Figure 41: GDP elasticities final energy and electricity consumption, Luxembourg



Source: IEA; own calculations

There was only natural gas in fossil electricity production in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply are the positive correlation between hydro and renewables, the changing correlation between supply and fossils, the decreasing positive correlation between supply and net imports and the substitutional relationship fossils and net imports.

Table 68: Shares in electricity production from fossils, Luxembourg

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	60%	94%	92%	55%	0%	0%	0%	0%
Petroleum products	13%	5%	2%	1%	0%	0%	0%	0%
Natural gas	27%	1%	7%	44%	100%	100%	100%	100%

Source: IEA; own calculations

Table 69: Shares in electricity supply, Luxembourg

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	21%	10%	11%	6%	4%	47%	46%	40%
Nuclear	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	3%	2%	2%	2%	2%	1%	2%	2%
Renewables	1%	1%	1%	1%	1%	2%	2%	3%
Net imports	76%	87%	86%	91%	93%	49%	50%	55%

Table 70: Correlations components of electricity supply, 1980-1993 and 1994-2007, Luxembourg

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.57	-	0.19	0.32	0.71
	1994-2007	1.00	-0.08	-	0.37	0.34	0.33
Fossils	1980-1993		1.00	-	-0.10	-0.10	-0.16
	1994-2007		1.00	-	-0.22	-0.12	-0.97
Nuclear	1980-1993			-	-	-	-
	1994-2007			-	-	-	-
Hydro	1980-1993				1.00	0.69	0.18
	1994-2007				1.00	0.38	0.27
Renewables	1980-1993					1.00	0.36
	1994-2007					1.00	0.18
Net imports	1980-1993						1.00
	1994-2007						1.00

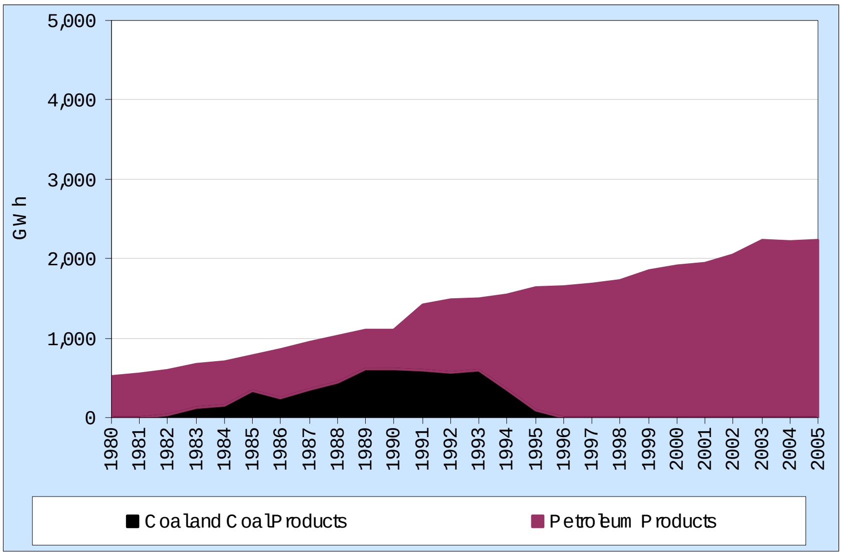
Source: IEA; own calculations

Malta

Petroleum products were the only energy source in electricity production in 2005.

It was not possible to compute GDP elasticities due to data restrictions.

Figure 42: Structure of total electricity output, Malta



Source: IEA; own calculations

As stated above petroleum products was the only energy source in electricity production in 2005.

As fossils are the only energy source in electricity production the correlation coefficient between supply and fossils is one.

Table 71: Shares in electricity production from fossils, Malta

	1980	1985	1990	1995	2000	2005
Coal and coal products	0%	44%	56%	6%	0%	0%
Petroleum products	100%	56%	44%	94%	100%	100%
Natural gas	0%	0%	0%	0%	0%	0%

Source: IEA; own calculations

Table 72: Shares in electricity supply, Malta

	1980	1985	1990	1995	2000	2005
Fossils	100%	100%	100%	100%	100%	100%
Nuclear	0%	0%	0%	0%	0%	0%
Hydro	0%	0%	0%	0%	0%	0%
Renewables	0%	0%	0%	0%	0%	0%
Net imports	0%	0%	0%	0%	0%	0%

Table 73: Correlations components of electricity supply, 1980-1993 and 1994-2005, Malta

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	1.00	-	-	-	-
	1994-2005	1.00	1.00	-	-	-	-
Fossils	1980-1993		1.00	-	-	-	-
	1994-2005		1.00	-	-	-	-
Nuclear	1980-1993			-	-	-	-
	1994-2005			-	-	-	-
Hydro	1980-1993				-	-	-
	1994-2005				-	-	-
Renewables	1980-1993					-	-
	1994-2005					-	-
Net imports	1980-1993						-
	1994-2005						-

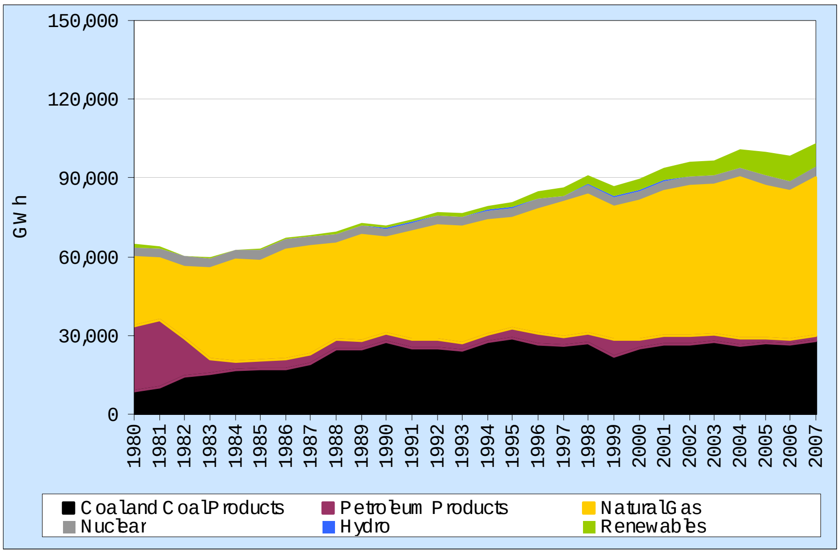
Source: IEA; own calculations

Netherlands

The share of natural gas in electricity production was high in 2007 (58%). The remaining electricity production mainly comes from coal and renewables.

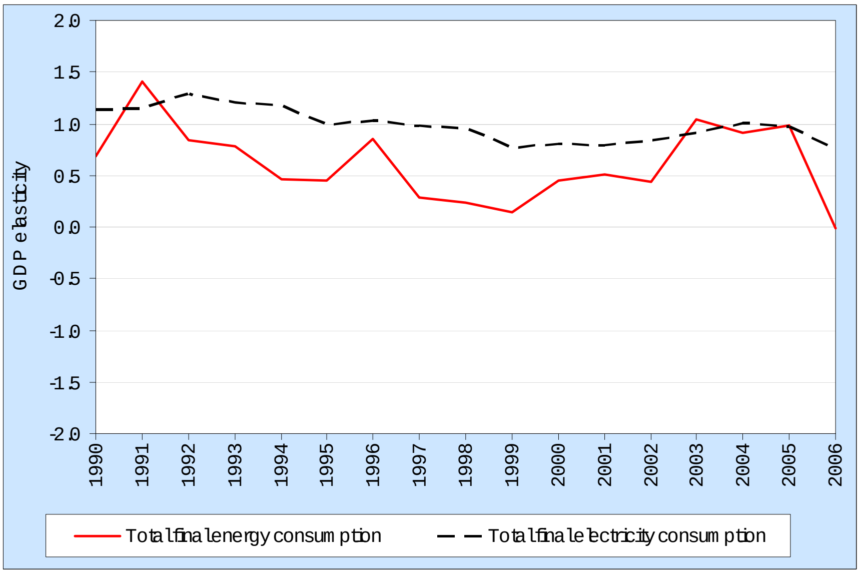
The GDP elasticities both with respect to total energy consumption and total electricity consumption showed a slightly decreasing trend since 1990.

Figure 43: Structure of total electricity output, Netherlands



Source: IEA; own calculations

Figure 44: GDP elasticities final energy and electricity consumption, Netherlands



Source: IEA; own calculations

The share of natural gas in fossil electricity production increased considerably from 1980 to 2007. The share of coal also increased. Petroleum products had a high share in electricity production from fossils in 1980 but decreased their share to 2% in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply is the decreasing positive correlation between supply and fossils and the substitutional relationship between fossils and net imports.

