Overall Energy Efficiency Trends and Policies in the EU 27

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Lessons from the ODYSSEE MURE project

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This brochure was prepared by Bruno Lapillonne from Enerdata and Wolfgang Eichhammer from the Fraunhofer Institute for Systems and Innovation Research. All the information on energy efficiency indicators is taken from the Odyssee database and website, managed by Enerdata in France. The information on policy measures relies on the MURE database, developed and maintained at ISIS in Italy by Stefano Faberi, Michela Fioretto and Nicola Piccioni and coordinated by Wolfgang Eichhammer and Barbara Schlomann from Fraunhofer ISI in Germany. These researchers continually propose improvements which resulted in the ODYSSEE-MURE tools becoming the leading instrument in European monitoring and evaluation of energy efficiency trends.

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Didier Bosseboeuf
project leader

[1] Alphabetic order of countries

Key Messages

This publication presents an overall view on energy efficiency policies and trends in energy use and energy efficiency in the EU27. It relies on the following two databases that cover all EU-27 member countries plus Croatia and Norway:

- ✓ The **ODYSSEE** database on energy efficiency indicators, with data on energy trends, drivers for energy use, explaining variables and energy-related CO_2 emissions (**www.odyssee-indicators.org**).
- ✓ The **MURE** database with policy measures on energy efficiency, including the impact of the measures (**www.mure2.com**).

Both tools are used to support energy policy formulation by the European Commission, e.g. as part of the monitoring and evaluation of the Energy Service Directive. The following points summarise the key messages from the analysis in this study:

- The energy efficiency of final consumers improved by 13 % on average in the EU-27 between 1996 and 2007. This resulted in energy savings of about 160 Mtoe, of which half in industry.

- Energy efficiency improvements, for the EU-27 as a whole, as measured with ODEX, seemed to be in line or above the indicative target of the Directive for Energy Efficiency and Energy Services (ESD) for many countries. However, the definition of energy savings is not directly comparable as the ESD target comprises also Early Action (e.g. savings achieved in 1995-2007 which is the time span before the main period 2008-2016 for which the ESD target of 9% is defined).

- In most countries and sectors, there has been a slowdown in energy efficiency progress since 2000, which is partly explained by the slower economic growth (business cycle effect). The performances achieved by the various countries range from 2 to 20 %.

- The decoupling between energy use and economic activity is continuing: since 1990, energy consumption has been growing at only one third of the rate of the GDP. In the period 2004-2007 this rate has further slowed down to nearly a full decoupling[2]. Electricity use was still growing with three quarters of the GDP rate since 1990, slowing down to around 60% of GDP growth in 2004-2007.

- Structural changes in the economy had a marginal influence on the energy intensity reduction of final consumers and explain about 10 % of this reduction from 1990 to 2007 in the EU as a whole.

[2] Final energy normalised for annual climate variations. The uncorrected final energy use was even decreasing during that period.

- CO_2 emissions have decreased by 0.3 %/year on average since 1990, mainly from 1990 to 2004 (-1.6 %/y) and since 2003 (-0.6 %/y). Almost 40 % of this reduction is due to substitution to fuels with lower emission factors, the rest is due to a reduction in energy intensity.

- Major new energy efficiency policies have been introduced over the past years and are at present implemented although some of them face major delays and strong debate about the exact design. This includes measure such as the revised Energy Performance Directive for Buildings (EPBD), the Eco-design Directive and its implementing regulation, the CO_2 strategy for cars, the Energy Efficiency and Services Directive etc. The latter was suffering from a lengthy debate about methodological questions how to measure energy efficiency. The Odyssee indicators made major contributions to its implementation with the development of top-down evaluation methods. Although one can debate in how far this Directive has already had a strong impact in terms of energy savings, it has structured and given much more public view to the energy efficiency measures undertaken by each Member States. Through this achievement, one could say that this Directive has already achieved substantial progress although much more progress is aimed at, in particular with the creation of a market for energy services.

- Energy efficiency policies have developed a considerable dynamics with a strongly increasing number of energy efficiency measures in all sectors over time. The patterns of policy measures undertaken across the different Member States and the different sectors vary according to the national debate and practices and to the specific energy uses.

- EU energy efficiency policies have an increasing impact at the national level. However, the impact is still quite different from sector to sector. While EU measures represent already nearly one third of all measure in the residential sector (in particular due to the impact of the appliance labelling Directives) and in the general cross-cutting measures (due to measures such as the CHP Directive, renewables policies which impact on decentralised renewables, and the eco-design Directive), it is still weaker in Transport, Industry and the Tertiary sectors.

- The EU aims in the present debate for a stringent energy efficiency target (20 % by 2020), possibly on a mandatory basis. This raises many questions about the interaction of such a stringent policy with existing policy instruments such as the EU ETS or the renewables promotion schemes. White certificates, which are also discussed in this context, may further complicate the debate and could sharpen the debate about the interaction of instruments such as the White Certificate Scheme and energy efficiency regulation. In such cases the integrity of an existing instrument could be a strong argument not to introduce a new instrument, because existing instruments tend to develop their own “lobby” who believes that this particular instrument is the most suitable one. This implies that ways need to found between providing a relatively stable environment for a policy tool to develop its impact on one hand, and the need to adapt the instruments, once potentially more suitable policy instruments are debated. The present problem with the debate on energy efficiency targets is that it comes years after the debate on supply side measures (on particular renewables) and has to cope now with a rather crowded policy landscape. The development of the energy efficiency action plan by the EU needs to deal with these policy interactions and possibly also reshape other policy instruments.

- Substantial further energy efficiency potentials remain to be opened up by new or enhanced policy measures. This was shown in a parallel work to this study with the MURE simulation tool: even under cautious assumptions on energy prices 20 % reduction of final energy consumption may be achievable in economic terms by 2020. This requires nevertheless an ambitious approach which has not been the case over the past decade with the delays encountered for example with the Energy Performance Directive for Buildings since 2002.

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1. Introduction

1.1. Objective of the brochure

The aim of this brochure is to provide insight into past developments for energy use, energy efficiency trends and related policy measures across all sectors of the economy in the EU-27. Three other brochures complement this brochure with a more detailed view on the residential and tertiary sectors, the transport sector and the industrial sector. This should help policymakers and other parties involved in energy efficiency and CO_2 emission reduction in adapting present policy and formulating new effective policy measures. Although the main focus is on energy efficiency improvement and the effect of various policy measures, other drivers affecting the energy demand trends are also considered, such as the impact of economic growth, economic cycles and energy prices.

This analysis is based on two databases, ODYSSEE on energy efficiency indicators (**Box 1.1**) and MURE (**Box 1.2**) on policy measures that cover the EU-27 plus Croatia and Norway.

Box 1.1: ODYSSEE database

The ODYSSEE database (www.odyssee-indicators.org) is used for the monitoring and evaluation of annual energy efficiency trends and energy-related CO_2 emissions. The energy indicators are calculated for the years from 1990 on (EU-15 countries) or from 1996 on (new Member States). The inputs for the indicators are provided by national energy agencies or institutes according to harmonised definitions and guidelines.
ODYSSEE encompasses the following types of indicators[3]:

- Energy/CO_2 intensities: relate the energy used in the economy or a sector to macroeconomic variables (e.g. GDP, value added).
- Specific energy consumption: relate energy consumption to physical indicators (e.g. specific consumption per ton of product);
- Energy efficiency indices by sector (ODEX) to evaluate energy efficiency progress (in %).
- Energy savings to measure the amount of energy saved through energy efficiency improvements.
- Adjusted indicators to allow the comparison of indicators across countries (in particular adjustments for differences in industrial structure).
- Benchmark/target indicators by sector to show the potential improvement based on countries with the best performance (evaluation based on adjusted indicators).
- Indicators of diffusion to monitor the market penetration of energy-efficient technologies (e.g. share of high efficiency motors).

The indicators from the ODYSSEE database are now used to monitor trends in energy efficiency among countries in a harmonised way. They are increasingly used by the European Commission as well as by several international organisations, among others:

[3] The methodological issues and precise definitions of indicators and data are dealt with at the end in a specific section "Definitions and Glossary".

- DG-TREN: the EC has made explicit reference to the ODEX indicators in the Energy Service Directive as a way of contributing towards monitoring the Directive in a so-called "top-down" approach. The EMOS database (Energy Market Observatory) includes about 20 indicators from ODYSSEE. The Energy Demand Management Committee of ESD has proposed indicators similar to those of ODYSSEE to measure energy savings with top-down methods.
- EEA (European Environmental Agency): uses data and indicators taken from the ODYSSEE database for different annual reports: Energy and Environment Report[4] and TERM report[5], for instance. ODYSSEE indicators were also used in the fourth pan-European environment assessment report (UNECE).
- IEA, The International Energy Agency: ODYSSEE data are used by the IEA to construct their own indicators for European countries. In addition, IEA has developed a questionnaire to collect the data necessary to calculate the indicators similar to the ODYSSEE data template.

Box 1.2: MURE database

The MURE database (www.mure2.com) provides an overview of the most important energy efficiency policy measures by sector (households, industry, transport and tertiary), as well as general or cross-cutting measures. Information about these measures is collected by national energy agencies or institutes according to harmonised guidelines. The measures are classified according to various criteria:

- their status (completed, on-going or planned);
- their year of introduction and completion;
- their type: legislative/normative (e.g. standards for new dwellings), legislative/informative (e.g. obligatory labels for appliances), financial (e.g. subsidies), fiscal (e.g. tax deductions), information/education, cooperative (e.g. voluntary agreements) and taxes (on energy or CO_2-emissions).
- their qualitative impact: low, medium or high impact, based on quantitative evaluations or expert estimates (see methodological issues)
- the targeted energy users, the actors involved, etc.

For each policy measure a detailed description is available which contains, if available, a quantitative impact in terms of energy-savings and/or CO_2 emission reduction.

The MURE database provides a structuring format to EU Member States for reporting measures in the National Energy Efficiency Action Plans requested by the European Commission within the implementation of the Energy Service Directive (ESD). In addition, the MURE simulation tool, attached to the database, has been used by the EU Commission to assess the energy-saving potentials over the period 2010-2030[6].

[4] EEA: Energy and environment report 2008, November 2008; http://www.eea.europa.eu/publications/eea_report_2008_6

[5] TERM monitors indicators tracking transport and environment integration in the European Union; http://www.eea.europa.eu/publications/transport-at-a-crossroads

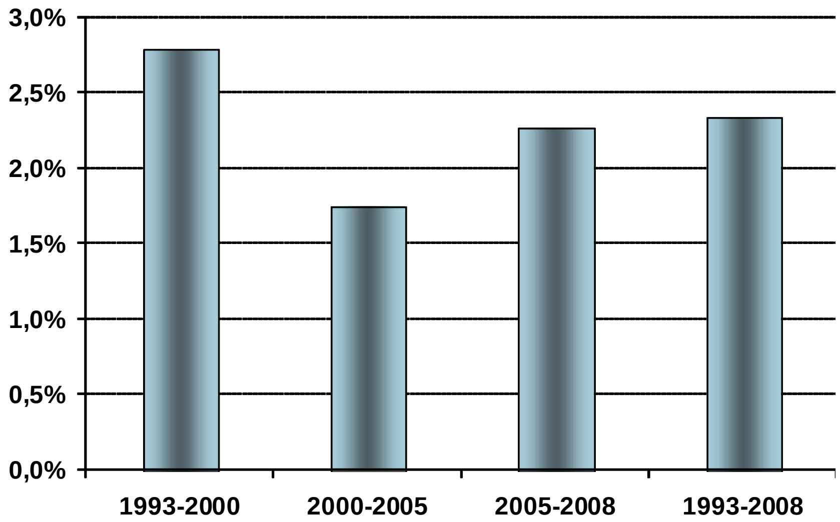
[6] DG TREN: Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries, March 2009 http://ec.europa.eu/energy/efficiency/studies/efficiency_en.htm

2. The economic and energy price context

2.1. The economic context

Since 1993, the GDP has increased by 2.3%/year on average in the European Union **(Figure 2.1)**. The economic growth was more sustained over the period 1993-2000 (2.8 %/year). After a lower growth between 2000 and 2005 (1.8 %/year), the GDP growth rate increased to around 3%/year between in 2006 and 2007 and slowed down significantly in 2008 (0.8 %).

Figure 2.1 : Economic growth in the EU



Source: Odyssee

2.2. Energy prices

The average prices of imported fuels (oil[7] , steam coal, natural gas) remained quite stable until 1999 **(Figure 2.2)**. A first increase in prices occurred in 2000: respectively 59 % for oil (from 18 $/bl to 28 $/bl) and 48 % for gas. After a period of relative stability from 2000 to 2004, international fuel prices started to rise sharply in 2004. Between 2004 and 2008, these prices have been multiplied by a factor 2 for gas, 3 for oil (97 $/bl) and 4 for coal. In 2009, the oil price has decreased to reach at the minimum the level of 2005 (around 50 $/bl). In recent month oil prices have re-increased to beyond 75 $/bl again.

In Euro, the growth in energy prices is lower than in US dollar due to the effect of change in US$ / € parity; indeed in Euro since 1990 the oil price has been multiplied by 3.5 (compared to 4.1 if prices are expressed in $), the price of gas by 3.2 (3.7 in $) and the price of coal by 2.2 (2.6 in $).

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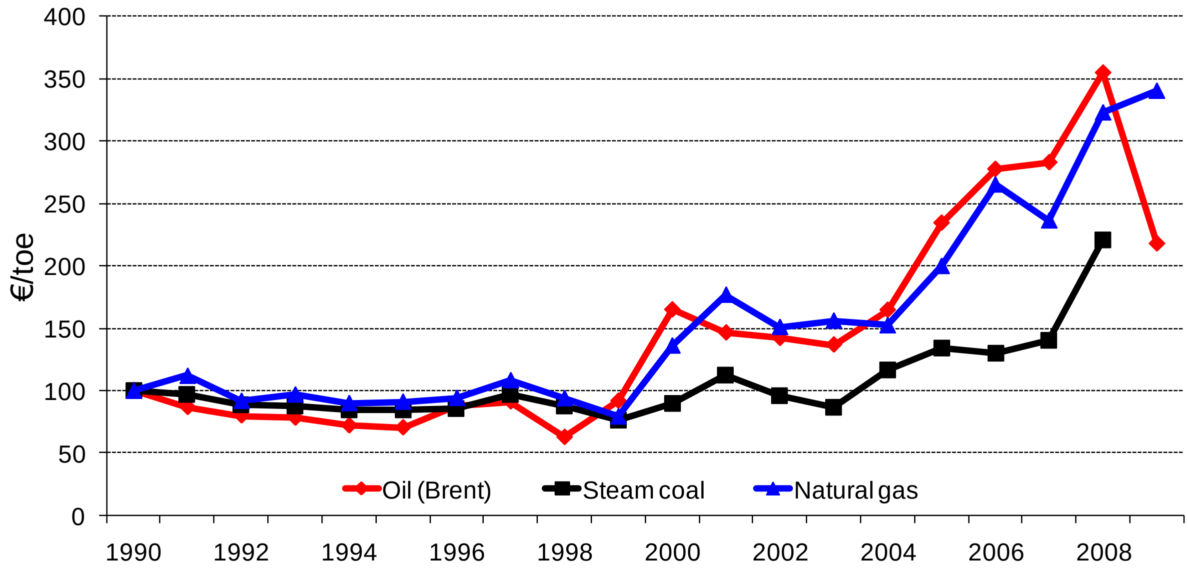
[7] Brent

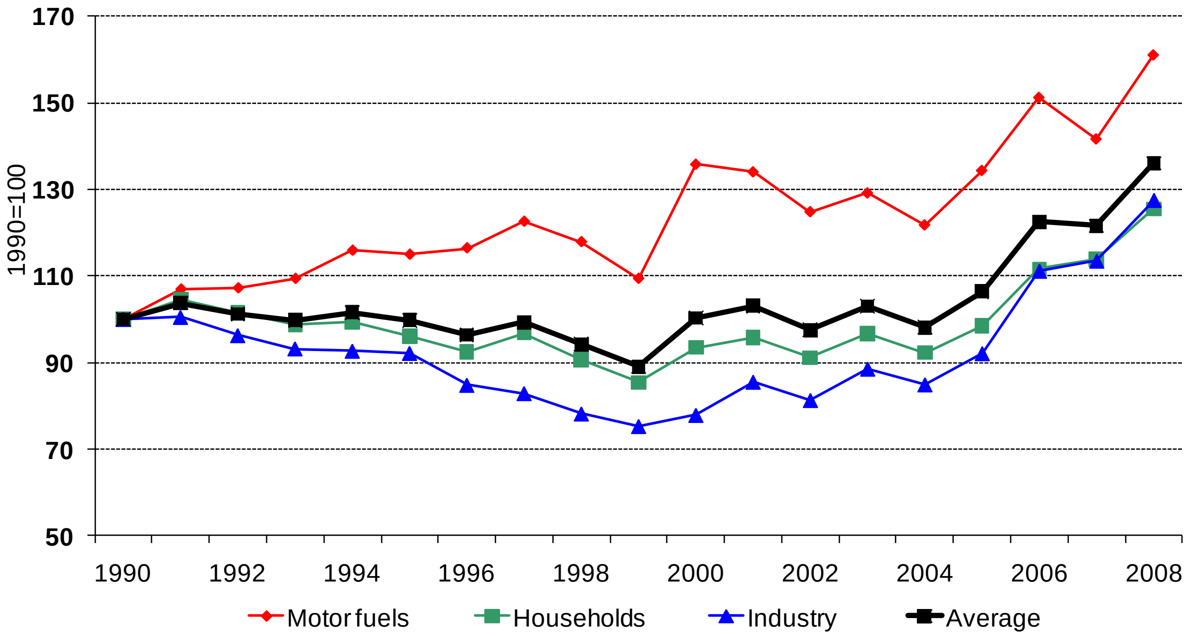
Figure 2.2 : International energy prices[8] in Euro



Final consumers saw 50% energy price increase in real terms between 1990-2008

The average energy price paid by final consumers has increased regularly in real terms[9]. The progression was the most rapid since 1999 and reached 53 % over 1999-2008: the progression was 47 % in road transport (average for motor fuels), 47 % for households (weighted average of electricity, gas and fuel oil) and 69 % in industry **(Figure 2.3)**.