Table 74: Shares in electricity production from fossils, Netherlands

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	15%	29%	41%	39%	31%	31%	31%	31%
Petroleum products	42%	6%	5%	5%	4%	3%	2%	2%
Natural gas	43%	65%	54%	56%	65%	66%	66%	67%

Source: IEA; own calculations

Table 75: Shares in electricity supply, Netherlands

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	92%	86%	83%	81%	75%	73%	71%	75%
Nuclear	7%	6%	4%	4%	4%	3%	3%	3%
Hydro	0%	0%	0%	0%	0%	0%	0%	0%
Renewables	2%	1%	1%	2%	4%	8%	8%	7%
Net imports	0%	8%	11%	12%	17%	15%	18%	15%

Table 76: Correlations components of electricity supply, 1980-1993 and 1994-2007, Netherlands

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.50	-0.20	0.44	0.58	0.13
	1994-2007	1.00	0.37	-0.05	0.48	0.05	-0.03
Fossils	1980-1993		1.00	0.12	0.18	0.37	-0.77
	1994-2007		1.00	0.12	0.26	-0.41	-0.88
Nuclear	1980-1993			1.00	-0.14	-0.21	-0.45
	1994-2007			1.00	-0.04	-0.08	-0.40
Hydro	1980-1993				1.00	0.13	0.13
	1994-2007				1.00	0.07	-0.11
Renewables	1980-1993					1.00	-0.09
	1994-2007					1.00	0.23
Net imports	1980-1993						1.00
	1994-2007						1.00

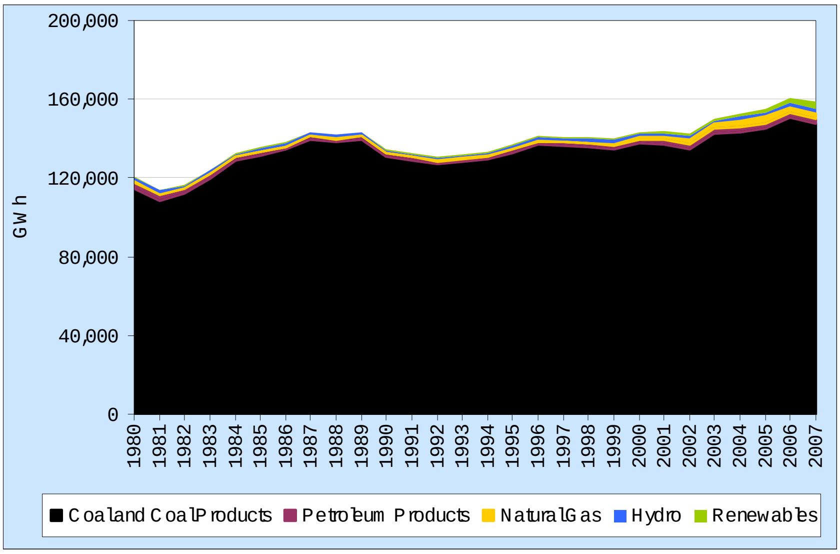
Source: IEA; own calculations

Poland

The share of coal in electricity production was very high in 2007 (93%). The remaining electricity production comes from natural gas, petroleum products, hydro and renewables.

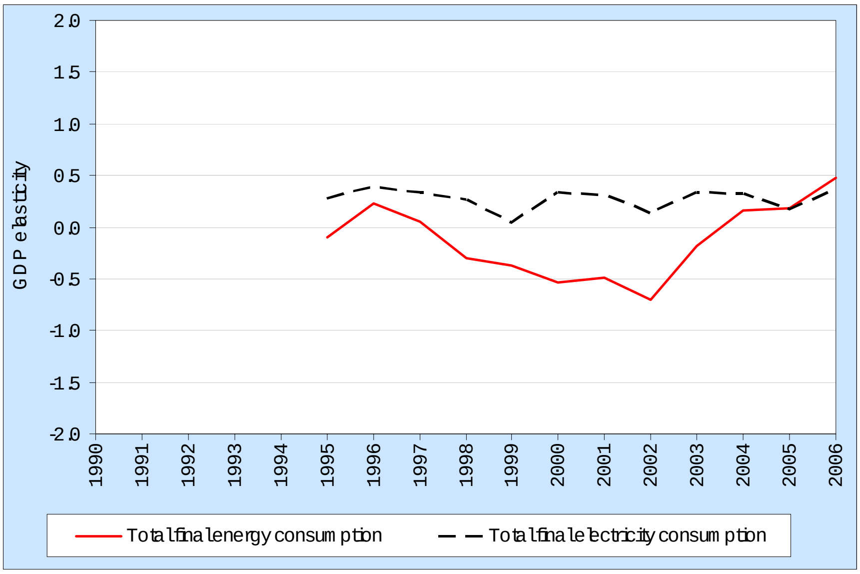
The GDP elasticities both with respect to total energy consumption and total electricity consumption showed a slightly decreasing trend from 1995 to 2002 and an increasing trend since then.

Figure 45: Structure of total electricity output, Poland



Source: IEA; own calculations

Figure 46: GDP elasticities final energy and electricity consumption, Poland



Source: IEA; own calculations

The share of coal is on a high level since 1980 and was 97% in 2007. The two other fossil fuels play no important role in electricity production.

The most interesting features when looking at the correlation coefficients of total electricity supply are the highly positive but decreasing correlation between supply and fossils and the changing correlations between fossils and hydro, fossils and net imports, hydro and net imports and renewables and imports.

Table 77: Shares in electricity production from fossils, Poland

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	97%	99%	99%	99%	98%	96%	96%	97%
Petroleum products	3%	1%	1%	1%	1%	2%	2%	1%
Natural gas	0%	0%	0%	0%	1%	2%	2%	2%

Source: IEA; own calculations

Table 78: Shares in electricity supply, Poland

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	98%	100%	100%	100%	103%	105%	104%	100%
Nuclear	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	2%	1%	1%	1%	2%	2%	1%	2%
Renewables	0%	0%	0%	0%	0%	1%	2%	2%
Net imports	0%	-2%	-1%	-2%	-5%	-8%	-7%	-3%

Table 79: Correlations components of electricity supply, 1980-1993 and 1994-2007, Poland

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.93	-	0.30	-0.22	0.49
	1994-2007	1.00	0.64	-	-0.18	0.33	0.25
Fossils	1980-1993		1.00	-	0.12	-0.06	0.14
	1994-2007		1.00	-	-0.63	-0.28	-0.58
Nuclear	1980-1993			-	-	-	-
	1994-2007			-	-	-	-
Hydro	1980-1993				1.00	0.03	0.40
	1994-2007				1.00	0.34	0.54
Renewables	1980-1993					1.00	-0.53
	1994-2007					1.00	0.62
Net imports	1980-1993						1.00
	1994-2007						1.00

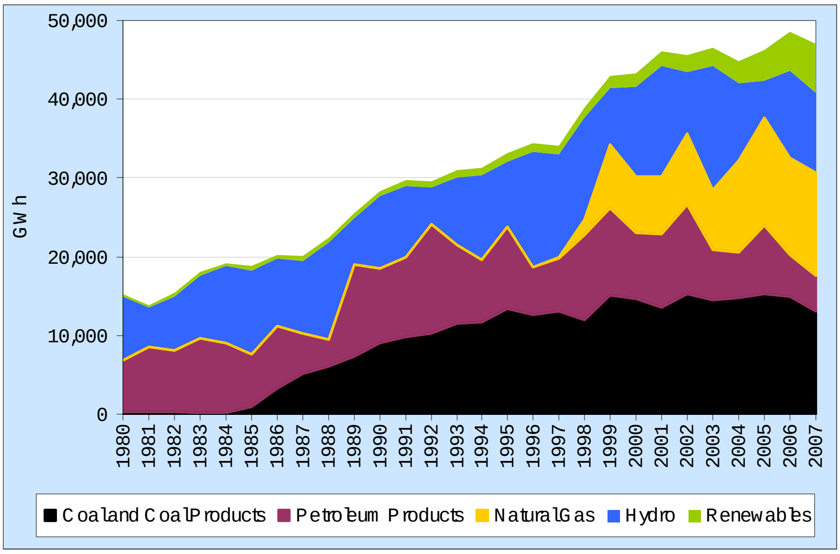
Source: IEA; own calculations

Portugal

The allocation of energy sources in electricity production except nuclear is very balanced with coal (28%) and natural gas (28%) showing the highest shares.

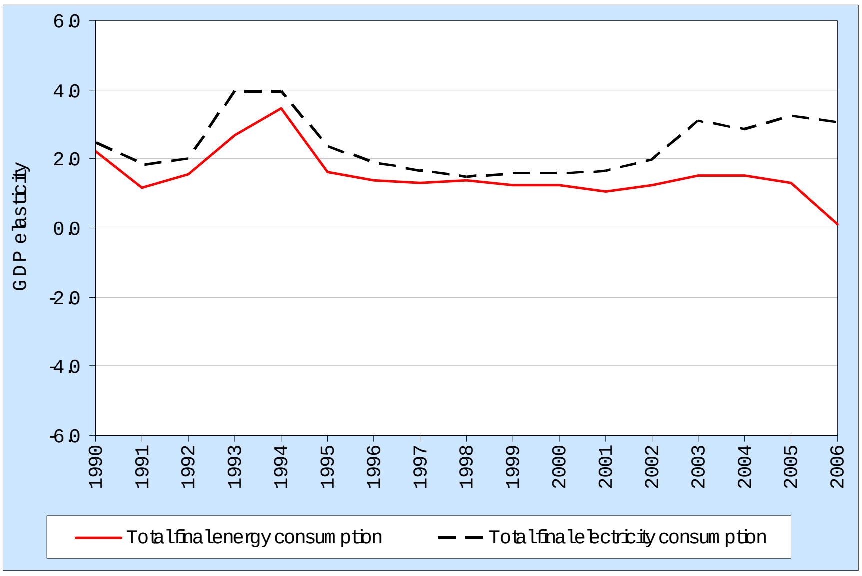
The GDP elasticity with respect to total energy consumption decreased since 2001. The elasticity with respect to total electricity consumption showed an increasing development. Thus the two elasticities showed a diverging trend since 2001.

Figure 47: Structure of total electricity output, Portugal



Source: IEA; own calculations

Figure 48: GDP elasticities final energy and electricity consumption, Portugal



Source: IEA; own calculations

The share of coal and gas in electricity production from fossils is the same (43%). Petroleum products lost its dominant role and decreased its share from 95% in 1980 to 15% in 2007.

The most interesting feature when looking at the correlation coefficients of total electricity supply is strong substitutional relationship between fossils and hydro.

Table 80: Shares in electricity production from fossils, Portugal

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	5%	13%	49%	57%	49%	40%	46%	43%
Petroleum products	95%	87%	51%	43%	28%	23%	16%	15%
Natural gas	0%	0%	0%	0%	24%	36%	38%	43%

Source: IEA; own calculations

Table 81: Shares in electricity supply, Portugal

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	40%	36%	65%	70%	68%	71%	60%	56%
Nuclear	0%	0%	0%	0%	0%	0%	0%	0%
Hydro	47%	51%	32%	24%	26%	9%	20%	18%
Renewables	2%	3%	2%	3%	4%	7%	9%	12%
Net imports	11%	11%	0%	3%	2%	13%	10%	14%

Table 82: Correlations components of electricity supply, 1980-1993 and 1994-2007, Portugal

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.40	-	-0.13	0.33	-0.24
	1994-2007	1.00	0.45	-	-0.20	-0.43	-0.28
Fossils	1980-1993		1.00	-	-0.89	-0.08	-0.05
	1994-2007		1.00	-	-0.91	-0.06	-0.13
Nuclear	1980-1993			-	-	-	-
	1994-2007			-	-	-	-
Hydro	1980-1993				1.00	-0.01	-0.38
	1994-2007				1.00	-0.12	-0.25
Renewables	1980-1993					1.00	0.33
	1994-2007					1.00	0.10
Net imports	1980-1993						1.00
	1994-2007						1.00

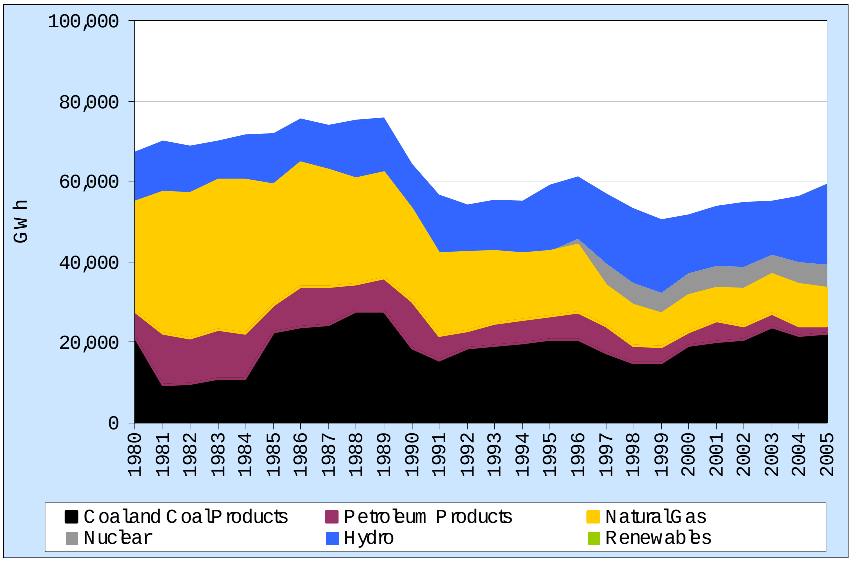
Source: IEA; own calculations

Romania

The shares of coal and hydro in electricity production were high in 2005 (37% and 34%). The remaining electricity production comes from natural gas, petroleum products and nuclear.

It was not possible to compute GDP elasticities due to data restrictions.

Figure 49: Structure of total electricity output, Romania



Source: IEA; own calculations

The share of coal increased from 1980 to 2005 to 66%. Natural gas and petroleum products decreased their share in electricity production from fossils.

The most interesting features when looking at the correlation coefficients of total electricity supply are the highly positive correlation between supply and fossils and the substitutional relationship between fossils and nuclear and fossils and hydro.

Table 83: Shares in electricity production from fossils, Romania

	1980	1985	1990	1995	2000	2005
Coal and coal products	39%	38%	35%	49%	61%	66%
Petroleum products	12%	11%	22%	14%	11%	6%
Natural gas	49%	51%	43%	38%	28%	29%

Source: IEA; own calculations

Table 84: Shares in electricity supply, Romania

	1980	1985	1990	1995	2000	2005
Fossils	81%	79%	72%	71%	62%	60%
Nuclear	0%	0%	0%	0%	11%	10%
Hydro	19%	17%	15%	28%	29%	36%
Renewables	0%	0%	0%	0%	0%	0%
Net imports	1%	4%	13%	1%	-1%	-5%

Table 85: Correlations components of electricity supply, 1980-1993 and 1994-2005, Romania

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.83	-	0.13	-0.31	0.50
	1994-2005	1.00	0.71	-0.36	0.05	0.15	0.35
Fossils	1980-1993		1.00	-	-0.34	0.08	0.13
	1994-2005		1.00	-0.68	-0.54	-0.12	0.19
Nuclear	1980-1993			-	-	-	-
	1994-2005			1.00	0.17	0.25	0.06
Hydro	1980-1993				1.00	-0.40	0.09
	1994-2005				1.00	0.14	-0.32
Renewables	1980-1993					1.00	-0.62
	1994-2005					1.00	0.24
Net imports	1980-1993						1.00
	1994-2005						1.00

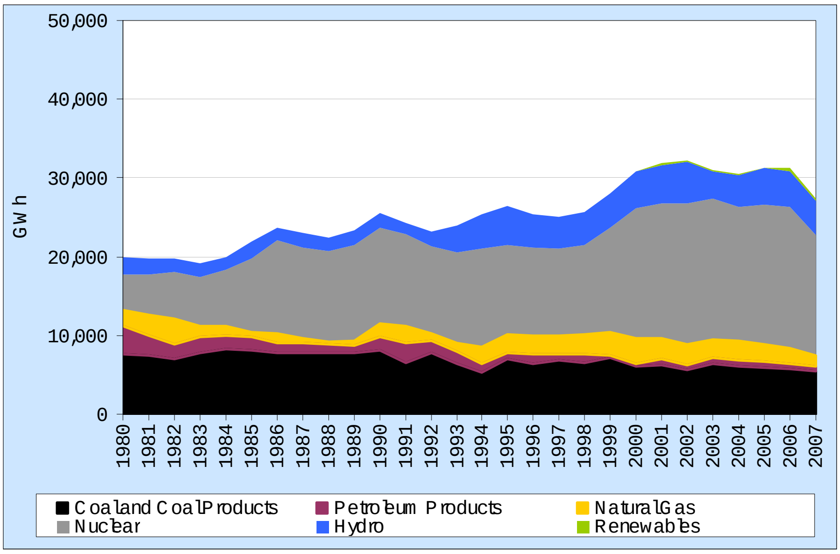
Source: IEA; own calculations

Slovakia

The share of nuclear in electricity production was high in 2007 (56%). The remaining electricity production mainly comes from coal, hydro and natural gas.

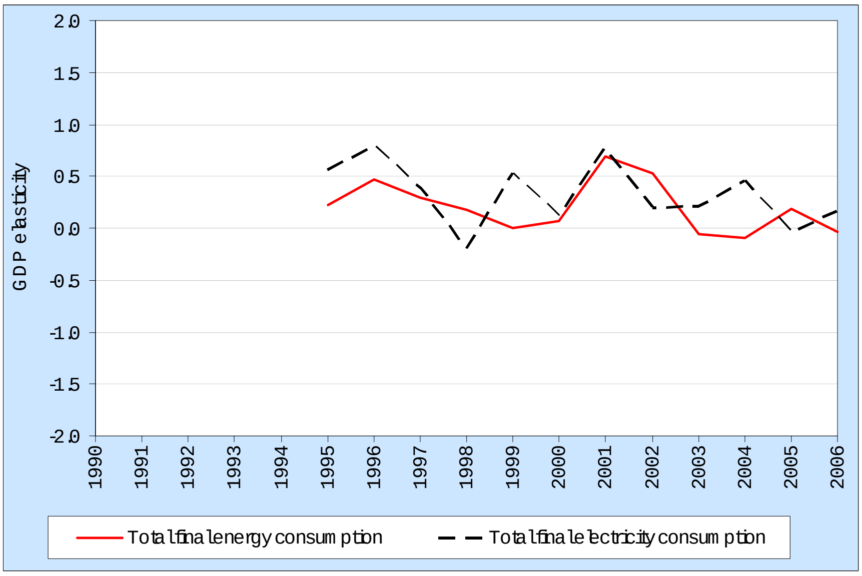
The GDP elasticity both with respect to total energy consumption and total electricity consumption deceased since 1995 and were close to zero in 2007.