Figure 2.3 : Trend in energy prices for final consumers



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[8] Prices of 2009 based on the two first quarter

[9] Prices corrected for inflation.

Fuel prices have strongly increased especially for oil products (+113 % for fuel oil in industry, +68 % for heating oil for households) and natural gas (+89 % in industry, +31 % for households). Electricity prices, both in industry and for households, have, however, decreased between 1990 and 2008 (by 3 and 4 % respectively).

3. Overall energy efficiency trends

3.1. Energy consumption trends

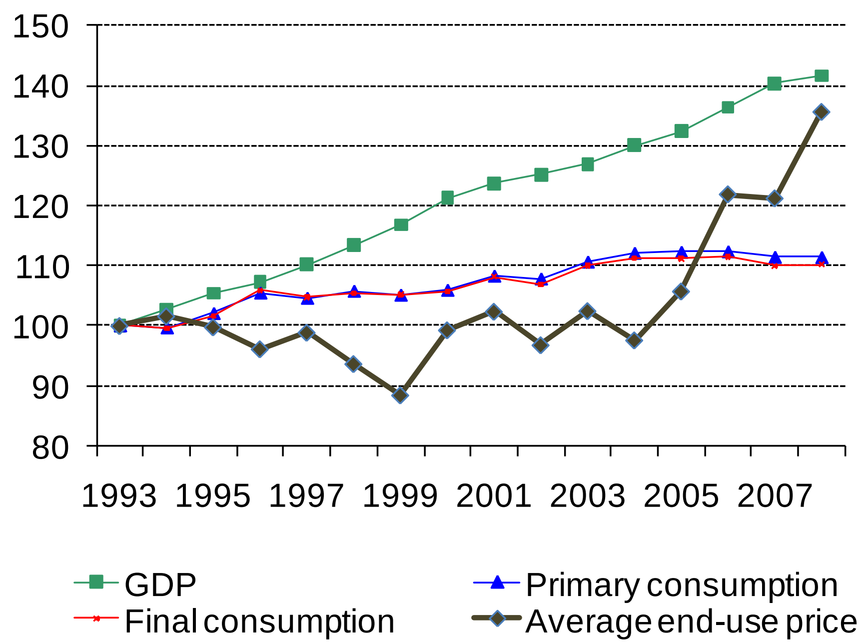
Decrease of the primary and final energy consumption since 2005

Since 2005, the energy consumption has been decreasing (-0.5%/year)[10] despite a rapid expansion of the economy, at least until 2007 (+3 %/year for the GDP) (**Figure 3.1** and **Figure 3.2**). This trend was probably influenced by the rapid increase in international energy prices as well as the energy efficiency and climate policies implemented by the EU Commission and by national governments.

The period 1993-2000 was characterized by a rather low progression of the energy consumption (0.8 %/year) compared to the rapid economic growth (2.8 %/year). Between 2000 and 2004, the lower economic growth (1.8 %/year) was accompanied by a more rapid evolution of the consumption (+1.1 %/year). On average since 1993, energy consumption has progressed three times slower than the GDP.

The primary and final energy consumption increased at approximately the same rate between 1993 and 2008 (0.7%/year on average) in the EU-27 (**Figure 3.1**) and amounted to around 1900 Mtoe and 1200 Mtoe, respectively.

Figure 3.1 : Energy consumption[11] and GDP in the EU

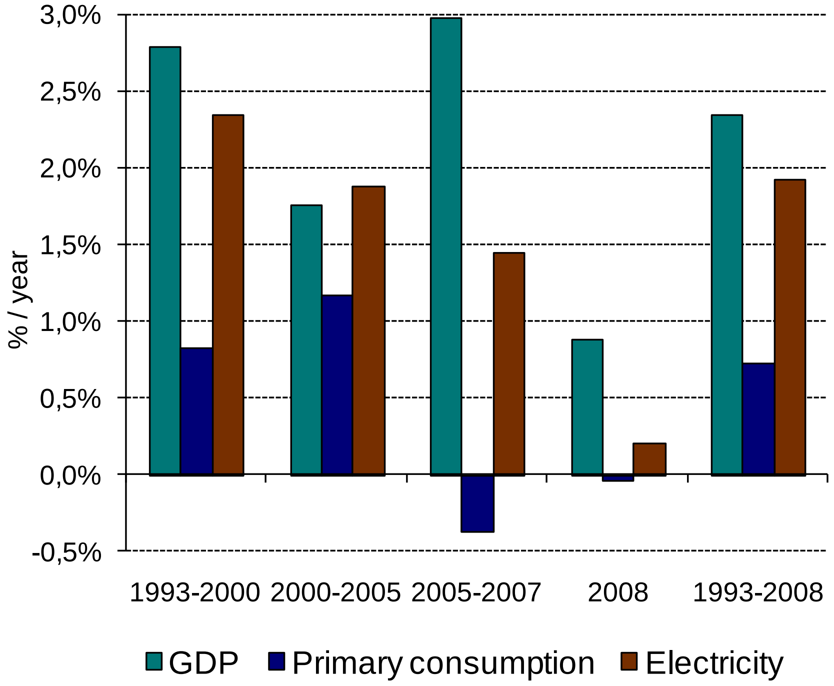


[10] After normalisation for annual climate variations energy consumption was still slightly increasing.

[11] Source of data: elaboration Enerdata from Eurostat; energy consumption under normal climate conditions, i.e. with climatic corrections, excluding non-energy uses, which are not affected by energy efficiency issues.

Electricity consumption underwent a more rapid progression than the total energy consumption (1.9 %/year on average since 1993), slowing down to 1.5 %/year since 2005.

Figure 3.2 : Trends in GDP, primary consumption and electricity consumption (EU)



In almost all new member countries, data are available since 1996/1997; this is why comparisons between countries will be based on this period.

The trends by country show a large decoupling between the primary/final energy consumption and the economic growth **(Figure 3.3)**. In most countries, the high economic growth was possible with a low progression in energy consumption (UK, Lithuania, Belgium, Estonia) or even a reduction in some countries (Romania, Germany, Poland); in Slovenia, Malta and Cyprus, there is, however, a rapid progression of the energy consumption (around 2 %/year).

Around 70% of the total EU consumption in 7 countries

Around 50 % of the final energy is consumed by three countries (Germany, France and UK) and almost 60 % by four countries if Italy is added and around 70% with two more countries (Spain and Poland). EU-15 countries plus Poland represent around 90% of the total final energy consumption of the EU **(Figure 3.4)**.

Figure 3.3 : Primary energy consumption and GDP in EU countries (1997-2007)

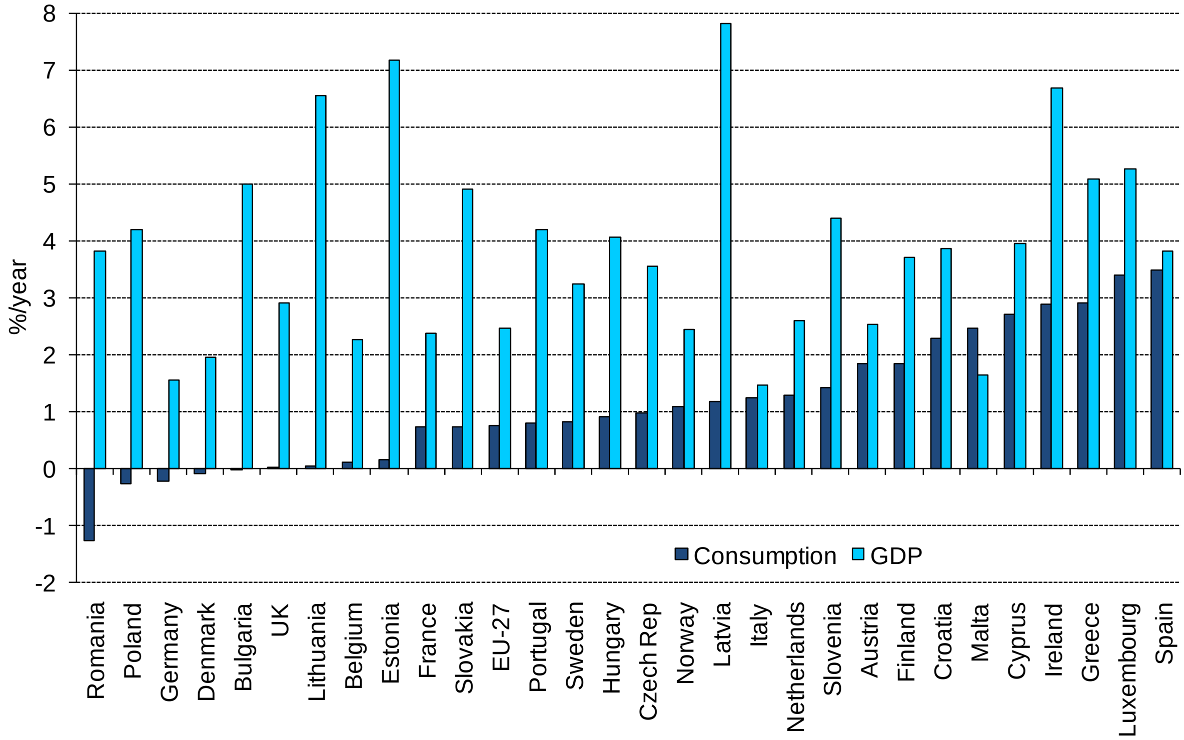


Figure 3.4 : Final energy consumption by country in the EU

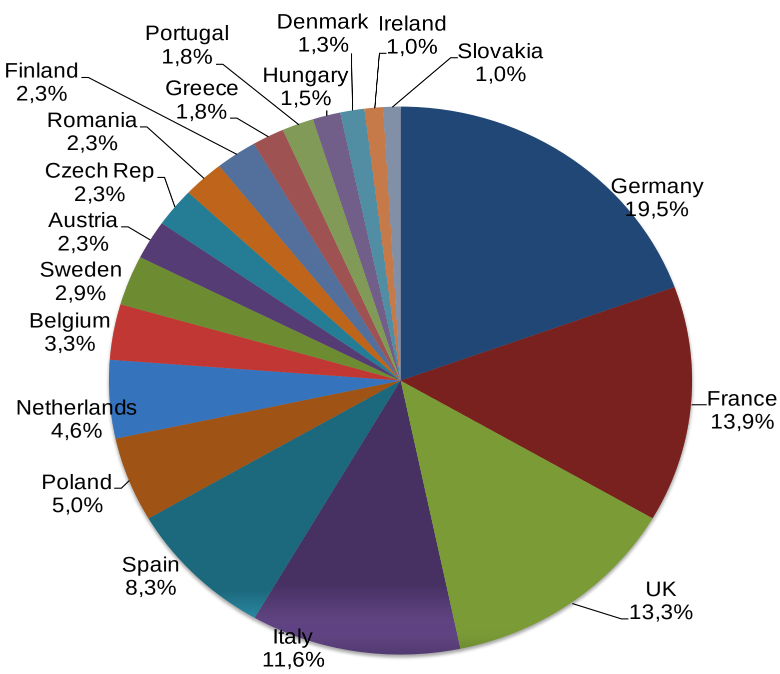
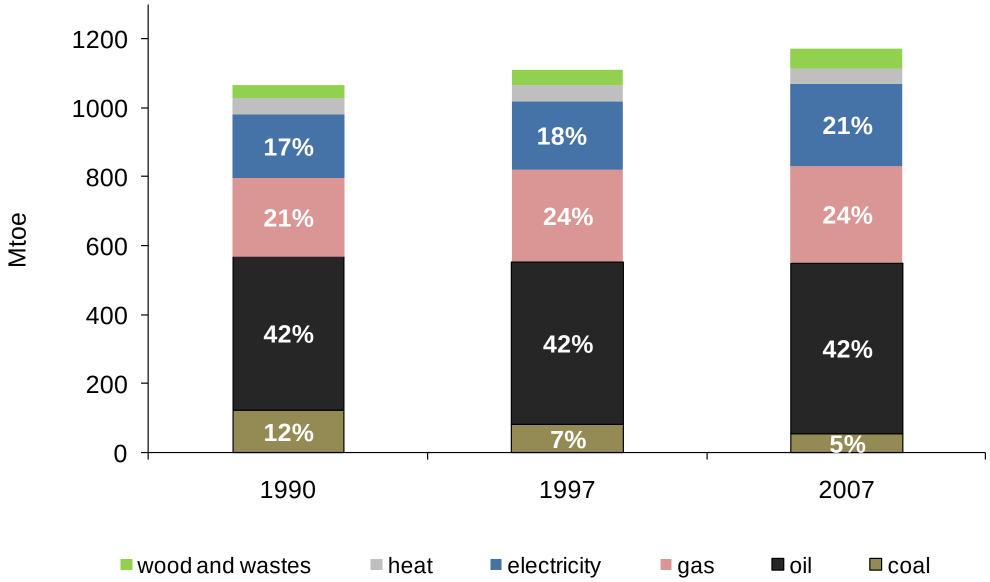


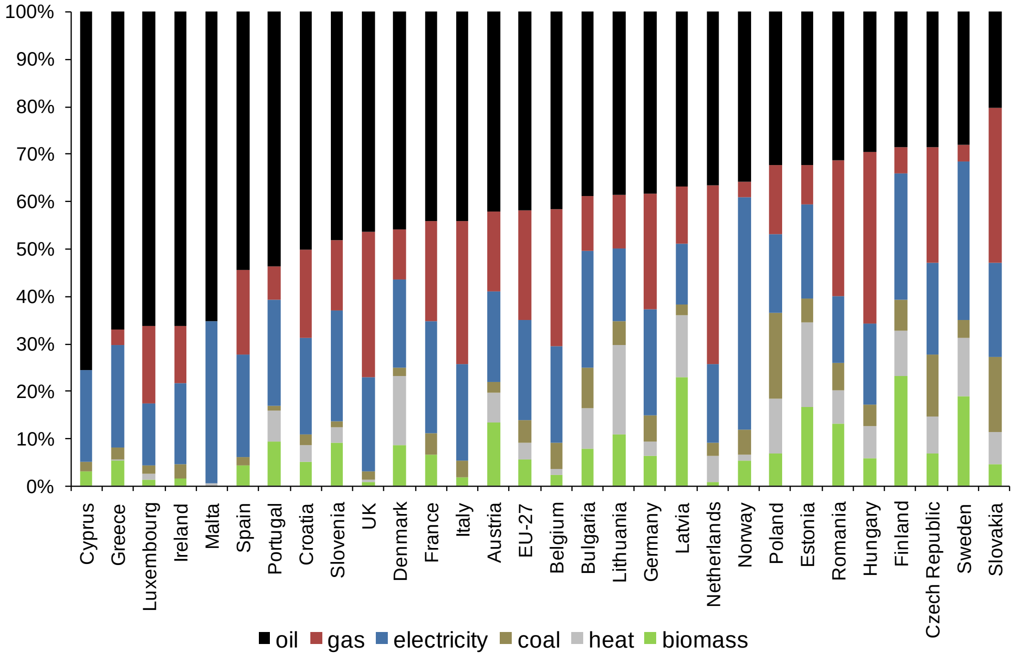
Figure 3.5 : Final energy consumption by energy source in the EU-27[12]



Increasing contribution of electricity

The contribution of oil, the dominant energy source in the final energy consumption, remained almost stable over the period 1990 -2007 (around 42 %) (**Figure 3.5**): its substitution by gas and other fuels in thermal uses in industry, households and services was offset by a rapid increase in motor fuel demand (1.6 %/ year on average over the period 1990-2007).