Figure 50: Structure of total electricity output, Slovakia



Source: IEA; own calculations

Figure 51: GDP elasticities final energy and electricity consumption, Slovakia



Source: IEA; own calculations

The share of coal in electricity production from fossils increased between 1980 and 2007 from 57% to 74%; the share of natural gas stayed almost constant.

The most interesting features when looking at the correlation coefficients of total electricity supply are the positive correlation between supply and fossils, the substitutional relationship between nuclear and net imports and the changing relationship between supply and nuclear.

Table 86: Shares in electricity production from fossils, Slovakia

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	57%	78%	70%	69%	63%	67%	69%	74%
Petroleum products	27%	16%	14%	7%	2%	8%	9%	7%
Natural gas	16%	6%	16%	24%	35%	25%	23%	19%

Source: IEA; own calculations

Table 87: Shares in electricity supply, Slovakia

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	57%	40%	38%	36%	34%	32%	29%	26%
Nuclear	19%	36%	39%	41%	59%	63%	62%	54%
Hydro	10%	8%	6%	18%	16%	17%	15%	15%
Renewables	0%	0%	0%	0%	0%	0%	2%	1%
Net imports	14%	16%	17%	5%	-10%	-12%	-8%	3%

Table 88: Correlations components of electricity supply, 1980-1993 and 1994-2007, Slovakia

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.54	0.62	-0.13	-0.34	0.37
	1994-2007	1.00	0.51	-0.06	-0.17	0.19	0.47
Fossils	1980-1993		1.00	0.06	-0.33	-0.30	0.00
	1994-2007		1.00	-0.19	-0.20	-0.06	0.14
Nuclear	1980-1993			1.00	0.00	-0.07	-0.22
	1994-2007			1.00	0.13	0.24	-0.79
Hydro	1980-1993				1.00	0.77	-0.45
	1994-2007				1.00	-0.03	-0.48
Renewables	1980-1993					1.00	-0.57
	1994-2007					1.00	-0.11
Net imports	1980-1993						1.00
	1994-2007						1.00

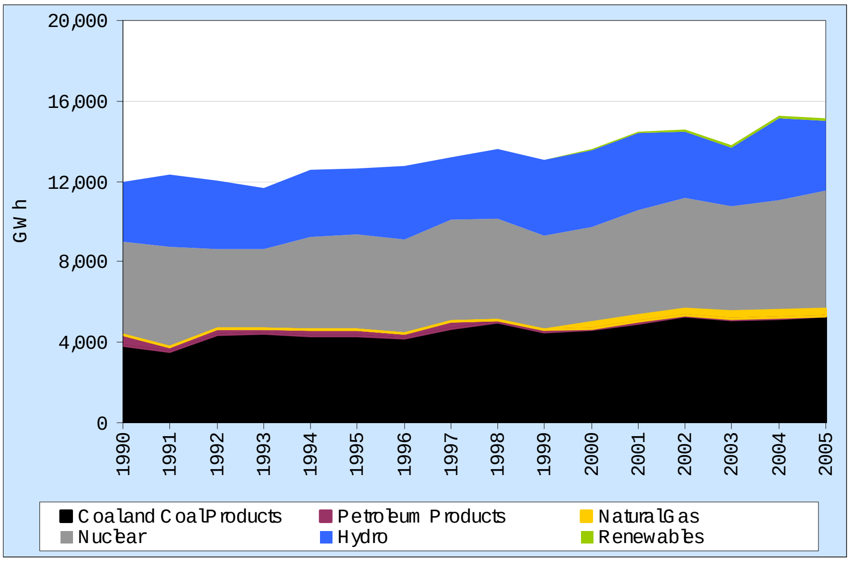
Source: IEA; own calculations

Slovenia

The share of nuclear, coal and hydro in electricity production were high in 2005 (39%, 35% and 23%). The remaining electricity production mainly comes from natural gas.

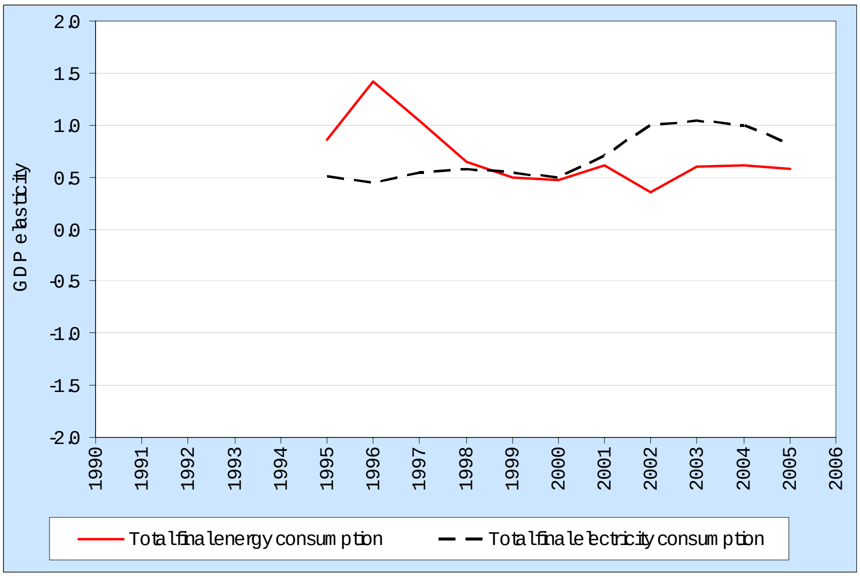
The GDP elasticity both with respect to total energy consumption and total electricity consumption show no clear development from 1995 to 2005.

Figure 52: Structure of total electricity output, Slovenia



Source: IEA; own calculations

Figure 53: GDP elasticities final energy and electricity consumption, Slovenia



Source: IEA; own calculations

The share of coal in electricity production from fossils increased between 1990 and 2005 from 87% to 93%; the share of natural gas also increased from 0% to 6%.

The most interesting features when looking at the correlation coefficients of total electricity supply are the positive correlation between supply and fossils, supply and renewables and fossils and nuclear and the substitutional relationships between nuclear and net imports and hydro and net imports.

Table 89: Shares in electricity production from fossils, Slovenia

	1980	1985	1990	1995	2000	2005
Coal and coal products	-	-	87%	94%	93%	93%
Petroleum products	-	-	13%	6%	1%	1%
Natural gas	-	-	0%	0%	6%	6%

Source: IEA; own calculations

Table 90: Shares in electricity supply, Slovenia

	1980	1985	1990	1995	2000	2005
Fossils	-	-	40%	42%	40%	38%
Nuclear	-	-	42%	44%	39%	40%
Hydro	-	-	27%	30%	31%	23%
Renewables	-	-	0%	0%	1%	1%
Net imports	-	-	-9%	-15%	-11%	-2%

Table 91: Correlations components of electricity supply, 1980-1993 and 1994-2005, Slovenia

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	-	-	-	-	-	-
	1994-2005	1.00	0.57	0.35	-0.21	0.61	0.04
Fossils	1980-1993		-	-	-	-	-
	1994-2005		1.00	0.58	-0.39	0.28	-0.27
Nuclear	1980-1993			-	-	-	-
	1994-2005			1.00	-0.13	-0.22	-0.57
Hydro	1980-1993				-	-	-
	1994-2005				1.00	-0.16	-0.66
Renewables	1980-1993					-	-
	1994-2005					1.00	0.28
Net imports	1980-1993						-
	1994-2005						1.00

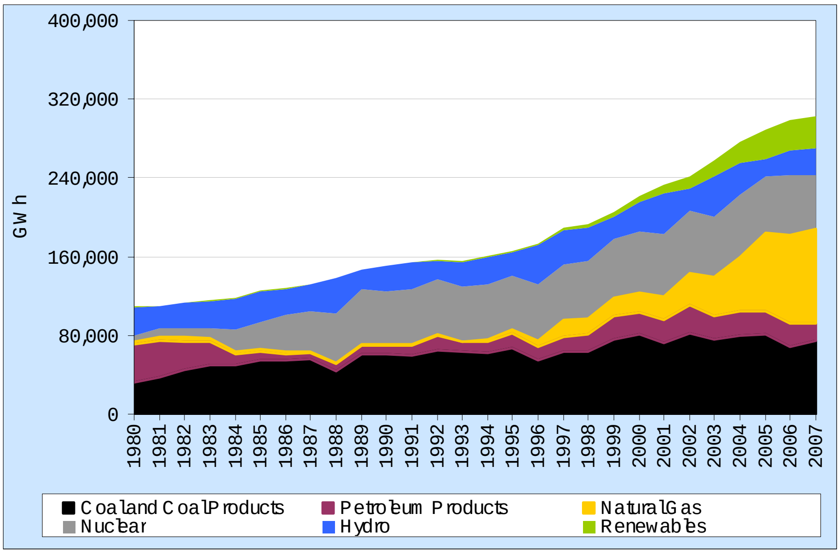
Source: IEA; own calculations

Spain

The allocation of energy sources in electricity production is very balanced with coal (28%) and natural gas (31%) showing the highest share.

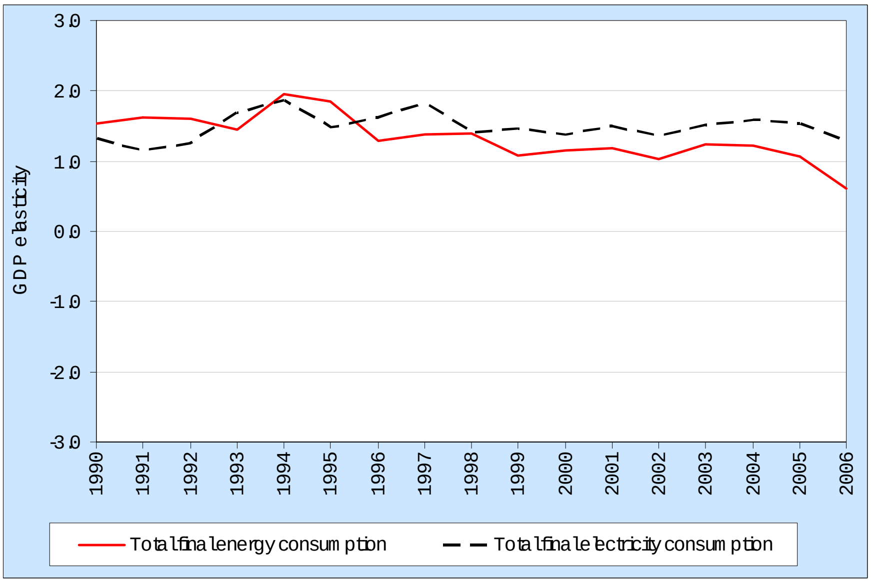
The GDP elasticity both with respect to total energy consumption and total electricity consumption show a slightly decreasing trend from 1990 to 2007.

Figure 54: Structure of total electricity output, Spain



Source: IEA; own calculations

Figure 55: GDP elasticities final energy and electricity consumption, Spain



Source: IEA; own calculations

The shares of coal and petroleum products in electricity production from fossils decreased considerably from 1980 to 2007. This development was accompanied by a significant increase of natural gas from 4% to 52%.

The most interesting features when looking at the correlation coefficients of total electricity supply are the positive correlation between supply and fossils but also between supply and renewables and the substitutional relationship between fossils and hydro.

Table 92: Shares in electricity production from fossils, Spain

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	44%	84%	86%	78%	65%	44%	37%	40%
Petroleum products	52%	12%	12%	17%	18%	13%	13%	10%
Natural gas	4%	4%	2%	4%	16%	43%	50%	51%

Source: IEA; own calculations

Table 93: Shares in electricity supply, Spain

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	69%	53%	47%	50%	55%	64%	62%	63%
Nuclear	5%	23%	36%	33%	27%	20%	20%	19%
Hydro	27%	25%	17%	14%	13%	6%	9%	9%
Renewables	0%	0%	0%	1%	3%	10%	10%	11%
Net imports	-1%	-1%	0%	3%	2%	0%	-1%	-2%

Table 94: Correlations components of electricity supply, 1980-1993 and 1994-2007, Spain

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.24	0.28	-0.20	0.04	0.12
	1994-2007	1.00	0.51	0.25	-0.36	0.51	0.07
Fossils	1980-1993		1.00	-0.47	-0.90	0.23	-0.24
	1994-2007		1.00	-0.39	-0.94	0.55	0.18
Nuclear	1980-1993			1.00	0.12	-0.44	0.04
	1994-2007			1.00	0.30	-0.38	0.10
Hydro	1980-1993				1.00	-0.05	0.12
	1994-2007				1.00	-0.44	-0.44
Renewables	1980-1993					1.00	0.04
	1994-2007					1.00	-0.17
Net imports	1980-1993						1.00
	1994-2007						1.00

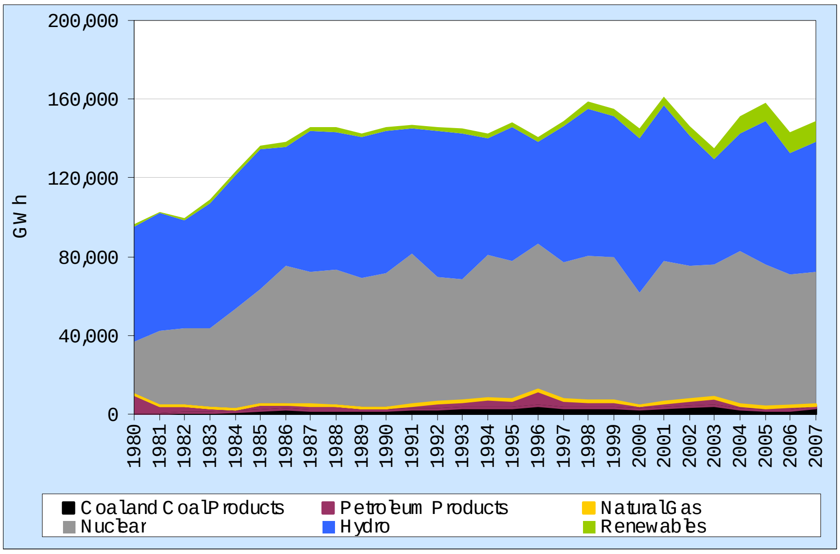
Source: IEA; own calculations

Sweden

There are two dominant energy sources in electricity production in 2007: Nuclear (45%) and hydro (44%). The remaining electricity production mainly comes from renewables.

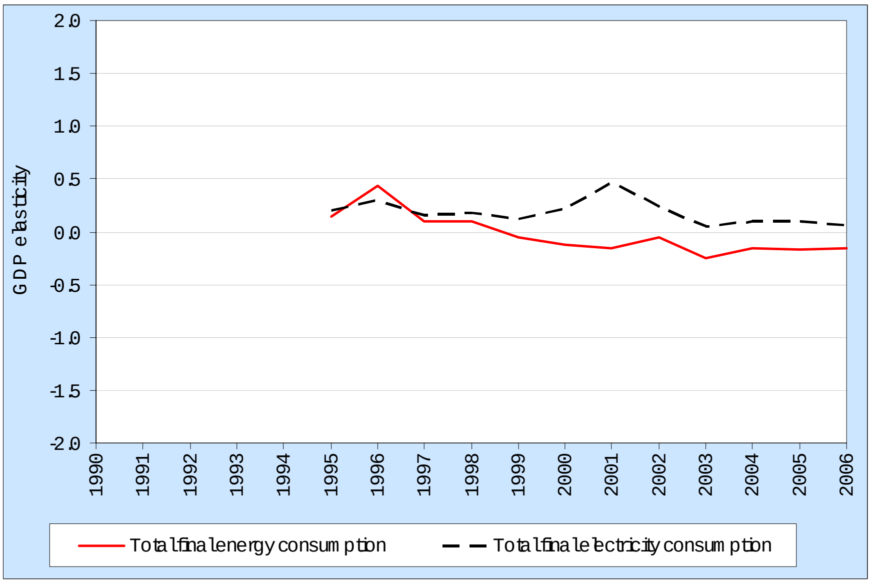
The GDP elasticity both with respect to total energy consumption and total electricity consumption showed a decreasing trend 1995 to 2007; the elasticity with respect to total electricity consumption even has a negative value since 1999.

Figure 56: Structure of total electricity output, Sweden



Source: IEA; own calculations

Figure 57: GDP elasticities final energy and electricity consumption, Sweden



Source: IEA; own calculations

The shares of coal and natural gas in electricity production from fossils increased considerably from 1980 to 2007. The share of petroleum products decreased from 98% in 1980 to 24% in 2007.

The most interesting features when looking at the correlation coefficients of total electricity supply are the positive correlation between supply and hydro and the substitutional relationships between fossils and hydro, fossils and renewables, hydro and net imports and nuclear and net imports.