Figure 3.6 : Final energy consumption by energy source in EU countries (2007)



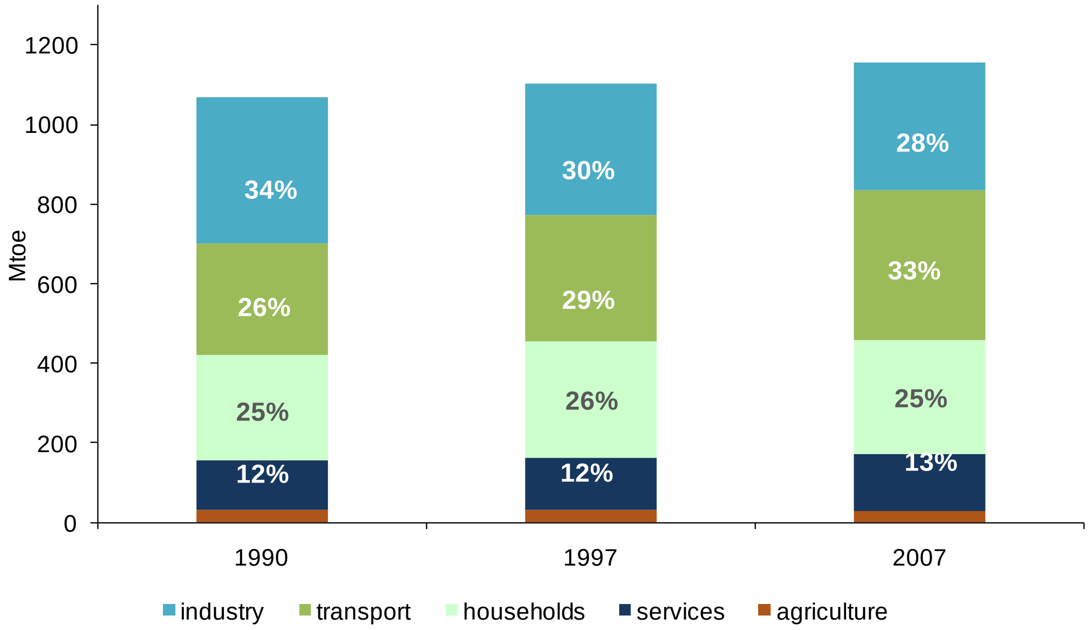
12 Energy consumption measured under normal climate conditions, excluding non-energy uses.

The share of gas increased from 21 % in 1990 to 24 % in 1996 and remained stable since then. The market share of electricity increased by 4 points and reached almost 21 % in 2007 compared to 17 % in 1990. Biomass plays a minor but increasing role (3 % in 1990, 5 % in 2007).

The contribution of each energy form varies quite a lot among countries, depending on their energy resources and climate (**Figure 3.6**); for some countries such as Cyprus, Greece, Luxemburg, Ireland and Malta, oil represents around 70 % of the energy consumed, due to a high share of transport (2007). On the opposite, in Nordic countries (Sweden, Finland, Norway) and some Central European countries (Slovakia, Czech Republic, Hungary and Romania), oil is no longer a dominant source of energy (20-30 %),and is replaced by gas or electricity. Biomass has a more significant contribution in Austria, Latvia, Estonia, Finland and Sweden.

Buildings (households and service sector) absorb around 40 % of the final energy consumption (**Figure 3.7**). The share of industry has decreased from 34% to 28% contrary to transport which represents nowadays 33 % of the final consumption (up from 26 % in 1990).

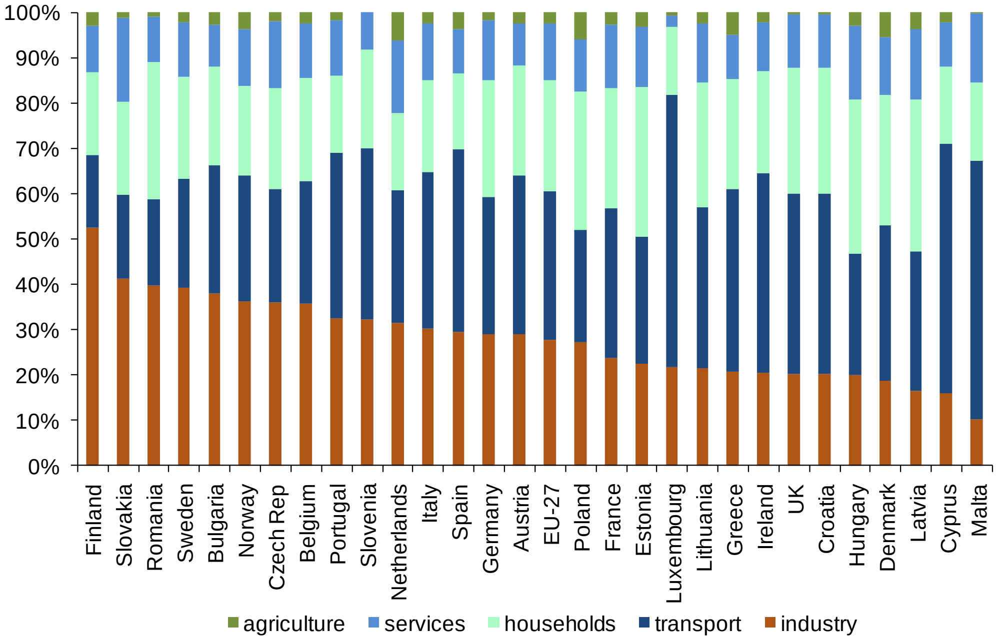
Figure 3.7 : Final energy consumption by sector in the EU-27[13]



The sector mix between countries is quite diverse with a share of industry ranging from more than 50% in Finland and around 25% in Latvia and Cyprus (**Figure 3.8**).

[13] Energy consumption measured under normal climate conditions, excluding non-energy uses.

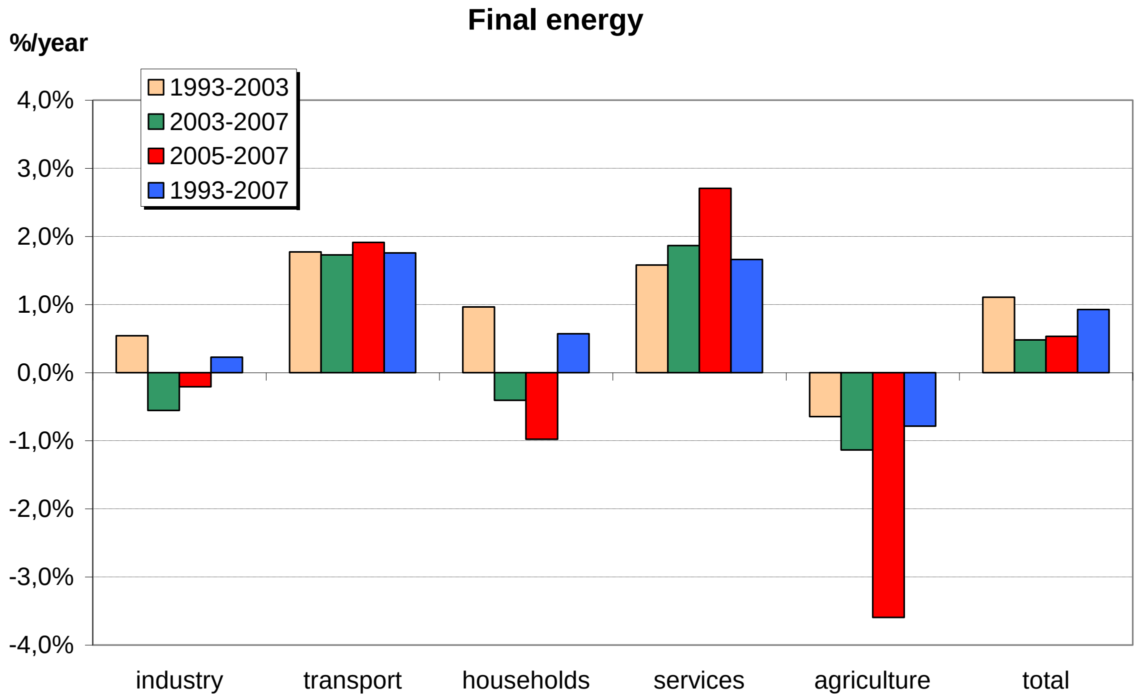
Figure 3.8 : Final energy consumption by sector in EU countries (2007)



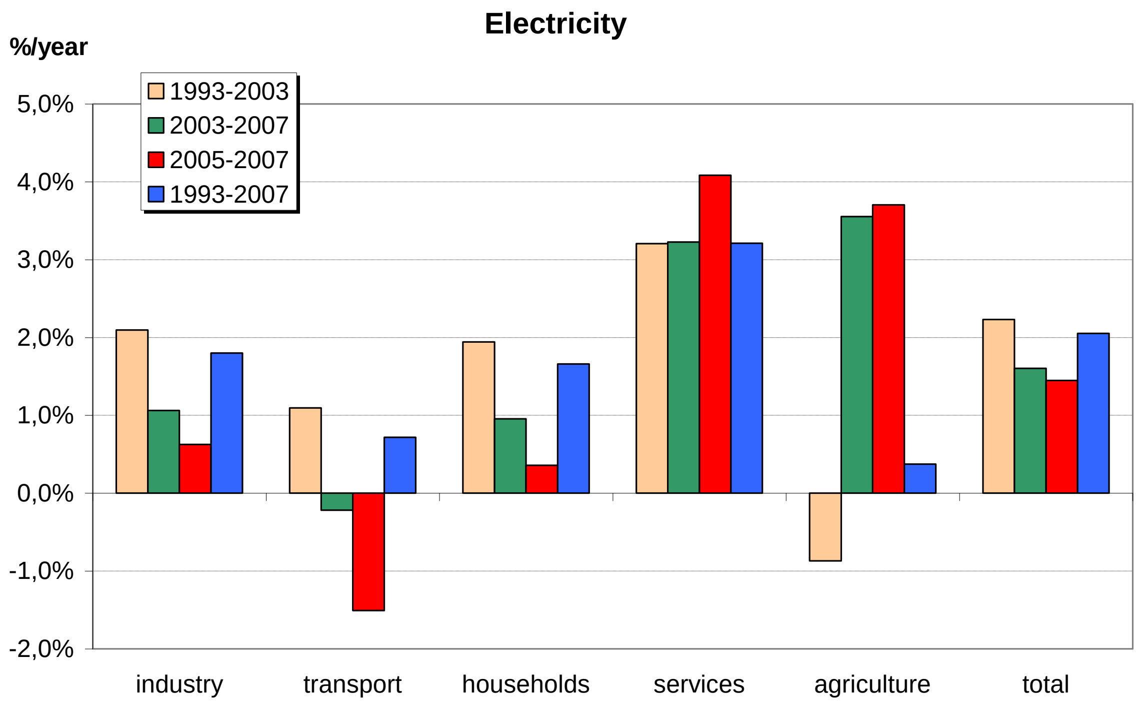
Slowdown since 2003 of the energy consumption in all sectors except in services

Figure 3.9 shows the average annual trends in final energy and electricity consumption per sector in the periods 1993-2003, 2003 to 2007 and for the total period. We have also added the more recent period 2005-2007 which is interesting due to the strong increase in energy prices for fossil fuels. Since 2003, the slowdown in the final energy consumption (0.5 %/year compared to 1.1 %/year for the period before) can be observed in all sectors except services where the consumption continues its rapid growth (+1.7 %/year). For electricity, the slowdown after 2003 is less important (1.6 %/year compared to 2.2 %/year over 1993-2003) and mainly takes place in industry and households. In services the electricity consumption progression remains vigorous (+3.2 %/year). Electricity in transport and agriculture presents a minor part of consumption.

Figure 3.9 : Annual average final energy trend by sector: total and electricity



Note: Households, services and total at normal climate



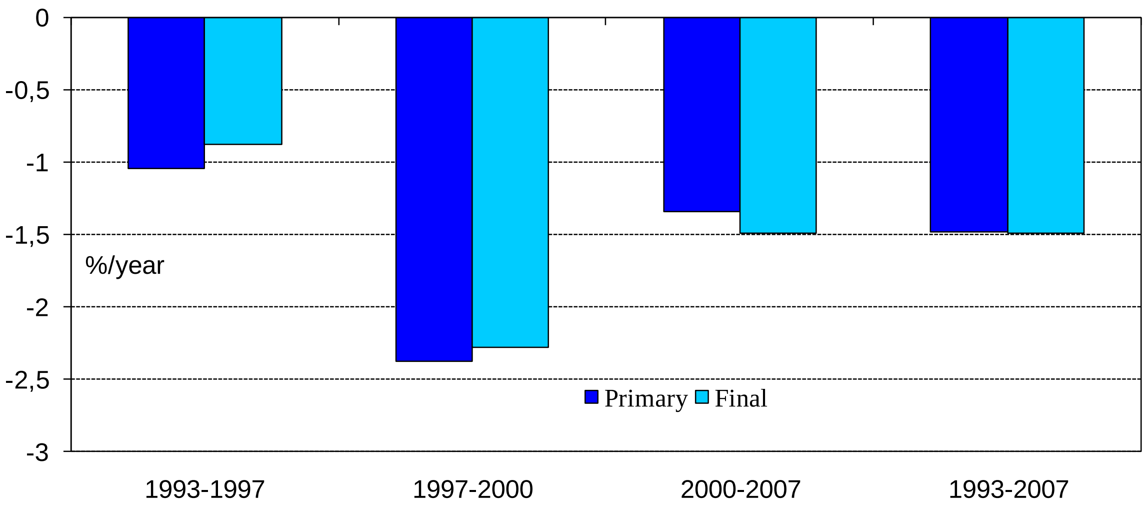
3.2. Trends in primary and final energy intensities

The primary energy intensity, which relates the primary energy consumption[14] of a country to its GDP, measures how much energy is required to generate one unit of GDP. Its variation over time reflects the influence of various factors, which include energy efficiency improvements but also changes in the nature of the economic activity (the "economic structure") or in the structure of the energy mix, changes in lifestyle (more appliances, more cars) etc.

Since 1993, there is a continuous decoupling between energy use and GDP

Since 1993, primary and final energy intensities have been decreasing by about 1.5 %/year in the EU-27; in 2007, these intensities were 20 % below their 1992 values. If we take into account the average economic growth over this period, this effectively means that energy consumption is growing three times less rapidly than the GDP. Between 1997 and 2000, the reduction in energy intensities was more rapid, and slightly more pronounced for the primary than for the final energy intensity: 2.4 %/year and 2.3 %/year respectively (**Figure 3.10**). Since 2000, there is a slowdown in the intensity reduction, 1.3 %/year and 1.5 %/year for the primary and final energy intensity respectively.

Figure 3.10 :Primary and final energy intensities in the EU-27[15]



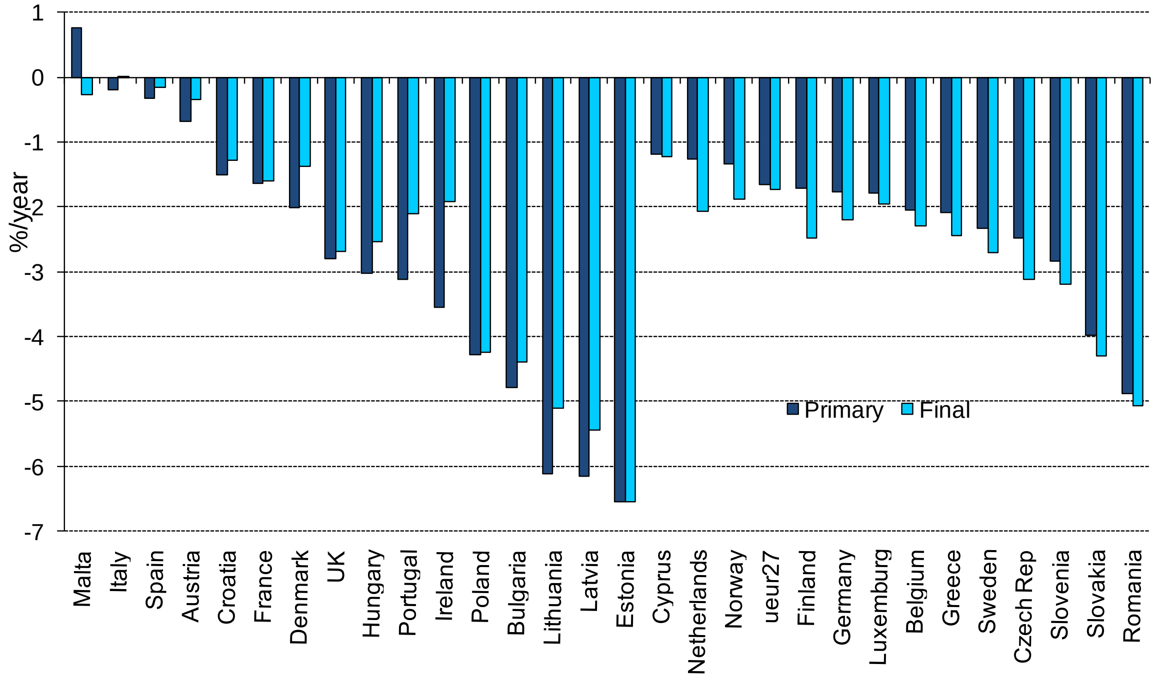
[14] The primary energy consumption of a country represents its total energy consumption; it is also called "total primary energy supply"

[15] Under normal climate conditions.

The primary energy intensity has decreased faster than the final intensity in half of the countries because of an improvement in the efficiency of electricity generation

Since 1997, the primary energy intensity decreased faster on average – or increased slower- than the final energy intensity in half of the countries (**Figure 3.11**). This tendency results from an overall improvement in the average efficiency of power generation linked to the rapid penetration of gas-combined cycles, cogeneration and wind.