Table 95: Shares in electricity production from fossils, Sweden

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	2%	39%	48%	40%	56%	50%	47%	56%
Petroleum products	98%	60%	40%	51%	34%	35%	39%	24%
Natural gas	0%	1%	12%	9%	10%	15%	14%	19%

Source: IEA; own calculations

Table 96: Shares in electricity supply, Sweden

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	11%	4%	2%	5%	3%	3%	3%	3%
Nuclear	27%	43%	47%	48%	38%	48%	45%	44%
Hydro	61%	53%	50%	46%	52%	48%	41%	44%
Renewables	1%	1%	1%	2%	3%	6%	7%	7%
Net imports	1%	-1%	-1%	-1%	3%	-5%	4%	1%

Table 97: Correlations components of electricity supply, 1980-1993 and 1994-2007, Sweden

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.06	0.28	0.47	0.11	-0.16
	1994-2007	1.00	-0.22	0.10	0.63	0.03	-0.54
Fossils	1980-1993		1.00	-0.24	-0.07	-0.41	0.16
	1994-2007		1.00	0.29	-0.79	-0.62	0.45
Nuclear	1980-1993			1.00	-0.59	0.05	-0.48
	1994-2007			1.00	-0.27	-0.12	-0.57
Hydro	1980-1993				1.00	0.16	-0.07
	1994-2007				1.00	0.27	-0.63
Renewables	1980-1993					1.00	-0.10
	1994-2007					1.00	-0.16
Net imports	1980-1993						1.00
	1994-2007						1.00

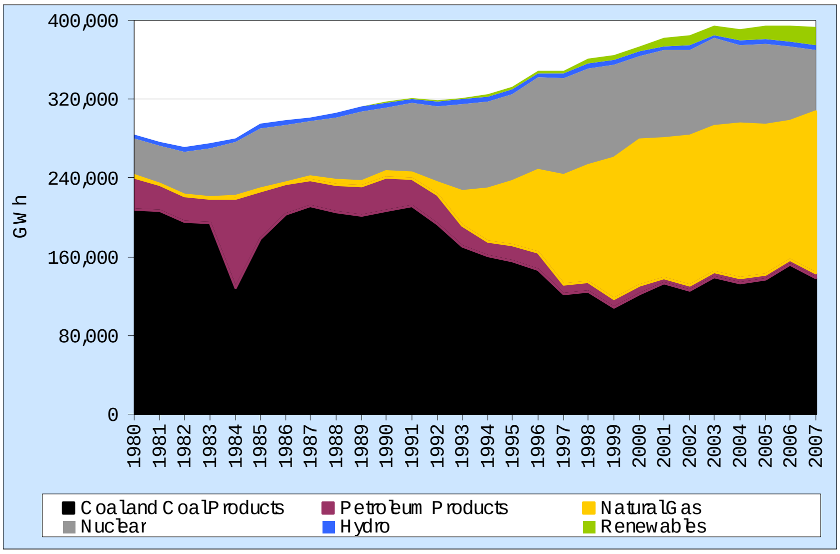
Source: IEA; own calculations

United Kingdom

The share of natural gas in electricity production was high in 2007 (42%). The remaining electricity production mainly comes from nuclear and coal.

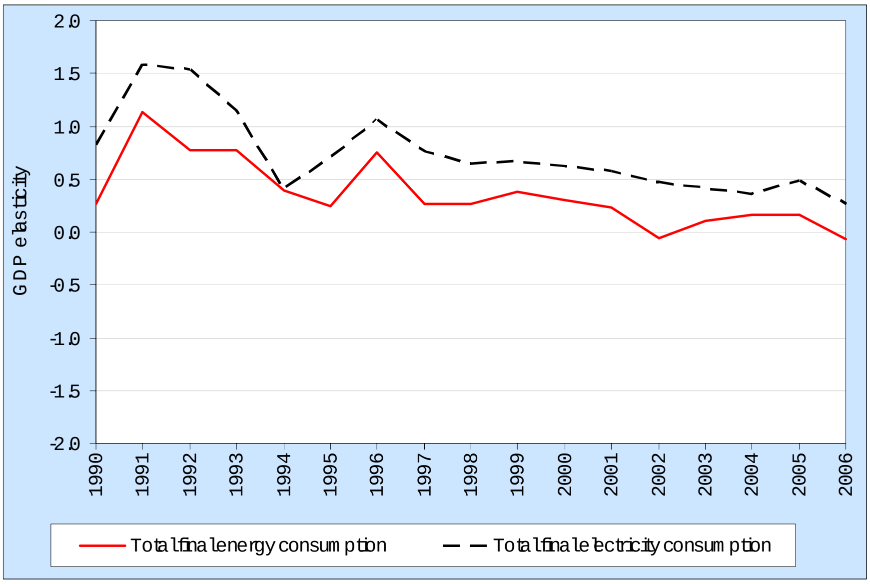
The GDP elasticity both with respect to total energy consumption and total electricity consumption showed a decreasing trend from 1990 to 2007.

Figure 58: Structure of total electricity output, United Kingdom



Source: IEA; own calculations

Figure 59: GDP elasticities final energy and electricity consumption, United Kingdom



Source: IEA; own calculations

The share of natural gas in electricity production from fossils increased considerably from 1980 to 2007. The shares of coal and petroleum products decreased in the same period.

The most interesting feature when looking at the correlation coefficients of total electricity supply is the clearly positive correlation between supply and fossils.

Table 98: Shares in electricity production from fossils, United Kingdom

	1980	1985	1990	1995	2000	2005	2006	2007
Coal and coal products	85%	78%	84%	66%	44%	46%	51%	45%
Petroleum products	14%	21%	14%	7%	3%	2%	2%	2%
Natural gas	1%	1%	2%	27%	53%	52%	47%	54%

Source: IEA; own calculations

Table 99: Shares in electricity supply, United Kingdom

	1980	1985	1990	1995	2000	2005	2006	2007
Fossils	86%	78%	75%	68%	72%	73%	74%	77%
Nuclear	13%	21%	20%	26%	22%	20%	19%	16%
Hydro	1%	1%	2%	1%	1%	1%	1%	1%
Renewables	0%	0%	0%	1%	1%	4%	4%	5%
Net imports	0%	0%	4%	5%	4%	2%	2%	1%

Table 100: Correlations components of electricity supply, 1980-1993 and 1994-2007, United Kingdom

		Total supply	Fossils	Nuclear	Hydro	Renewables	Net imports
Total supply	1980-1993	1.00	0.81	0.11	-0.06	0.00	0.42
	1994-2007	1.00	0.54	0.47	-0.49	-0.41	0.02
Fossils	1980-1993		1.00	-0.46	0.06	0.11	0.40
	1994-2007		1.00	-0.33	-0.41	-0.35	-0.21
Nuclear	1980-1993			1.00	-0.20	-0.07	-0.38
	1994-2007			1.00	-0.41	-0.09	-0.29
Hydro	1980-1993				1.00	-0.05	-0.19
	1994-2007				1.00	-0.03	0.50
Renewables	1980-1993					1.00	-0.27
	1994-2007					1.00	-0.15
Net imports	1980-1993						1.00
	1994-2007						1.00

Source: IEA; own calculations

Appendix 2: Time dependent correlation coefficients between total electricity supply and the components nuclear, hydro, renewables and net imports

Nuclear

Table 101: Time dependent correlation coefficients between total electricity supply and electricity production from nuclear, 1980-2007

	1980	1985	1990	1995	2000	2005	2006	2007
Austria	-	-	-	-	-	-	-	-
Belgium	0.55	0.58	0.10	-0.11	-0.30	-0.06	-0.13	-0.18
Bulgaria	-0.52	0.13	0.44	0.64	0.64	0.42	-	-
Cyprus	-	-	-	-	-	-	-	-
Czech Republic	0.45	0.60	0.43	0.21	0.22	0.17	0.17	0.18
Denmark	-	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	-
Finland	-0.47	-0.54	-0.31	-0.12	0.01	-0.02	-0.15	-0.15
France	0.61	0.56	0.52	0.34	0.33	0.18	0.32	0.39
Germany	0.62	0.64	0.74	0.62	0.28	0.26	0.25	0.34
Greece	-	-	-	-	-	-	-	-
Hungary	0.60	0.39	0.44	0.43	0.37	0.14	0.10	0.12
Ireland	-	-	-	-	-	-	-	-
Italy	-0.21	-0.19	-0.45	-0.40	-0.28	-0.26	-0.26	-0.23
Latvia	-	-	-	-	-	-	-	-
Lithuania	-	-	1.00	0.92	0.88	0.77	-	-
Luxembourg	-	-	-	-	-	-	-	-
Malta	-	-	-	-	-	-	-	-
Netherlands	-0.06	0.05	-0.17	-0.10	0.01	-0.05	0.04	-0.09
Poland	-	-	-	-	-	-	-	-
Portugal	-	-	-	-	-	-	-	-
Romania	-	-	-	-	-0.16	-0.19	-	-
Slovakia	0.94	0.84	0.40	0.25	0.06	0.05	0.04	0.18
Slovenia	-	-	1.00	0.96	0.95	0.91	-	-
Spain	0.25	0.34	0.19	0.10	-0.07	-0.30	-0.31	-0.01
Sweden	0.00	0.04	0.12	0.16	0.13	0.25	0.30	0.30
United Kingdom	0.78	0.77	0.12	0.01	-0.12	0.04	0.16	0.35

Table 102: Time dependent correlation coefficients between total electricity supply and electricity production from nuclear, 2000-2007

	2000	2001	2002	2003	2004	2005	2006	2007
Austria	-	-	-	-	-	-	-	-
Belgium	-0.30	-0.11	-0.11	-0.10	-0.12	-0.06	-0.13	-0.18
Bulgaria	0.64	0.65	0.65	0.37	0.39	0.42	-	-
Cyprus	-	-	-	-	-	-	-	-
Czech Republic	0.22	0.26	0.05	0.25	0.22	0.17	0.17	0.18
Denmark	-	-	-	-	-	-	-	-
Estonia	-	-	-	-	-	-	-	-
Finland	0.01	0.00	-0.03	-0.03	-0.02	-0.02	-0.15	-0.15
France	0.33	0.31	0.27	0.15	0.13	0.18	0.32	0.39
Germany	0.28	0.26	0.24	0.23	0.23	0.26	0.25	0.34
Greece	-	-	-	-	-	-	-	-
Hungary	0.37	0.33	0.29	0.13	0.09	0.14	0.10	0.12
Ireland	-	-	-	-	-	-	-	-
Italy	-0.28	-0.28	-0.28	-0.27	-0.26	-0.26	-0.26	-0.23
Latvia	-	-	-	-	-	-	-	-
Lithuania	0.88	0.86	0.85	0.85	0.84	0.77	-	-
Luxembourg	-	-	-	-	-	-	-	-
Malta	-	-	-	-	-	-	-	-
Netherlands	0.01	0.01	0.02	0.01	-0.03	-0.05	0.04	-0.09
Poland	-	-	-	-	-	-	-	-
Portugal	-	-	-	-	-	-	-	-
Romania	-0.16	-0.18	-0.18	-0.22	-0.18	-0.19	-	-
Slovakia	0.06	0.06	0.06	0.03	0.06	0.05	0.04	0.18
Slovenia	0.95	0.94	0.94	0.92	0.92	0.91	-	-
Spain	-0.07	-0.08	-0.12	-0.19	-0.17	-0.30	-0.31	-0.01
Sweden	0.13	0.21	0.27	0.27	0.26	0.25	0.30	0.30
United Kingdom	-0.12	-0.13	-0.07	-0.07	0.04	0.04	0.16	0.35

Hydro

Table 103: Time dependent correlation coefficients between total electricity supply and electricity production from hydro, 1980-2007

	1980	1985	1990	1995	2000	2005	2006	2007
Austria	-0.65	-0.45	-0.36	-0.46	-0.29	-0.44	-0.45	-0.38
Belgium	-0.21	-0.33	-0.28	0.11	0.37	0.45	0.50	0.44
Bulgaria	-0.29	0.53	0.54	0.42	0.40	0.31	-	-
Cyprus	-	-	-	-	-	-	-	-
Czech Republic	0.68	0.61	0.69	0.30	0.24	0.01	0.03	0.06
Denmark	-0.67	-0.51	-0.11	-0.30	-0.58	-0.48	-0.44	-0.51
Estonia	-	-	-	-0.04	-0.08	0.03	-	-
Finland	-0.20	-0.29	-0.09	-0.48	-0.11	0.06	-0.15	-0.23
France	0.09	-0.25	0.06	-0.04	-0.07	0.21	0.05	0.02
Germany	-0.49	-0.53	-0.10	0.08	0.27	0.25	0.24	0.22
Greece	-0.51	-0.49	-0.45	-0.28	-0.45	-0.03	-0.08	-0.57
Hungary	0.40	0.34	0.07	0.25	0.25	0.13	0.07	0.10
Ireland	-0.74	-0.02	-0.12	-0.01	0.18	0.25	0.31	0.29
Italy	0.89	0.84	0.05	-0.06	-0.17	-0.20	-0.20	-0.07
Latvia	-	-	-	0.93	0.73	0.70	-	-
Lithuania	-	-	-	0.86	0.78	0.71	-	-
Luxembourg	-0.48	-0.43	-0.23	0.39	0.49	0.31	0.34	0.33
Malta	-	-	-	-	-	-	-	-
Netherlands	-	0.38	0.50	0.37	0.40	0.49	0.41	0.39
Poland	0.33	0.35	0.32	0.27	0.20	0.03	-0.05	0.02
Portugal	0.39	0.50	0.08	-0.26	-0.26	-0.09	-0.21	-0.15
Romania	0.78	0.67	0.50	0.27	-0.01	0.10	-	-
Slovakia	0.85	0.67	0.49	-0.11	-0.13	-0.24	-0.27	-0.25
Slovenia	-	-	-	0.93	0.85	0.62	-	-
Spain	0.04	0.16	-0.07	-0.20	-0.20	-0.22	-0.23	-0.23
Sweden	0.90	0.87	0.77	0.49	0.31	0.47	0.52	0.52
United Kingdom	-0.20	-0.21	-0.02	-0.15	-0.38	-0.36	-0.30	-0.34

Table 104: Time dependent correlation coefficients between total electricity supply and electricity production from hydro, 2000-2007

	2000	2001	2002	2003	2004	2005	2006	2007
Austria	-0.29	-0.42	-0.34	-0.51	-0.45	-0.44	-0.45	-0.38
Belgium	0.37	0.39	0.46	0.43	0.46	0.45	0.50	0.44
Bulgaria	0.40	0.26	0.21	0.27	0.26	0.31	-	-
Cyprus	-	-	-	-	-	-	-	-
Czech Republic	0.24	0.29	0.20	-0.08	0.00	0.01	0.03	0.06
Denmark	-0.58	-0.58	-0.59	-0.48	-0.51	-0.48	-0.44	-0.51
Estonia	-0.08	-0.05	-0.02	0.03	0.02	0.03	-	-
Finland	-0.11	-0.15	-0.18	-0.19	-0.22	0.06	-0.15	-0.23
France	-0.07	-0.06	0.17	0.15	0.15	0.21	0.05	0.02
Germany	0.27	0.28	0.28	0.22	0.22	0.25	0.24	0.22
Greece	-0.45	-0.45	-0.48	-0.03	-0.02	-0.03	-0.08	-0.57
Hungary	0.25	0.25	0.26	0.22	0.15	0.13	0.07	0.10
Ireland	0.18	0.21	0.24	0.25	0.24	0.25	0.31	0.29
Italy	-0.17	-0.18	-0.21	-0.24	-0.32	-0.20	-0.20	-0.07
Latvia	0.73	0.73	0.72	0.72	0.70	0.70	-	-
Lithuania	0.78	0.78	0.77	0.76	0.72	0.71	-	-
Luxembourg	0.49	0.43	0.42	0.22	0.30	0.31	0.34	0.33
Malta	-	-	-	-	-	-	-	-
Netherlands	0.40	0.34	0.37	0.44	0.49	0.49	0.41	0.39
Poland	0.20	0.18	0.20	-0.08	0.03	0.03	-0.05	0.02
Portugal	-0.26	-0.20	-0.06	0.01	-0.08	-0.09	-0.21	-0.15
Romania	-0.01	-0.01	-0.01	-0.08	0.05	0.10	-	-
Slovakia	-0.13	-0.14	-0.15	-0.19	-0.21	-0.24	-0.27	-0.25
Slovenia	0.85	0.85	0.79	0.77	0.65	0.62	-	-
Spain	-0.20	-0.10	-0.19	0.00	-0.12	-0.22	-0.23	-0.23
Sweden	0.31	0.30	0.42	0.53	0.51	0.47	0.52	0.52
United Kingdom	-0.38	-0.33	-0.38	-0.32	-0.37	-0.36	-0.30	-0.34

Renewables

Table 105: Time dependent correlation coefficients between total electricity supply and electricity production from renewables, 1980-2007

	1980	1985	1990	1995	2000	2005	2006	2007
Austria	0.26	0.38	-0.17	0.11	-0.14	0.14	0.30	0.05
Belgium	0.37	0.53	0.52	0.48	0.19	-0.25	0.16	0.11
Bulgaria	-	-	-	-	-0.22	-0.34	-	-
Cyprus	-	-	-	-	-	-	-	-
Czech Republic	-	-	-	0.03	-0.43	-0.33	-0.21	-0.21
Denmark	0.30	0.30	-0.11	-0.12	-0.48	-0.42	-0.52	-0.54
Estonia	-	-	-	-0.06	-0.08	-0.04	-	-
Finland	-	-	0.02	0.14	0.41	0.51	0.58	0.59
France	0.35	0.04	-0.15	0.09	-0.15	-0.32	-0.57	-0.47
Germany	-0.14	-0.07	-0.15	-0.20	0.50	0.32	0.19	-0.10
Greece	-	-	-0.09	0.04	0.77	0.74	0.49	0.41
Hungary	0.72	0.75	0.14	-0.24	-0.22	0.05	-0.06	-0.03
Ireland	-	-	-	0.06	0.64	0.18	0.53	0.21
Italy	0.66	0.58	0.26	0.06	0.35	0.15	0.15	-0.06
Latvia	-	-	-	-	-0.08	0.02	-	-
Lithuania	-	-	-	-	-	0.02	-	-
Luxembourg	-0.11	-0.13	-0.01	0.57	0.64	0.24	0.42	0.37
Malta	-	-	-	-	-	-	-	-
Netherlands	0.30	0.46	0.60	0.60	0.72	0.12	0.13	0.24
Poland	0.77	0.76	-0.06	-0.18	-0.01	0.01	0.21	0.27
Portugal	0.79	0.65	0.36	0.40	0.66	0.26	-0.02	-0.29
Romania	-	-	-	-0.12	-0.11	-0.09	-	-
Slovakia	-	-	-	-0.25	0.06	-0.03	0.19	0.25
Slovenia	-	-	-	-	0.01	0.04	-	-
Spain	-0.15	-0.25	-0.13	0.48	0.92	0.71	0.71	0.65
Sweden	0.47	0.23	0.29	0.30	0.13	-0.03	-0.07	-0.08
United Kingdom	0.58	0.35	0.10	0.06	0.18	0.01	-0.06	-0.21