Figure 3.11 : Variation of primary and final energy intensities in EU countries[16]



In the other countries, part of the reduction in the final energy intensity is offset by increasing losses in energy transformation

For the other countries as well as for the EU-27 as a whole, the final energy intensity has decreased faster than the primary energy intensity: this means that increasing losses in energy transformation offset part of the reduction in the final energy intensity. These higher losses may come from more rapid growth in electricity consumption for final end-users (compared to fossil fuels), which results in increased losses in the electricity sector[17], and/or changes in the electricity generation mix (towards less efficient technologies, such as nuclear). A third reason for a larger increase in primary energy use than in final energy is the non-energy use of fuels, in particular in the chemical industry. This phenomenon is particularly apparent in Norway, Finland and The

16 Under normal climate conditions (1997-2007)

17 If electricity is produced by nuclear or thermal power plants, there are significant losses in electricity generation that are accounted for in the transformation sector (losses of 66 % for nuclear and between 65 and 50 % on average for conventional thermal power plants)

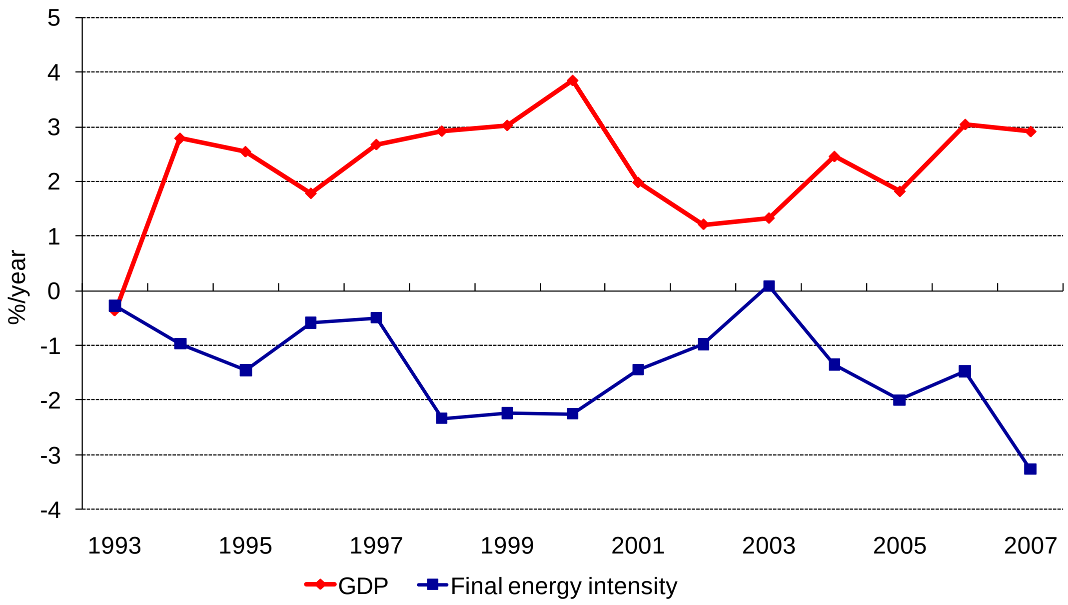
Netherlands, where about one third of the final energy intensity decrease "disappears" at the level of primary energy intensity.

The higher the GDP growth, the faster the energy intensity decreases

The final energy intensity of the EU-27 tends to decrease more if economic growth accelerates and especially if it is above 2 %/year (1994-1995, 1997-2000, 2004, 2006-2007) (**Figure 3.12)**. Otherwise, it decreases less or even increases with very slow economic growth or a recession. This phenomenon is due to the fact that part of the final energy consumption is not correlated with the GDP and remains stable regardless of the state of the economy.

Nevertheless, several years of steady economic growth, a more intensive use of industrial facilities as well as a faster replacement of existing equipment by new more efficient ones all contribute to improving energy efficiency and therefore to lowering energy intensity.

Figure 3.12 :Development of GDP and final energy intensity in the EU-27[18]



[18] Under normal climate conditions.

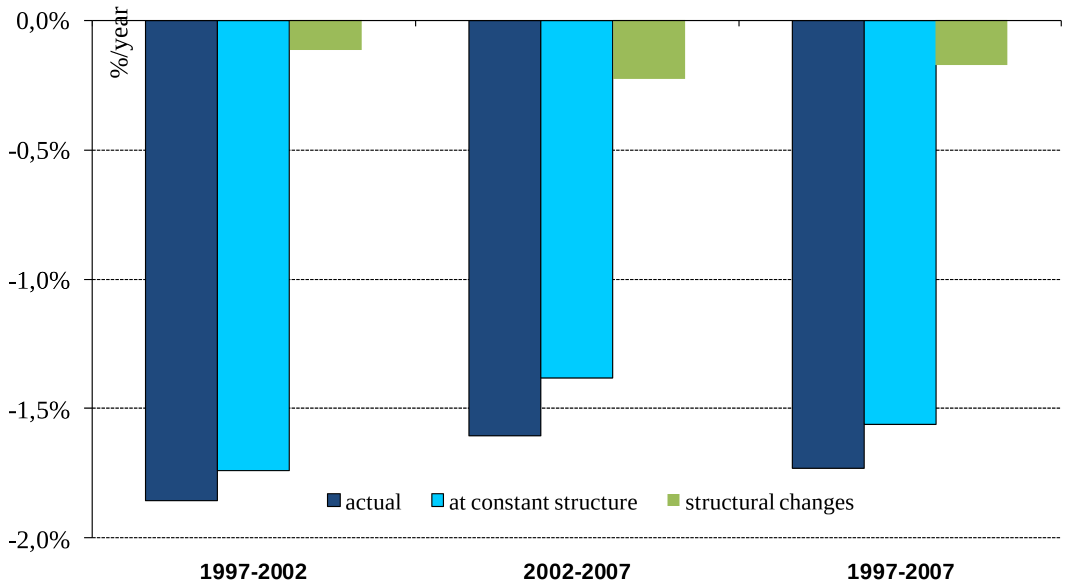
3.3. Effect of structural changes in the economy on the energy intensity

In most EU countries and at EU level, changes in the economic structure towards less energy-intensive branches contributed to slightly lower the energy intensity

Final energy intensities are influenced by structural changes in the economy i.e. shifts in the GDP structure among economic or industrial branches. For instance, an increasing share of services in the GDP, all other things being equal, results in a decrease of the final energy intensity because it requires much less energy to create one unit of GDP in the services sector than in the manufacturing industry (by a factor of 7 as an average for the EU-27[19]). For the same reason, a falling contribution of energy-intensive branches to the industry value added also results in a decrease of the final energy intensity.

The impacts that modifications in the economic structure have on the energy intensities will of course depend on the magnitude of these structural changes[20]. In the EU as a whole, the contribution of services to the GDP has only increased marginally from 61.7 % in 1997 to 64.4 % in 2007 and changes in the industry structure were on average rather limited. As a result, structural changes had a small effect on the final intensity reduction[21] and only explain 10 % of the reduction over 1997-2007 (**Figure 3.13**).

Figure 3.13 : Impact of structural changes in the economy on the final intensity (EU)



19 Manufacturing is 10 to 15 times more intensive than services in Belgium, Bulgaria, Portugal, Cyprus, Spain, Greece and even higher in Norway (17)

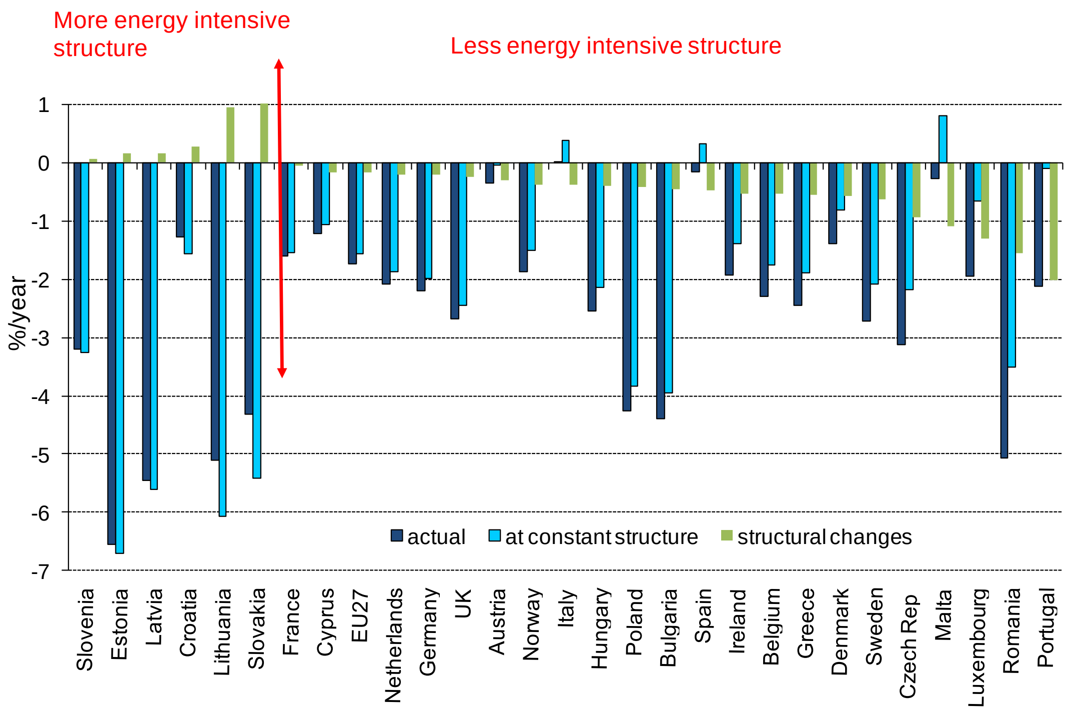
20 Changes in the industry structure are discussed in the industry chapter

21 Structural changes taken into account include changes in the share of the different economic sectors in the GDP (services, agriculture, construction, mining and manufacturing), as well as changes within manufacturing branches. Changes in the industry structure are discussed in a separate brochure on the industry sector.

The services' share in the GDP varies presently from around 40 % in Romania or Ireland to around 66-70 % for Greece, Latvia, Netherlands, France, UK and even 71 % and 76 % for Estonia and Luxemburg.

In most countries, the observed final energy intensity has decreased faster than the intensity at constant structure; this means that these countries have moved to a less energy intensive economic structure (**Figure 3.14**). Structural changes have a significant impact in the intensity reduction in Denmark, Luxembourg and Portugal; in Ireland, Czech Republic and Romania, these structural changes were responsible for about 30 % of the intensity reduction. In Greece Sweden and Belgium, their contribution was around 25%. In Greece and Romania, the high growth in services explains most of this trend: the share of services in the GDP increased by 11 points in Romania and 8 points in Greece, compared with 4 points for the EU as a whole.

Figure 3.14 : Impact of structural changes on the final energy intensity[22]



In some other new member countries such as Slovakia, Lithuania, Latvia, Estonia, Slovenia and Croatia, structural changes had a negative impact on the energy intensity reduction because the actual intensity has decreased less than the intensity at constant structure: it means that these countries have a more energy intensive structure now than in former time. In Slovakia and Estonia, the share of services in the GDP decreased to the advantage of industry (-13 points for services and + 5 points for industry in Slovakia; -2 points for services, + 3 points for industry in Estonia).

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[22] 1997-2007; energy consumption under normal climate conditions; countries are ranked according to the importance of structural changes from the left to the right of the figure. The impact of structural changes within manufacturing is included in this figure; these effects are presented in more detail in the industry report.

3.4. Comparison of energy intensities

Energy intensities need to be adjusted before any comparison

The amount of energy required to generate one Euro of GDP varies quite a lot from one country to another, e. g. by a factor above 5 between Ireland or Denmark, the least energy-intensive countries in the EU, and Bulgaria, at the other extreme. Only 7 countries are within a range of 10 % around the EU average energy intensity. Some of the differences observed in the final energy intensity levels can be explained by specific national characteristics (e.g. climate, industrial specialisation, transport infrastructures, urban patterns). In order to make a more realistic comparison, the final energy intensities need to be corrected to account for these national characteristics.

Three types of adjustments are quantified in the ODYSSEE database :

- adjustment of the GDP in purchasing power parities to account for differences in the general price level;
- adjustment in heating requirements to account for climatic differences
- and finally, adjustment in the economic structures to account for differences in the nature of the economic and industrial activities.

Even if care has to be taken with such adjustments, they can give a more accurate picture of the relative position of countries than the usual energy intensities.

Figure 3.15 and **Figure 3.16** summarise the results of all the adjustments and rank the countries according the value of their adjusted intensities.

For countries with energy-intensive industrial activities (e. g. Finland and Greece), or with low general price levels (e. g new Member countries, Portugal or Greece), or with cold climate (e.g. Nordic and Baltic countries), the adjusted value is below the observed intensity. These adjustments narrow the gap among countries[23]. This is particularly true for new member countries where the average price level is much lower than in EU-15 countries: for instance, the adjusted intensity is twice lower than the observed one in Bulgaria, Romania, Latvia, Czech Republic and Estonia: for these countries, their adjusted intensity is more in line with other EU countries.

For most other countries (12 out of 29), the adjustments have the opposite effect and increase the final energy intensity: the adjustments show that in fact they require more energy per unit of GDP than indicated by the observed intensity: the adjustment is significant in Ireland, Denmark, UK, France, Norway, Italy, Austria and Sweden.

[23] In general, these adjustments are larger for small countries than for large countries which are by definition closer to the EU-27 average because of their respective weight in the EU-27 economy.

Figure 3.15 : Adjusted final energy intensities[24] (2007)

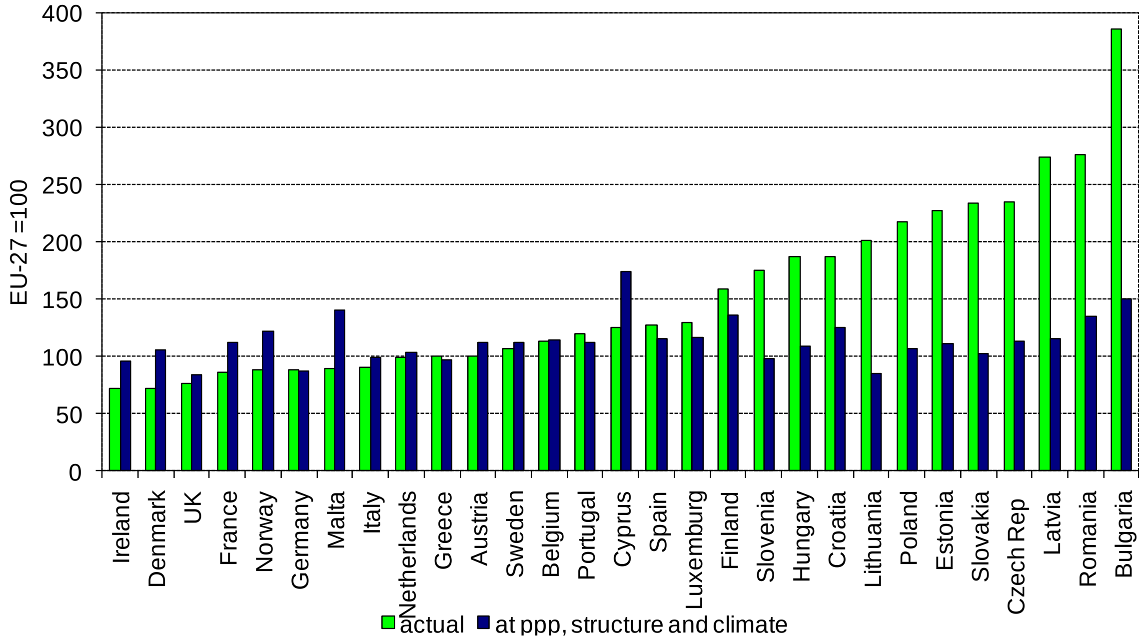
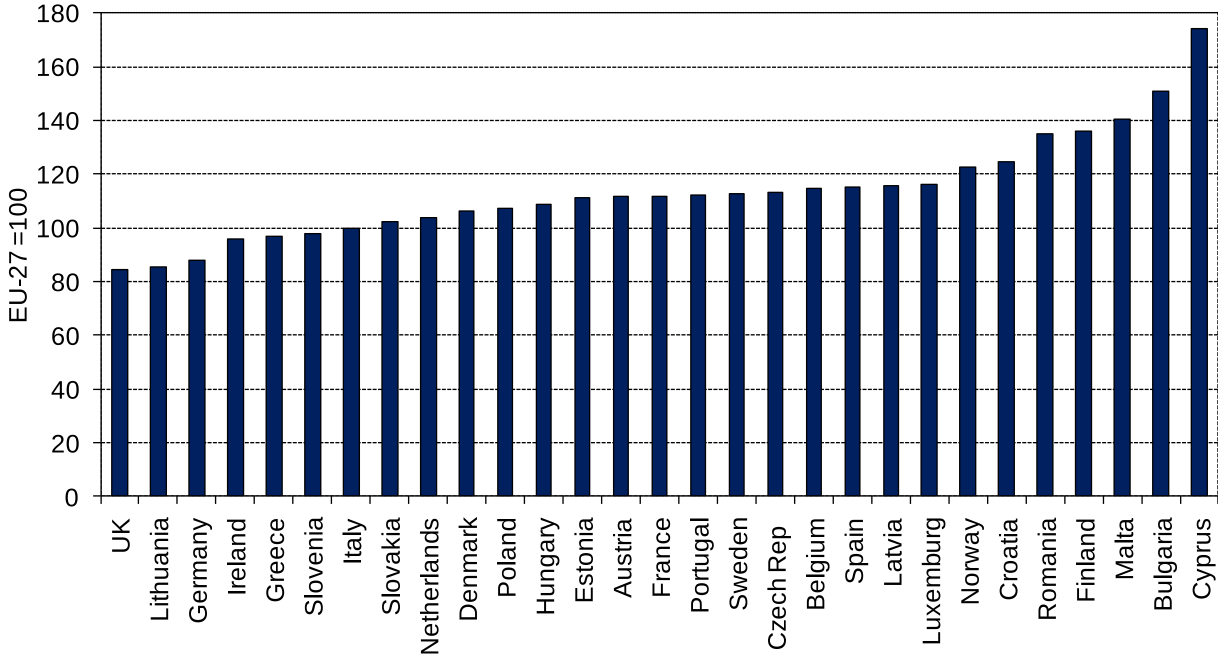


Figure 3.16 : Adjusted final energy intensities re-ordered (2007)



After these adjustments, UK turns out to be the country with the lowest final energy intensity, followed by Lithuania and Germany (**Figure 3.16**).