Table 106: Time dependent correlation coefficients between total electricity supply and electricity production from renewables, 2000-2007

	2000	2001	2002	2003	2004	2005	2006	2007
Austria	-0.14	0.01	0.06	0.23	0.20	0.14	0.30	0.05
Belgium	0.19	-0.08	-0.09	-0.08	0.08	-0.25	0.16	0.11
Bulgaria	-0.22	-0.24	-0.26	-0.28	-0.34	-0.34	-	-
Cyprus	-	-	-	-	-	-	-	-
Czech Republic	-0.43	-0.45	-0.41	-0.48	-0.33	-0.33	-0.21	-0.21
Denmark	-0.48	-0.48	-0.49	-0.39	-0.43	-0.42	-0.52	-0.54
Estonia	-0.08	-0.08	-0.08	-0.07	-0.05	-0.04	-	-
Finland	0.41	0.38	0.39	0.38	0.38	0.51	0.58	0.59
France	-0.15	-0.15	-0.36	-0.26	-0.25	-0.32	-0.57	-0.47
Germany	0.50	0.51	0.43	0.38	0.33	0.32	0.19	-0.10
Greece	0.77	0.64	0.65	0.75	0.75	0.74	0.49	0.41
Hungary	-0.22	-0.22	-0.24	-0.06	-0.15	0.05	-0.06	-0.03
Ireland	0.64	0.51	0.51	0.47	0.25	0.18	0.53	0.21
Italy	0.35	0.28	0.29	0.36	0.19	0.15	0.15	-0.06
Latvia	-0.08	-0.05	-0.01	0.02	0.02	0.02	-	-
Lithuania	-	0.04	0.04	0.05	0.05	0.02	-	-
Luxembourg	0.64	0.63	0.63	0.62	0.56	0.24	0.42	0.37
Malta	-	-	-	-	-	-	-	-
Netherlands	0.72	0.72	0.50	0.51	0.54	0.12	0.13	0.24
Poland	-0.01	-0.03	-0.10	-0.21	0.04	0.01	0.21	0.27
Portugal	0.66	0.67	0.55	0.53	0.51	0.26	-0.02	-0.29
Romania	-0.11	-0.11	-0.11	-0.11	-0.10	-0.09	-	-
Slovakia	0.06	-0.03	-0.02	-0.07	-0.01	-0.03	0.19	0.25
Slovenia	0.01	0.01	0.03	0.03	0.03	0.04	-	-
Spain	0.92	0.84	0.66	0.68	0.71	0.71	0.71	0.65
Sweden	0.13	0.04	-0.04	-0.09	-0.03	-0.03	-0.07	-0.08
United Kingdom	0.18	0.04	-0.02	-0.02	-0.06	0.01	-0.06	-0.21

Net imports

Table 107: Time dependent correlation coefficients between total electricity supply and electricity net imports, 1980-2007

	1980	1985	1990	1995	2000	2005	2006	2007
Austria	0.74	0.60	0.24	0.28	0.22	0.39	0.47	0.48
Belgium	-0.04	-0.17	-0.42	-0.05	0.18	0.20	0.32	0.47
Bulgaria	-0.16	-0.90	-0.19	0.05	0.11	0.02	-	-
Cyprus	-	-	-	-	-	-	-	-
Czech Republic	0.75	0.64	-0.22	0.46	-0.03	-0.02	0.00	0.03
Denmark	-0.34	-0.52	-0.52	-0.51	-0.81	-0.74	-0.78	-0.80
Estonia	-	-	-1.00	-0.96	-0.93	-0.90	-	-
Finland	0.55	0.26	0.00	-0.02	0.34	-0.64	-0.72	-0.70
France	-0.50	-0.12	-0.02	-0.17	-0.07	0.30	0.30	0.18
Germany	-0.47	-0.48	-0.38	-0.15	-0.08	-0.03	0.04	0.00
Greece	0.83	0.43	0.09	0.00	-0.15	-0.18	-0.18	0.14
Hungary	-0.16	0.07	0.38	0.87	0.57	0.43	0.45	0.29
Ireland	-	-	-	-0.35	-0.21	0.05	-0.22	0.24
Italy	0.66	0.70	0.46	0.18	0.20	0.21	0.17	0.15
Latvia	-	-	1.00	0.90	0.65	0.63	-	-
Lithuania	-	-	-1.00	-0.86	-0.80	-0.71	-	-
Luxembourg	0.41	0.33	0.38	0.89	0.89	0.22	0.28	0.24
Malta	-	-	-	-	-	-	-	-
Netherlands	-0.47	-0.41	0.12	0.01	-0.09	-0.13	-0.21	0.01
Poland	-0.53	-0.22	0.36	0.43	0.42	0.20	0.26	0.29
Portugal	-0.25	-0.24	-0.48	-0.16	-0.20	-0.06	0.05	-0.11
Romania	0.47	0.34	-0.13	0.44	0.47	0.39	-	-
Slovakia	-0.50	-0.39	-0.35	0.52	0.59	0.57	0.59	0.31
Slovenia	-	-	-1.00	-0.52	-0.47	-0.22	-	-
Spain	0.72	0.53	0.28	0.33	0.09	-0.17	-0.15	-0.02
Sweden	-0.22	-0.30	-0.20	-0.22	-0.04	-0.33	-0.41	-0.40
United Kingdom	-0.46	-0.26	0.37	0.36	0.10	-0.01	0.01	0.09

Table 108: Time dependent correlation coefficients between total electricity supply and electricity net imports, 2000-2007

	2000	2001	2002	2003	2004	2005	2006	2007
Austria	0.22	0.32	0.28	0.46	0.38	0.39	0.47	0.48
Belgium	0.18	-0.11	0.00	0.01	0.04	0.20	0.32	0.47
Bulgaria	0.11	0.06	0.03	0.08	0.08	0.02	-	-
Cyprus	-	-	-	-	-	-	-	-
Czech Republic	-0.03	0.01	0.04	-0.11	-0.07	-0.02	0.00	0.03
Denmark	-0.81	-0.81	-0.79	-0.74	-0.75	-0.74	-0.78	-0.80
Estonia	-0.93	-0.93	-0.93	-0.90	-0.90	-0.90	-	-
Finland	0.34	0.25	0.27	0.13	0.12	-0.64	-0.72	-0.70
France	-0.07	-0.06	0.11	0.34	0.35	0.30	0.30	0.18
Germany	-0.08	-0.08	-0.06	-0.05	-0.05	-0.03	0.04	0.00
Greece	-0.15	0.02	0.01	-0.15	-0.16	-0.18	-0.18	0.14
Hungary	0.57	0.55	0.56	0.52	0.51	0.43	0.45	0.29
Ireland	-0.21	-0.03	0.10	0.03	0.03	0.05	-0.22	0.24
Italy	0.20	0.18	0.18	0.13	0.27	0.21	0.17	0.15
Latvia	0.65	0.65	0.64	0.64	0.63	0.63	-	-
Lithuania	-0.80	-0.78	-0.77	-0.77	-0.76	-0.71	-	-
Luxembourg	0.89	0.89	0.26	0.29	0.24	0.22	0.28	0.24
Malta	-	-	-	-	-	-	-	-
Netherlands	-0.09	-0.09	-0.03	-0.02	-0.08	-0.13	-0.21	0.01
Poland	0.42	0.42	0.40	0.15	0.21	0.20	0.26	0.29
Portugal	-0.20	-0.23	-0.29	-0.26	-0.06	-0.06	0.05	-0.11
Romania	0.47	0.44	0.42	0.44	0.48	0.39	-	-
Slovakia	0.59	0.59	0.58	0.57	0.54	0.57	0.59	0.31
Slovenia	-0.47	-0.44	-0.35	-0.25	-0.21	-0.22	-	-
Spain	0.09	0.06	0.09	-0.07	-0.25	-0.17	-0.15	-0.02
Sweden	-0.04	-0.15	-0.32	-0.40	-0.33	-0.33	-0.41	-0.40
United Kingdom	0.10	0.10	0.16	0.11	-0.02	-0.01	0.01	0.09