[24] For Finland, a large part of the industry is dependant from the paper production: so the adjusted intensity is based on the physical production instead of value added. For Luxemburg, transport consumption is artificially high because of fuel purchase by foreign vehicles; for Malta and Cyprus, as the climate is much warmer than the EU average, no adjustment on climate is done. In addition in Malta, as the industrial activity is only based on few industries (water processing and machinery), no adjustment is done on the industrial structure.

Adjusted final energy intensities compare overall performances in energy productivity and not energy efficiency performances from a technical viewpoint: several additional factors are still embedded in the relative values of these adjusted intensities:

- difference in the diffusion of household appliances and cars and in behaviours (e.g. preference for large cars) and the building stock structure (e.g. share of single family houses, of recent buildings);
- differences in the fuel mix for final consumers ;
- differences in the mix between transport modes: between cars and public transport in passenger traffic, or between road and rail for freight transport;
- differences in the mix of product/process within industrial branches (e.g. share of electric steel).

Therefore more accurate comparisons can only be done at the sectoral level with technico-economic ratios rather than with energy intensities.

3.5. Energy efficiency progress in the EU-27

Energy intensities assess global energy productivity and not energy efficiency progress from a technical viewpoint

Trends in final energy intensities, even adjusted for the influence of changes in the structure of economic and industrial activities, as done above with the final energy intensity at constant structure, cannot be used to assess the results of policy measures dedicated to energy efficiency and more generally to monitor trends in energy efficiency. Indeed, three types of factors influence trends in final energy intensity, of which only the first two may be considered to measure energy efficiency:

- Spread of energy-efficient technologies and equipment, behaviour and practices.
- Energy substitutions in favour of energies with high end-use efficiency (e.g. district heating, natural gas or electricity);
- Economic and social changes not captured in the GDP structure:
    - in the mix between transport modes: substitution between cars and public urban transport modes in passenger traffic, or between road and rail goods transportation;
    - in the mix of products and processes within industrial branches (e.g. a larger share of electric steel);
    - or, finally, in living standards: increasing appliance or car ownership, changes in the size of cars and household appliances, changes in the share of single family houses in the building stock; increased heating comfort, diffusion of new services and appliances (air conditioning, PC's…).

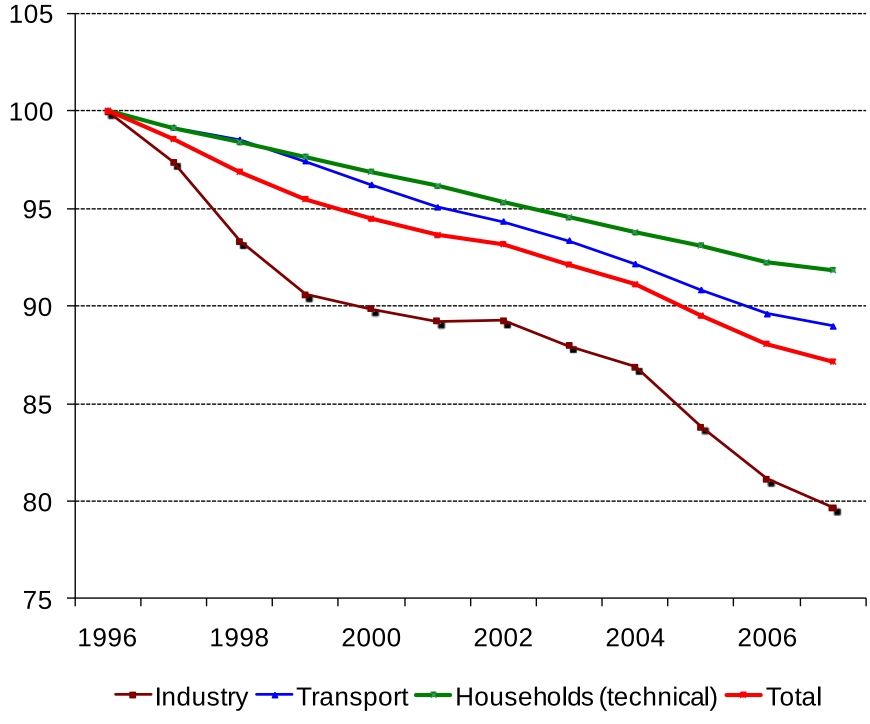
These factors usually have contradictory influences on energy intensities: the first two factors contribute to curbing final energy intensities at constant structure, whereas the third one often tends to increase these intensities, all other things being equal. The contribution of the last factor is all the more significant if the country is less developed: it probably plays a decisive role in Southern, Central and Eastern European countries.

In order to well identify the role of energy efficiency and better assess the actual results of energy efficiency policy measures, specific energy efficiency indicators, expressed as indices, have been developed in ODYSSEE to measure the achievements observed at the level of the main end-uses and appliances, the so-called **"ODEX"**. This index aggregates the trends revealed by the detailed indicators by end-use and equipment in a single indicator. It provides an alternative indicator for energy intensities (industry and transport) or unit consumption (per dwelling for households) to describe the overall trends by sector (see glossary).

Energy efficiency in the EU-27 improved by about 13 % between 1996 and 2007

Energy efficiency policies and measures implemented as well as autonomous technological progress have contributed to improving the energy efficiency by 1.2 %/year on average between 1996 and 2007 at the EU level (**Figure 3.17**).

Figure 3.17 :Energy efficiency progress in the EU-27[25]



Industry is the sector which achieved the largest energy efficiency improvement, with a regular energy efficiency gain of 1.9 %/year on average between 1996 and 2007. For households and transport, regular but lower progress has been registered (respectively

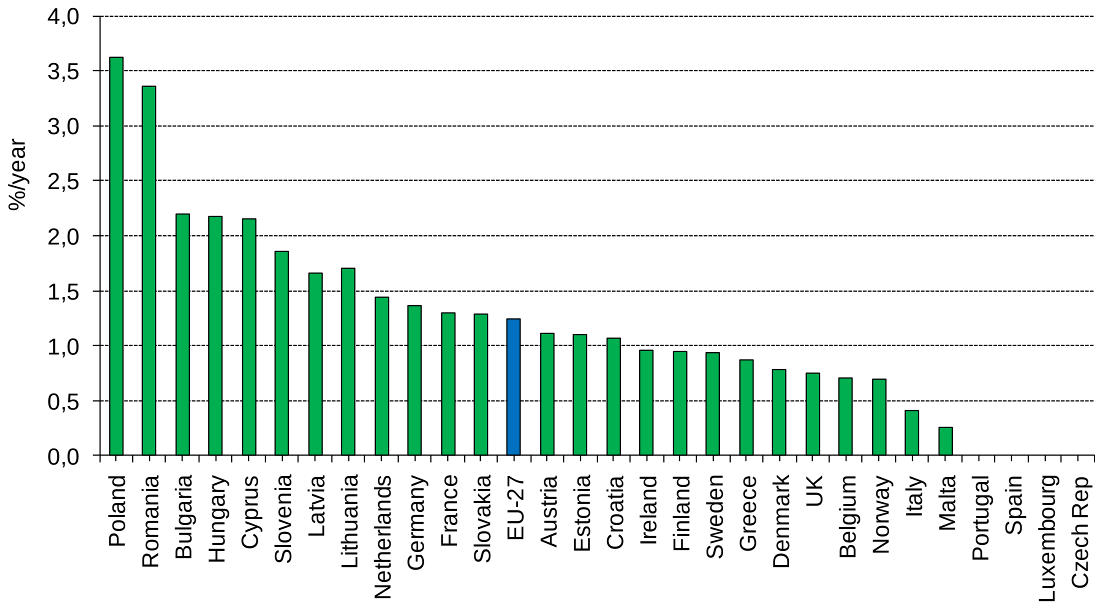
[25] The ODEX is calculated as a 3 years moving average to avoid short-term fluctuations (imperfect climatic corrections, behavioural factors, business cycles).It is calculated for households, industry and transport. Services are not included due to the difficulty of grasping energy saving with existing data.

0.7 % and 1 %/year). The progression is rather regular over time in all sectors: about the same annual decrease is observed after 2000 than over the whole period.

Compared to pure bottom-up evaluations, energy efficiency gains measured in ODYSSEE have a broader scope as they include all sources of energy efficiency improvements, whatever their driving factor: policy measures, price changes, autonomous technical progress or other market forces; in other words, the ODEX measures total energy savings.

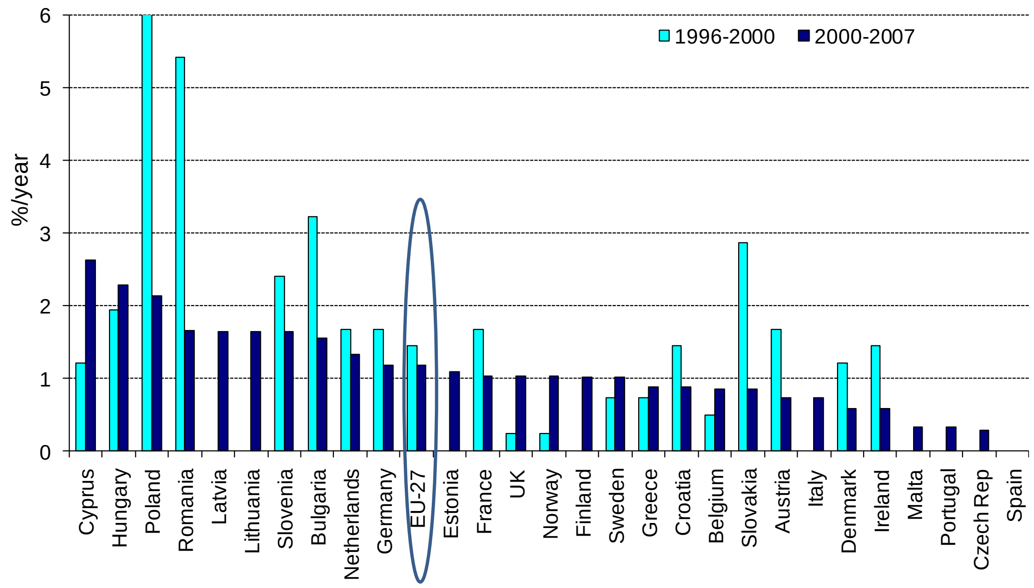
The improvement in energy efficiency is higher or close to 2 %/year for six new member countries, Poland, Romania, Bulgaria, Hungary, Cyprus and Slovenia (**Figure 3.18**); for 11 countries this improvement is close to 1%/year (1.2%/year for the EU-27 average). In four countries (Czech Republic, Luxembourg, Spain and Portugal), no energy efficiency gains have been registered over the period 1997-2007. These results should be obviously considered carefully because the energy efficiency gains are dependent on the time period; the results can also be influenced by the data quality and availability, especially in transport where a split of the energy consumption of road transport by mode (cars, trucks and light vehicles, bus) is not always available.

Figure 3.18 :Energy efficiency progress by country (1996-2007)



In almost all countries, there has been a slowdown in energy efficiency progress since 2000 except for some countries such as Cyprus, Hungary, UK, Norway, Sweden, Greece and Belgium (**Figure 3.19**).

Figure 3.19 : Energy efficiency progress in EU countries by period[26]



For some countries such as The Czech Republic, Portugal, Italy energy efficiency gains appeared since 2000 (no gain over the period 1996-2000). For Spain, no energy efficiency improvement has been registered since 1996 mainly due the transport sector. In more than half of the countries and in the EU as a whole, the rate of energy savings is in line or above the annual target set in the ESD[27].

About 160 Mtoe energy savings in 2007

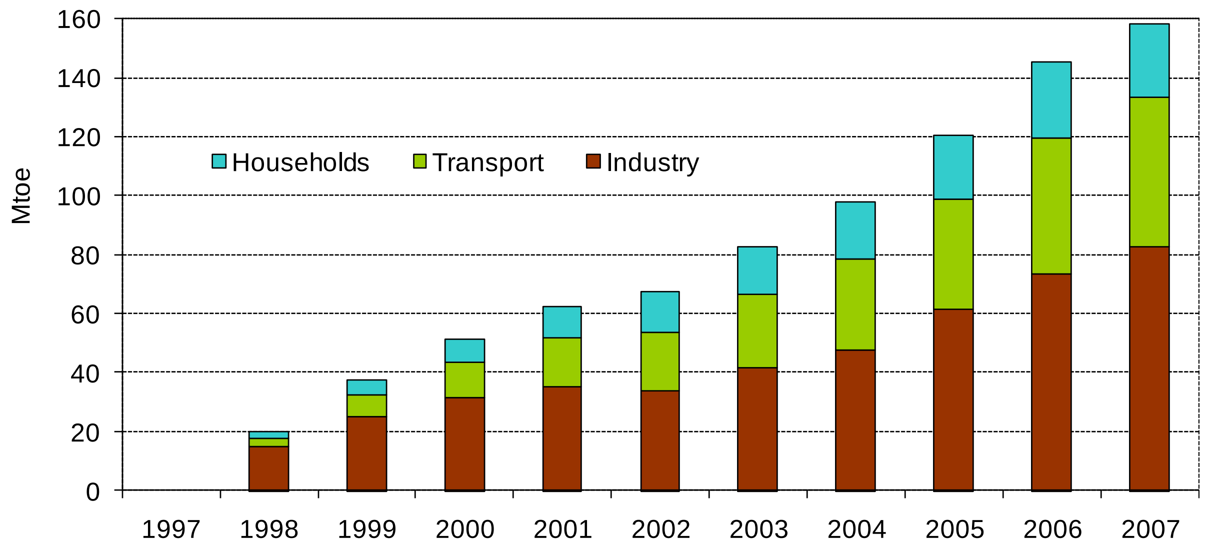
Energy savings can be directly derived from ODEX indicator as it also represents the ratio between energy consumption and a fictive consumption that would have occurred without the savings[28]. In 2007, the energy savings reached 160 Mtoe for the EU as a whole in comparison to 1997. In other words, without energy savings, final energy consumption would have been 160 Mtoe higher in 2007. More than half of the savings come from industry (52 %) and 32 % from transport (**Figure 3.20**).

[26] For Malta, Lithuania and Latvia, data is only available over the period 2000-2007.

[27] This is a very approximate estimate of the ESD savings, as savings measured with ODEX include energy intensive industries (ETS) and exclude savings in services.

[28] If for instance the energy consumption is equal to 50 Mtoe and ODEX = 80, the energy savings can be calculated as follows =50* ((100/80)-1) = 12.5 Mtoe.

Figure 3.20 :Energy savings in the EU-27[29]



3.6. Explanatory indicators of the consumption variation

The variation of the final energy consumption can be explained form the variation of the indicators that have been presented earlier:

- The unit consumption and ODEX can be used to capture the energy savings;
- Change in the energy intensity in industry can be used to measure the impact of structural changes in the industrial production
- Changes in size of dwellings and in the level of ownership of household appliances can be used to measure the effect of changes in lifestyles, as well as changes in the number of kilometres driven with private cars and the share of larger cars.
- Changes in the volume of the industrial activity, in the volume of goods traffic and in the number of employees in services can finally show the impact on the energy consumption of increase in the economic activity.

The analysis carried out on the EU as a whole shows that there are two dominant drivers that offset each others: the activity effect that would have contributed, all things being equal, to increase the consumption by 230 Mtoe between 1997 and 2007 and energy savings (175 Mtoe)[30] that contributed to limit the consumption increase (**Figure 3.21**).

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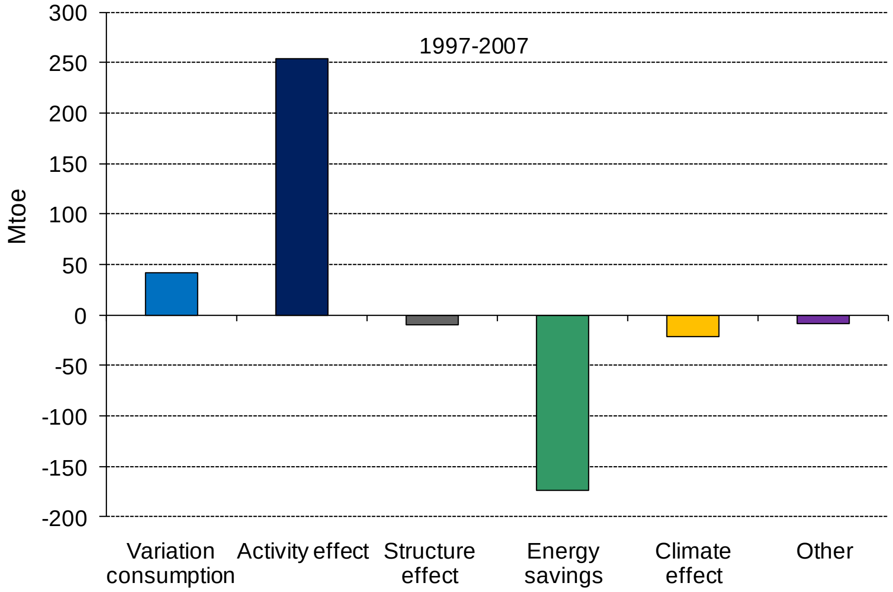
[29] Energy savings in services have not been accounted for due to data limitations.

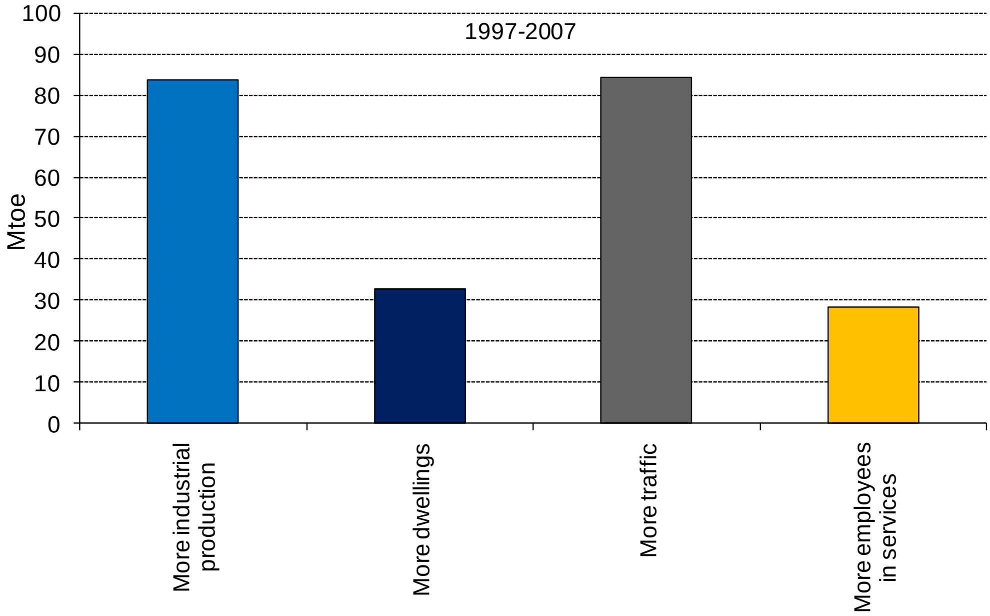
[30] These energy savings include the energy savings in transport, households and industry, as shown above in **Figure 3.20**, and an estimate of energy savings in services and agriculture (15 Mtoe), hence a value of 175 Mtoe instead of 160 Mtoe before.

Figure 3.21 : Drivers of the variation of the final energy consumption in the EU



The composition of this activity effect is shown in **Figure 3.22**: transport and industry have a similar contribution (around 85 Mtoe each) and represents almost ¾ of the total activity effect.

Figure 3.22 : Variation of the final energy consumption in the EU: activity effect



3.7. CO_2 indicators

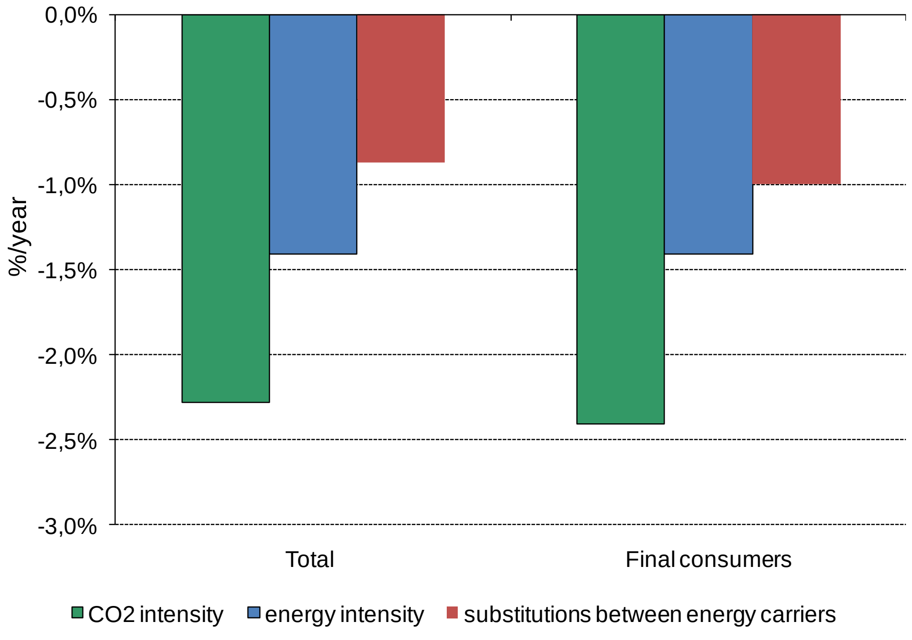
Total CO_2 emissions[31] from energy use were 5 % below their 1990 level in 2007. Over the period 1990-2007, CO_2 emissions from energy use have decreased on average by 0.3 %/year although the economic activity (GDP) increased by 2.3 %/year. After dropping until 1994 (-1.6 %/year), the CO_2 emissions have increased steadily (0.4 %/year on average) until 2003 and decreased slowly again since (on average by 0.6 %/year).

Total CO_2 emissions per capita decreased from 8.7 t in 1990 to 7.8 t in 2007, that is to say a decrease by 10 %.

Almost 40% of the reduction in CO_2 intensity is due to increased use of energy carriers with lower emission factors

Total CO_2 emissions per unit of GDP, the "CO_2 intensity", decreased more rapidly than energy intensity: by 2.3 %/year and 1.4 %/year, respectively, on average between 1990 and 2007 (**Figure 3.23**).

Figure 3.23 : Variation of CO_2 intensity in the EU between 1990 and 2007



This gap is due to switching to energy sources with lower CO_2 emissions factors: the average emission factor of one toe consumed decreased by 12 % over the period from

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31 This section deals with CO_2 emissions from energy combustion published in official inventories from the European Environment Agency. The indicators are not expressed under normal climate conditions (i. e. with climate corrections) to comply with the official definition of CO_2 inventories. CO_2 emissions of final consumers include the emissions of auto producers.

2.35 to 2.06 tCO_2/toe. In other words, the energy used contained less and less carbon contributing thus to the “decarbonisation” of the economy. These fuel switches explain around 40 % of the reduction in the total CO_2 intensity, the rest (60 %) is linked to the reduction in energy intensity.

4. Energy efficiency policies in the EU

4.1. Present state of European energy efficiency policies and recent developments

Energy efficiency policy has triggered important initiatives both at EU-wide and national levels. In this section we give a brief overview on the most important developments and policy measures over the past years. Much more details for the different sectors can be found in the sectoral reports. It is difficult to present in this section individual initiatives at the Member State level; we will concentrate on the European-wide developments. The view on national developments occurs in the sectoral reports.

Energy efficiency strategy development and cross-cutting policy measures

In 2006 the EU published an **Energy Efficiency Action Plan**[32] to cut its energy consumption by 20 % by 2020, to reduce CO_2 emissions and improve supply security while generating new employment. End 2009 the EU Commission was to present a **new Energy Efficiency Action Plan** (see **section 4.7**). However, the debate about whether or not to go for mandatory targets for energy efficiency and the interaction with other policy instruments such as the EU Emission Trading Scheme (EU ETS) has delayed its publication.

The **revised Lisbon Strategy for Growth and Jobs – Towards a Green and Innovative Economy**[33] for the period beyond 2010 shall set incentives for a greener economy including energy efficiency as a major element. A consultation paper[34] of the EU Commission mentions that "*the EU should compete more effectively and increase its productivity by a lower and more efficient consumption of non-renewable energy and resources in a world of high energy and resources prices, and greater competition for energy and resources. This will stimulate growth and help meet our environmental goals. It will benefit all sectors of the economy, from traditional manufacturing to new hi-tech start ups. Upgrading and inter-connecting infrastructure, reducing administrative burden and accelerating the market uptake of innovations will equally contribute to this goal*". In the context of the economic crises that started in 2008, a lot of financial means were directed towards supporting the economy. Part of this support went to improve energy efficiency although there is critics that, in difference to some Asian countries, too little opportunities have been seized to direct those substantial means towards a strong restructuring of the economy in the direction of more energy efficiency and a greener economy[35].

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[32] http://ec.europa.eu/energy/action_plan_energy_efficiency/doc/com_2006_0545_en.pdf
[33] http://ec.europa.eu/growthandjobs/index_en.htm
[34] http://ec.europa.eu/eu2020/index_en.htm
[35] See for example http://euractiv.com/en/enterprise-jobs/eu-outflanked-asian-rivals-green-economy/article-186846

The important **Directive on Energy End-use Efficiency and Energy Services**[36] was adopted in December 2005. The directive requires member states to draw up National Energy Efficiency Action Plans (NEEAPs) to achieve 9 % (final) energy savings between 2008 and 2016 including transport fuels. The target is only indicative but the National Energy Efficiency Action Plans need approval from the Commission and is reviewed every three years. The first wave of NEEAPs was submitted in 2007/2008 and reviewed by the EU Commission[37]. An intensive debate also occurred around the issue of how to measure energy savings[38] and whether or not to include for example autonomous change in the savings achieved because they may reflect market transformation. The deadline for the second round of national action plans is 30 June 2011.

Buildings

Revised Energy Performance Directive for Buildings EPBD[39]: Buildings represent around 40 % of all energy use. The EU addressed this large energy use with the Directive for the Energy Performance of Buildings (EPBD), adopted already seven years ago in December 2002. The directive provided a common methodology for calculating the energy performance of buildings and obliged member states to draw up minimum standards. These should be applied to all new buildings and to existing buildings with a usable floor area above 1,000 m² when they undergo a major renovation. However, no EU-wide minimum efficiency standards were imposed. To promote greater public awareness and debate on energy savings in buildings, the directive introduced an energy performance certificate, which has to be made available each time a house is built, sold or rented out. The certificate should help potential buyers or renters to compare the building's energy performance against established national standards and benchmarks, and to consider any cost-effective improvements they could make. Member States were obliged to implement the provisions of the directive in 2006, but most decided to delay transposition until January 2009 due to a lack of qualified independent experts for the building certificates. In November 2008 the Commission proposed a revision of the EPBD as part of its Second Strategic Energy Review which is now in the legislative process. Adoption may be achieved by early 2010 but the extent of the revision is still under debate. One of the key changes introduced by the draft was the extension of the scope of the directive by eliminating the current 1,000 m² threshold, meaning all existing buildings undergoing major renovations would have to meet minimum efficiency levels. At the same time, renewable energy systems would have to be considered for all new buildings. The

36 http://eur-lex.europa.eu/smartapi/cgi/sga_doc?smartapi!celexplus!prod!DocNumber&lg=en&type_doc =Directive&an_ doc=2006&nu_doc=32

37 http://ec.europa.eu/energy/efficiency/doc/sec_2009_0889.pdf

38 See for this issue in particular the EMEEES (Evaluation and Monitoring for the EU Directive on Energy End-Use Efficiency and Energy Services) project http://www.evaluate-energy-savings.eu/emeees/en/home/index.php
and in particular the report on top-down evaluation of savings using Odyssee indicators http://www.evaluate-energy-savings.eu/emeees/en/publications/reports/EMEEES_WP5_Summary_ report_May_2009.pdf

39 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0780:FIN:EN:PDF

European Parliament added in its first reading a condition that new buildings constructed as of 2020 would have to be zero-energy. As for existing buildings, the EU Parliament urged Member States to set percentages for a minimum share of existing buildings to become energy-neutral in 2015 and 2020.

Appliances

Eco-design directive to set Minimum Efficiency Standards (MEPS) for a large number of products (EUP Directive 2005/32/EC)[40]: It establishes a framework under which manufacturers of energy-using products will, at the design stage, be obliged to reduce the energy consumption and other negative environmental impacts occurring throughout the product life cycle. Detailed actions are introduced by the European Commission following a process of discussion with key stakeholders and through implementing Directives. The Eco-design Directive introduces minimum efficiency standards for up to 40 products[41] which cover the industrial sector, the tertiary sector and the building sector. MEPS for nine of these product groups have already been published, many of which in 2009 (e.g. standards on lighting with the more or less implicit phasing-out of incandescent light bulbs, on the stand-by of IT appliances, on electric motors and on pumps etc). This new framework also includes the previous products subject to labelling.

Transport sector

In the past, the influence of the European Union on the transport sector has been limited to the following three areas: voluntary agreements with car manufacturers, the biofuels directive and the mandatory labelling of cars. In the future it can be expected that the impact of EU policies will be greater with the new **Directive on mandatory CO_2 standards for cars** (Regulation 443/2009[42] of April 2009 setting emission performance standards for new passenger cars), a higher biofuels target in 2020 (10 %), the integration of air transport in the European Emission Trading scheme, and the Energy Service Directive that explicitly mentions transport as a field of action, although so far the number of measures proposed by the countries are still limited.

A recent EU draft regulation will introduce **fuel efficiency labels for new tyres** from November 2012[43]. The new label will follow the 'A to G' classification system of the European energy label, so the best-performing tyres will be awarded an 'A'. In addition to its impact on fuel use, the label will provide information about the product's performance in wet conditions and rolling noise in decibels.

Industry

The **EU Emission Trading Scheme** is considered to be one of the most important instruments for the reduction of greenhouse gases in the energy sector and the

40 http://europa.eu.int/comm/enterprise/eco_design/directive_2005_32.pdf
41 For an overview see http://www.eceee.org/Eco_design/products
42 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0001:0015:EN:PDF
43 http://register.consilium.europa.eu/pdf/en/09/st14/st14639.en09.pdf

industrial sector. The European Emission Trading Scheme (EU ETS) is governed by the EU ETS Directive (2003/87/EC and 2009/29/EC) and was launched in January 2005. As energy efficiency improvements are considered to be cornerstones of greenhouse gas reduction policies, the question is legitimate in how far the emission trading scheme gas has led to energy efficiency improvement. This issue is debated in detail in the industrial report from the Odyssee-MURE project. In addition to the industrial and energy sector emitters, air transport will be included from 2013 onwards.

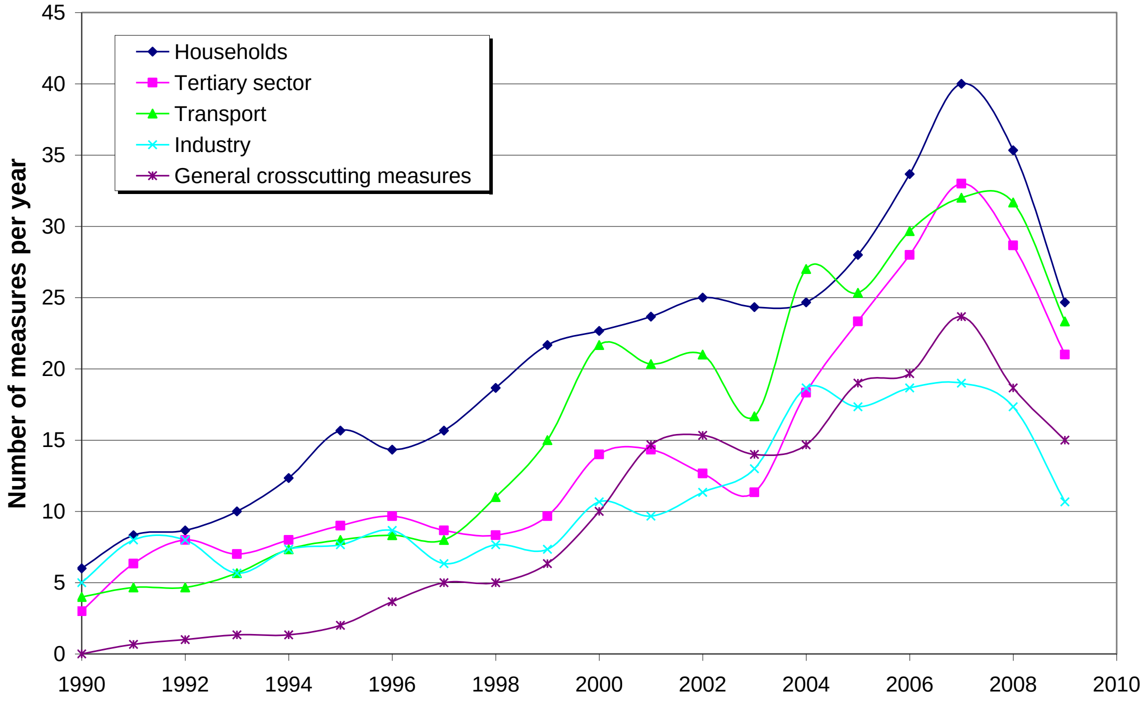
4.2. Patterns and dynamics of energy efficiency policies

This section provides a view on the patterns and dynamics of energy efficiency policies across the different sectors, however, in a very condensed way. Much more information and analysis of the trends behind these developments are provided in the sectoral reports.

Measure dynamics: Strongly increasing number of energy efficiency measures in all sectors over time

There has been a continuous increase in the number of measures that have come into force every year (**Figure 4.1**). This is valid for all four sectors as well as for the group of general cross-cutting measures. The sector with the least dynamics is the industrial sector but even there the increase in the number of measures was remarkable.

Figure 4.1 : Measure dynamics over time by sector



Note: The curves present the measures starting in a given year, however, as a gliding 3-year average to smooth annual fluctuations. The decrease in 2008/9 is an artefact from the smoothing procedure given that the 2009 measures are still incomplete in the MURE database (last update from June 2009)

Source: MURE database

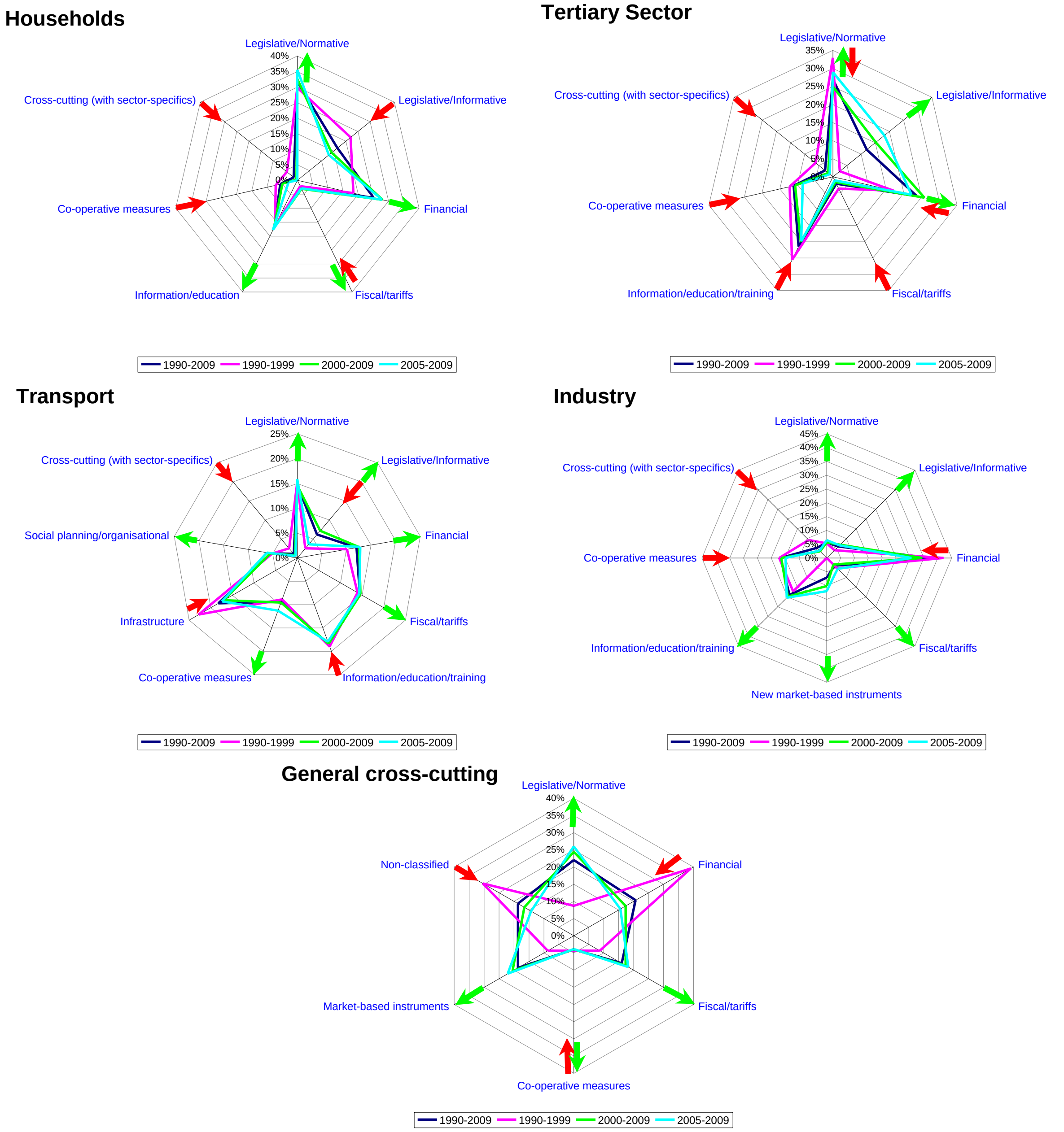
Measure patterns: Each sector is characterised by particular patterns of energy efficiency measures

Each sector has its own measure patterns and dynamics. **Figure 4.2** shows the measure patters for each sector. More details can be found in the sectoral reports.

- ***Households***: The prevalent measure types are legislative/normative (in particular building regulation) and financial (addressing mainly existing buildings). These measure types have even strengthened their dominant position. Legislative/informative measures such as labels have decreased in importance. However, this was the consequence of the fact that the very comprehensive labelling policy for the electric appliances has not been renewed. Only the eco-design Directive 2005/32/EC will give a further push to this measure type.
- ***Tertiary***: The tertiary sector is equally dominated by the prevalence of legislative/normative and financial measures as buildings are also the most important energy use in this sector. However, information/education/training measures and to less a degree cooperative measure play a larger role than in the household sector. Legislative/informative measures such as labels increase in importance and reflect the fact that building certificates have already been more largely implemented for larger buildings in the past.
- ***Transport***: The transport sector is not dominated by two or three measure types but shows a large coverage in measure types. Infrastructure measures as well as information/education/training, fiscal/tariffs and financial measures tend to be more largely employed. Regulation and co-operative measures are on the rise.
- ***Industry***: The industry sector is largely dominated by financial measures to support audits and investment in energy efficiency. New market-based instruments such as the EU ETS and education/training are on the rise while co-operative measures such as voluntary agreements have lost grounds.
- ***General cross-cutting measures***: These types of measures cover broadly all sectors with the same type of instruments (while cross-cutting measures with sector-specifics are particularly adapted to each sector, e.g. specific energy tax for the industrial sector). Like for the transport sector, the coverage is broad with market-based instruments (such as measures to promote Energy Service Companies ESCOs, White certificates etc.) being on the rise. Also legislative/normative measures such as regulation for CHP, certain types of energy carriers (e.g. district heat) or mandatory targets for energy suppliers become more important.

It must be emphasised that these patterns have also country-specifics. This is presented in detail in the sectoral reports.

Figure 4.2 : Patterns of energy efficiency policies by sector (1990-2010)



Note: red arrows indicate shrinking importance, green arrows increasing importance

Source: MURE database

Figure 4.3 shows also the share of the different measure types for each sector but comparing this time the unweighted distribution with a distribution that is weighted with the impact of the measures[44].

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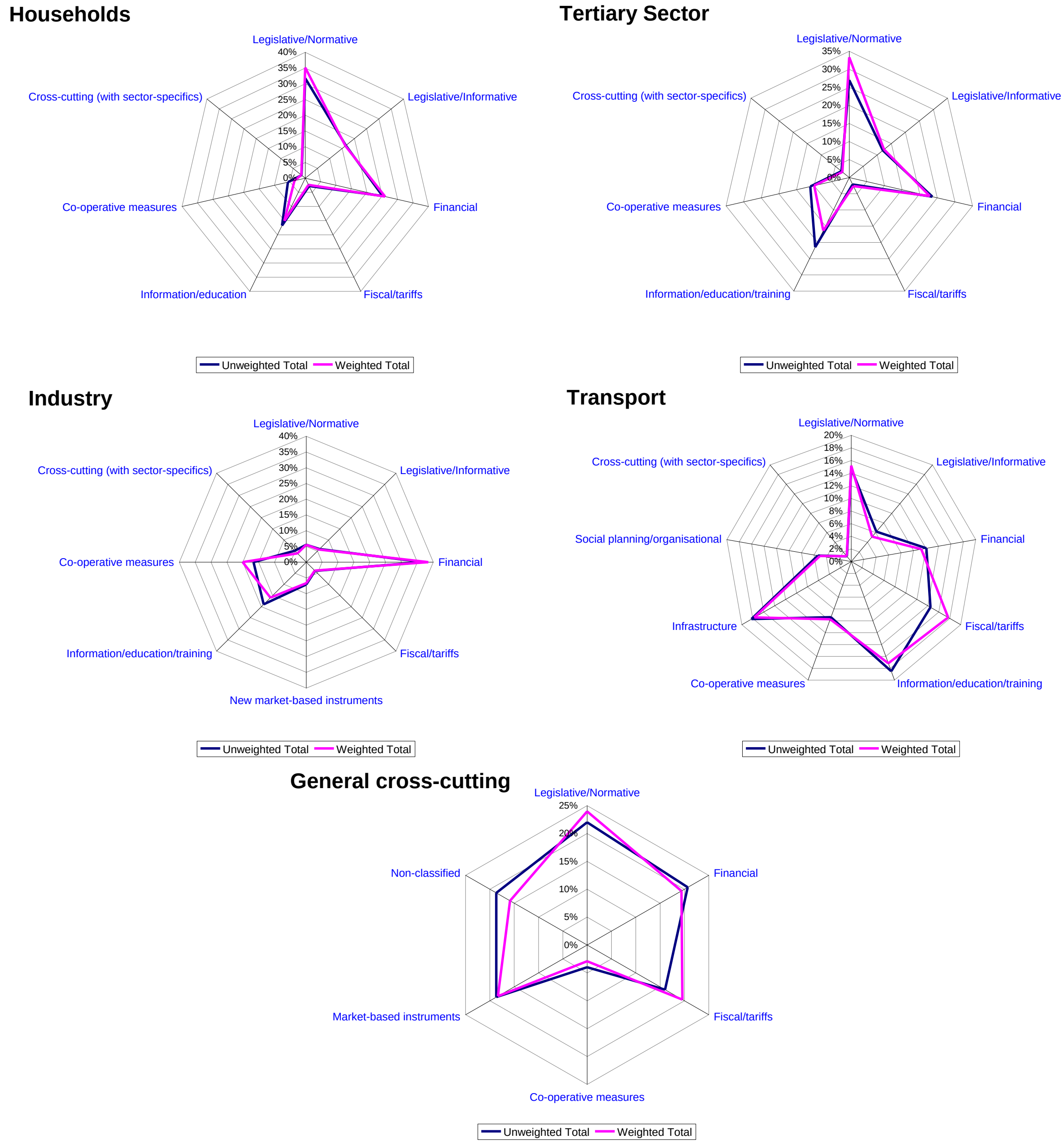
[44] In the MURE database the quantitative impact evaluations (which so far are only available for about one quarter of all measures given the lack of general measure evaluation at the national level) are complemented by semi-quantitative impact estimates for most of the measures provided by national experts from the energy agencies in the ODYSSEE-MURE network. This information contributes to understanding the impact of the measures at least in some semi-quantitative categories (high impact, medium impact, low impact) which are linked to the energy or electricity

Figure 4.3 : Impact-weighted patterns of energy efficiency policies by sector compared to un-weighted patterns (1990-2010)



Source: MURE database

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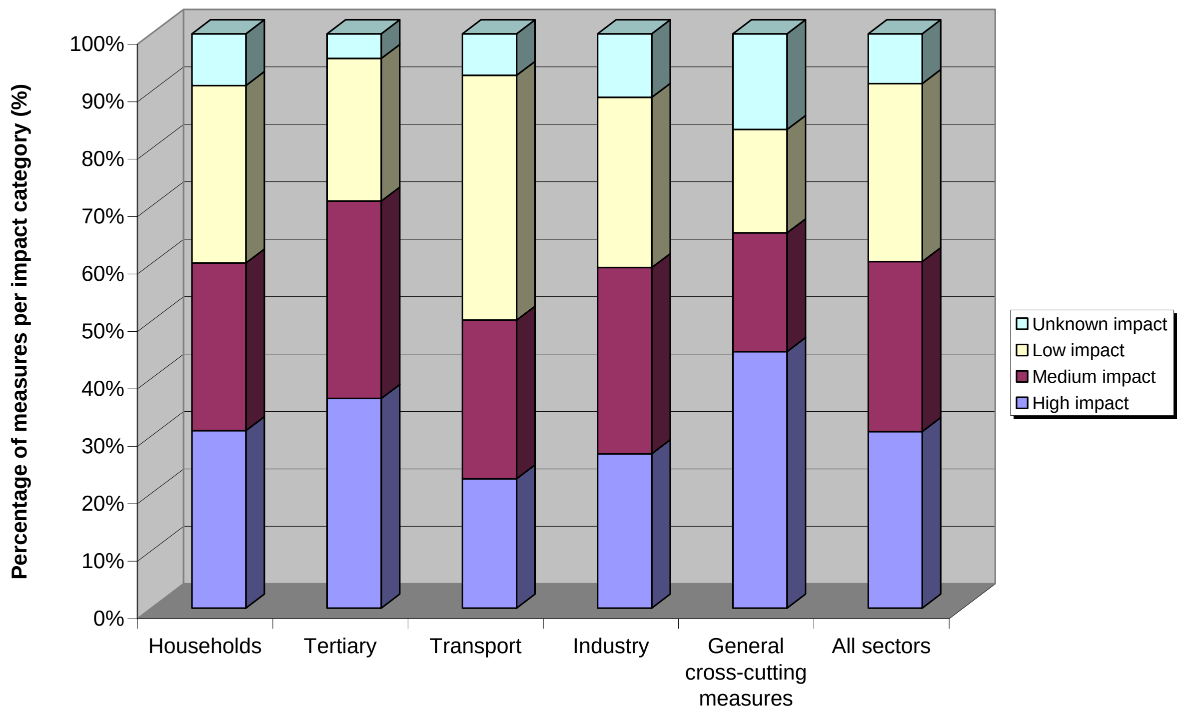
consumption of the sector through a percentage range. These ratings represent different ranges of energy savings, expressed as a percentage of the total consumption in the sector regarded. Low is given for 0-0.1% of total use, medium for 0.1-0.5% and high for >0.5%. For instance, the qualitative impact "medium" for a subsidy scheme on insulation measures means that the savings are estimated at about 0.3% of total fuel use. These semi-quantitative estimates are used to evaluate the overall impact of a larger set of measures for which fully quantitative impact evaluations are not always available. The categories are weighted with relative factors (high impact = 5, medium impact = 3, low impact = 1), which correspond to the originally defined bands of savings.

From this comparison the following observations can be made:

- The distribution between weighted and unweighted measures does not change completely the pattern. The unweighted pattern is therefore already some good indicator for the importance of each measure type.
- Nevertheless, some measure types, when weighted, tend to get a higher importance (in particular legislative normative and fiscal measures), while others tend to lose importance (in particular informative measures and partially co-operative measures, depending on the sector).

High impact measures can be more found in the households and tertiary sector (due to the large dominance of regulative measures in these two sectors) and also among the cross-cutting measure due to the dominance of fiscal measures (**Figure 4.4**). Low impact measures have the largest share in transport given a relatively strong share of informative measures. Overall, however, the impacts are rather equally spread over the different sectors. Measures without at least a semi-quantitative impact estimate represent only about 10% of the total.

Figure 4.4 : Distribution of measures by impact (1990-2010)

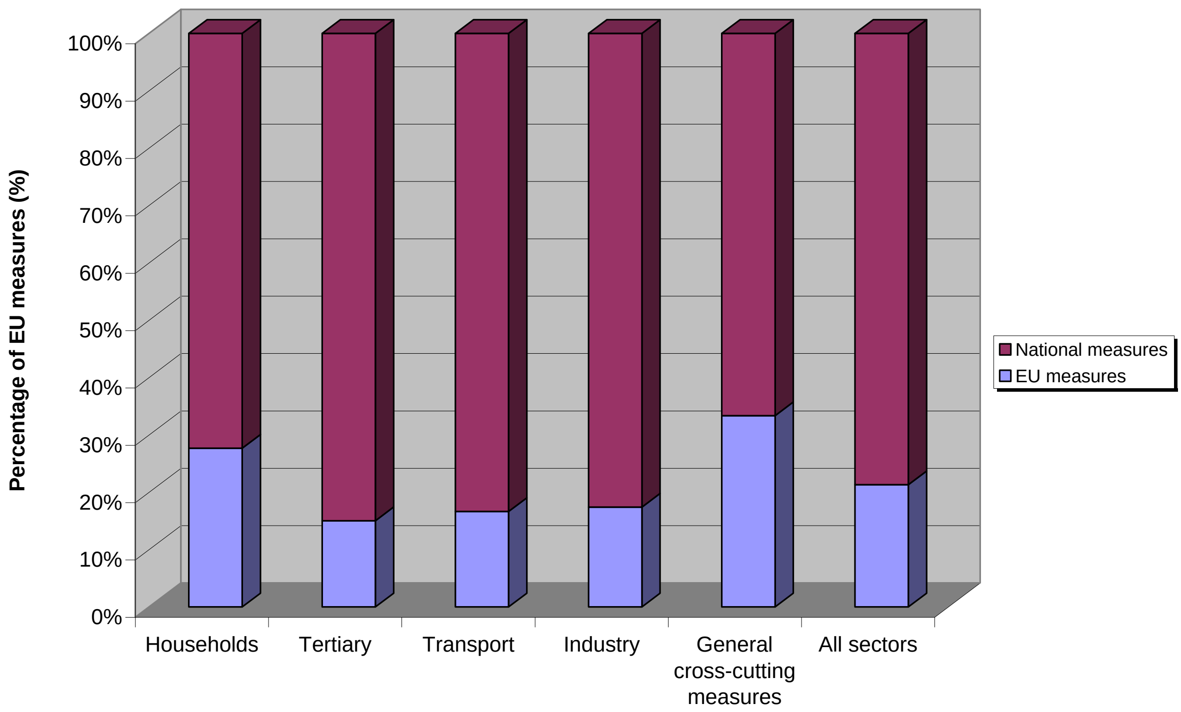


Source: MURE database

4.3. The weight of policies determined at the central EU level

EU energy efficiency policies have an increasing impact on the national level. However, the impact is still quite different from sector to sector. While EU measures represent already nearly one third of all measure in the residential sector (in particular due to the impact of the appliance labelling Directives) and in the general cross-cutting measures (due to measures such as the CHP Directive, renewables policies which impact also on decentral renewables, and the Eco-design Directive), it is still weaker in transport, industry and the tertiary sectors (around 15 % of all measures are EU-related). On average around 20 % of all measure are directly inspired by EU legislation. It can be expected that the impact of EU-wide triggered energy efficiency measures at national level will considerably increase with central measures such as the Eco-Design Directive, the revised Energy Performance of Buildings Directive (EPBD) and the forthcoming revision of the EU Energy Efficiency Action Plan.

Figure 4.5 : Share of EU-related measures (1990-2010)



Source: MURE database

4.4. Innovative energy efficiency policies

There are several ways how innovative measures for energy efficiency are introduced in the different EU Member States:

(1) First there are measures which are **innovative compared to the past with respect to their comprehensiveness**. This is the case with European legislation on Eco-design standards for Energy-using Products which comprises now 40 products of which around ten standards are already published. This is much more comprehensive as the few Minimum Energy Efficiency Standards published in the nineties, e.g. on cold appliances.

(2) Further, measures may be **innovative through the dynamic aspects they include in the measure design**. Also here the EuP Directive is a good example as it sets dynamic standards that get tighter over time for most products in order to cope with the foreseeable technical progress. A second example is the CO_2

strategy for cars which aims to provide a foreseeable frame for the further tightening of standards, although this is – in difference to the Eco-design standards - not yet translated to the legislative provisions.

(3) Measures may further be **innovative through the new context in which they are set** that is in which combination of measures they are applied (e.g. the combination of a learning process with the development of adapted tools, investment subsidies and information in "Learning Energy Efficiency Networks" in Germany for the industrial sector).

(4) Measures may be **innovative because they constitute a completely new type** of measures to improve energy efficiency such as the new market-based instruments like the EU Emission Trading Scheme, White Certificates and Clean Development Mechanism.

(5) Further, a measure type may develop further **innovative features** such as for example the EU ETS where - to encounter the danger of carbon leakage[45] - benchmarking systems are developed to limit the amount of free carbon allocation.

(6) Finally, **measures for energy efficiency may be innovative in a direct sense through the contribution they could make to the Lisbon strategy for growth and employment and the greening of the economy**. It is difficult to point particular policies out but again minimum standards for cars can be an important tool to develop innovative car designs which could help in the future to give European car makers, in difference to the US car makers in the past who have bed on energy consuming large cars, a competitive advantage.

All six innovation strategies are followed in the Community and have led to a substantial amount of new measures across all sectors in the past years.

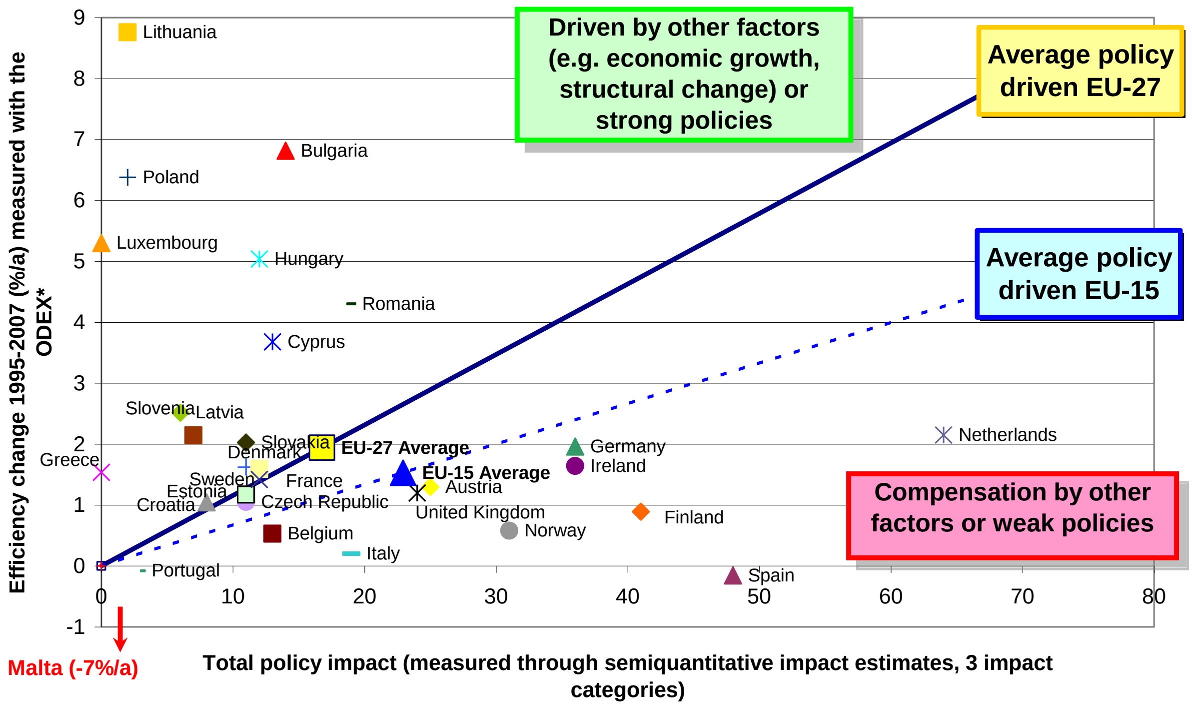
4.5. Quantitative impact of energy efficiency policies

Determining the quantitative impact of energy efficiency is still a rather difficult exercise. This has been shown by the debate around the Directive on Energy Efficiency and Energy Services and in the frame of the EMEEES project (see footnote 38). Many Member States are afraid that the effort to measure precisely energy savings and distinguish it from the background of autonomous energy efficiency changes and market energy price changes will need substantial measuring efforts. This debate may give hints how to avoid such pitfalls in the future in the case mandatory targets are set for energy efficiency for 2020. One way could be to set the targets sufficiently high so that the inclusion of autonomous change and other factors makes it still an ambitious target. However, this makes the target achievement more dependent on the fluctuations of parameters that cannot be controlled such as market energy prices.

[45] Displacement of carbon emissions outside the EU, for example to China, as production sites may close in Europe due to higher charges on the companies from the carbon price. This could undermine their competitiveness.

In the Odyssee-MURE project we have developed so-called **efficiency-impact plots** that present the evaluation of energy efficiency development with the ODEX (period 1995-2007) compared to the semi-quantitative impact[46] estimates of the measures collected under MURE (period 1990-2007, assuming that measures introduced several years earlier have also an impact on the ODEX). These plots are shown for the industrial sector, the residential sector and the transport sector and commented in the following[47]. They indicate that there is not a straightforward link between the ODEX und the impact analysis, although some trends can be seen. Nevertheless, also other factors impact very strongly on the position of a country in the efficiency-impact plot such as its economic development or the increase in comfort. This is most visible when comparing the different graphs among each other.

Figure 4.6 : Efficiency-Impact plot industrial sector



Source: Calculations based on Odyssee database, MURE database

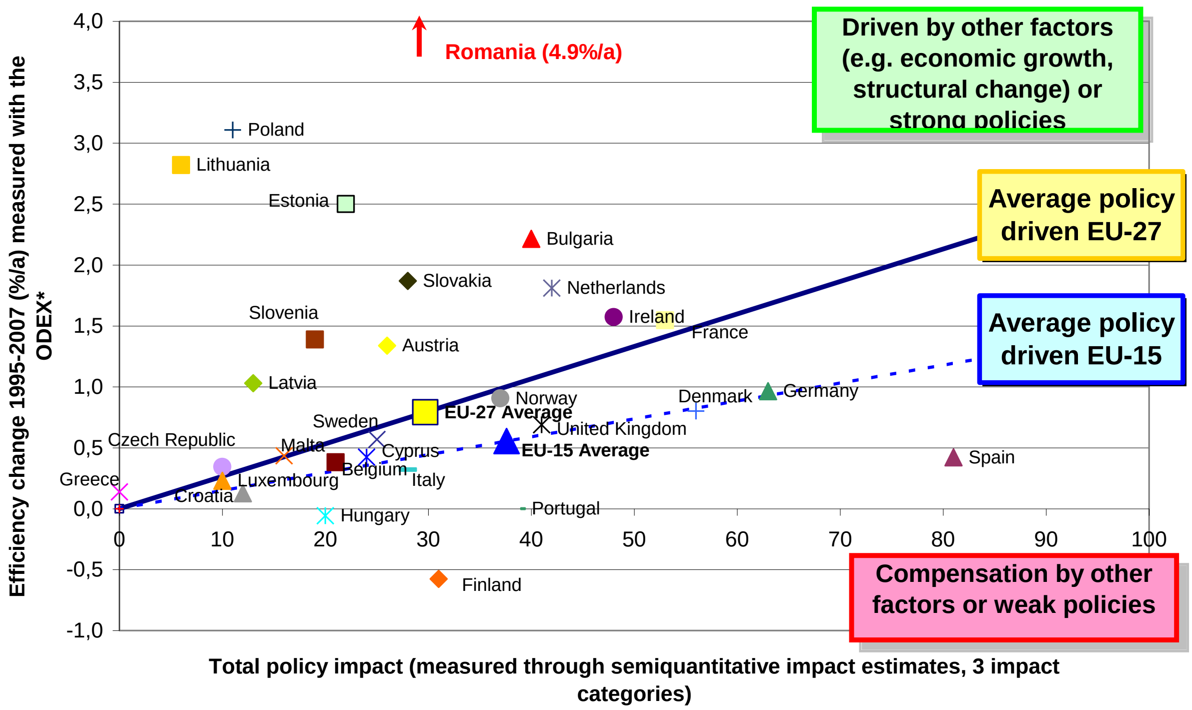
- The **industry sector** (**Figure 4.6**) is much more dominated by additional factors beyond energy efficiency policies such as the economic development, which tends to increase the efficiency improvement, especially in the new EU Member States which had a very strong economic development. However, also in the EU-15 these additional factors increase the efficiency as can be seen from the EU-15 average as

[46] The semi-quantitative estimate of the impact for each policy measure (ratings: High, Medium or Low based on fractions of the sector energy consumption that are addressed by the measure) is translated into a quantitative estimate by using weighting factors (Low > 1, Medium > 3, High > 5), and the total weighted impact is obtained as Nb-high * 5 + Nb-med * 3 + Nb-low * 1

[47] No such plots have yet been developed for the tertiary sector as the ODEX for this sector is still insufficient to describe energy efficiency progress given that the additional factors such as increasing electricity uses by far over-compensate the efficiency improvements achieved up to now.

compared to the other sectors. On the opposite there are, however, also countries such as Spain which despite strong economic growth (but mainly driven by the construction industry) have achieved little impact in terms of energy efficiency.

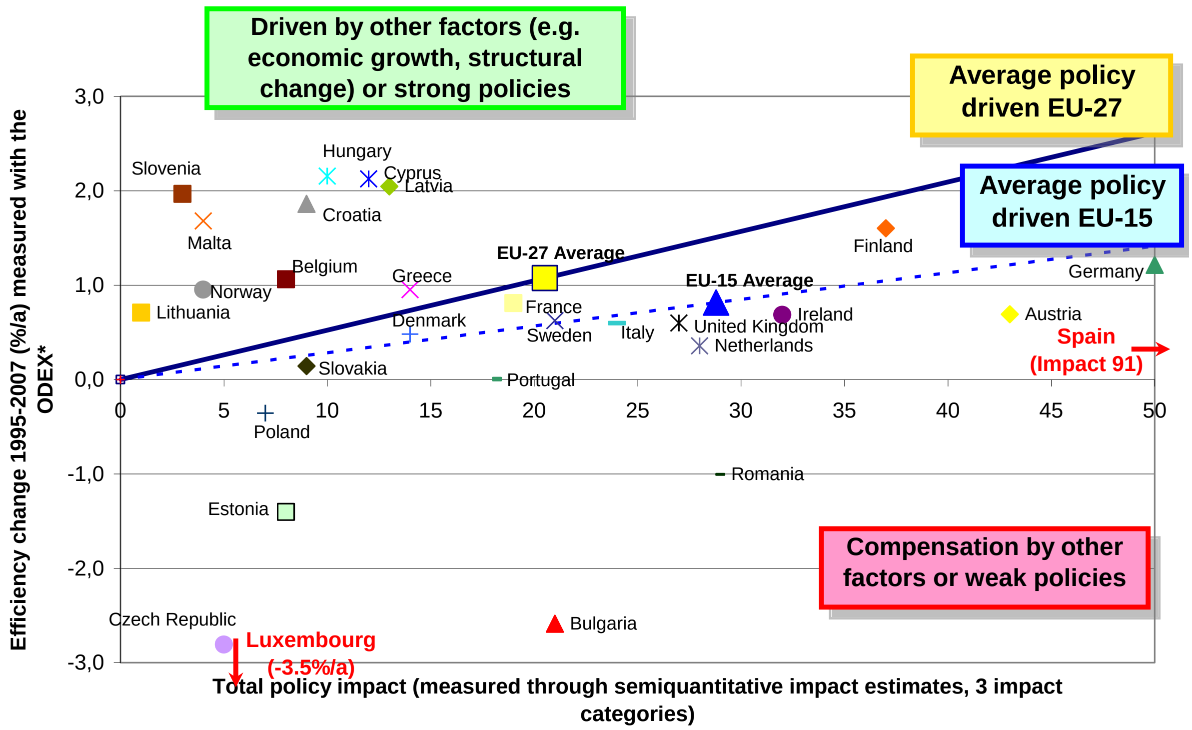
Figure 4.7 : Efficiency-Impact plot residential sector



Source: Calculations based on Odyssee database, MURE database

- The **residential sector** (**Figure 4.7**) takes an intermediate position between the industrial sector and the transport sector. It is relatively strongly dominated by energy efficiency policy while factors such as economic growth or comfort increase have less impact than in the industrial sector or the transport sector. Nevertheless, also in the residential sector, the strong economic growth in most of the new EU Member States has supported the renewal and rehabilitation of the building stock which was also accompanied by the thermal improvement of the building shell and the heating systems. EU-15 countries with higher improvement of the ODEX as compared to the expected energy efficiency policy impacts are Austria, France, Netherlands, Sweden and also Norway, most of which had quite ambitious policies for the buildings. The impact could therefore have been larger than estimated.
- The **transport sector** (**Figure 4.8**) is strongly dominated by compensating factors such as increased engine size; this is why the annual efficiency improvement is lowest compared to the industrial and residential sector.

Figure 4.8 : Efficiency-Impact plot transport sector



Source: Calculations based on Odyssee database, MURE database

4.6. Energy efficiency potentials

This section summarises the results of a study to investigate energy efficiency potentials. The work was not performed in the frame of the Odyssee-MURE project but relied on the MURE simulation model[48]. It shows that substantial further energy efficiency potentials remain, even in the cautious approach taken in that study which used rather low energy price levels and took into account the duration of investment cycles.

4 scenarios were considered in this work:

- **Autonomous Progress Scenario APS** (which comprises autonomous progress and earlier policies such as the labelling Directives for electric appliances but excluding the success of important recent EU policies which are not yet fully implemented such as the EU Performance Directive for Buildings and the CO_2 standards for cars and light duty commercial vehicles).
- A **variant of the Autonomous Progress Scenario** which includes the success of these recent policies (**APS+RP**).
- **Low Policy Intensity Scenario LPI** (which implies continued high barriers to energy efficiency, a low policy effort to overcome the barriers and high discount rates for investments in energy efficiency).

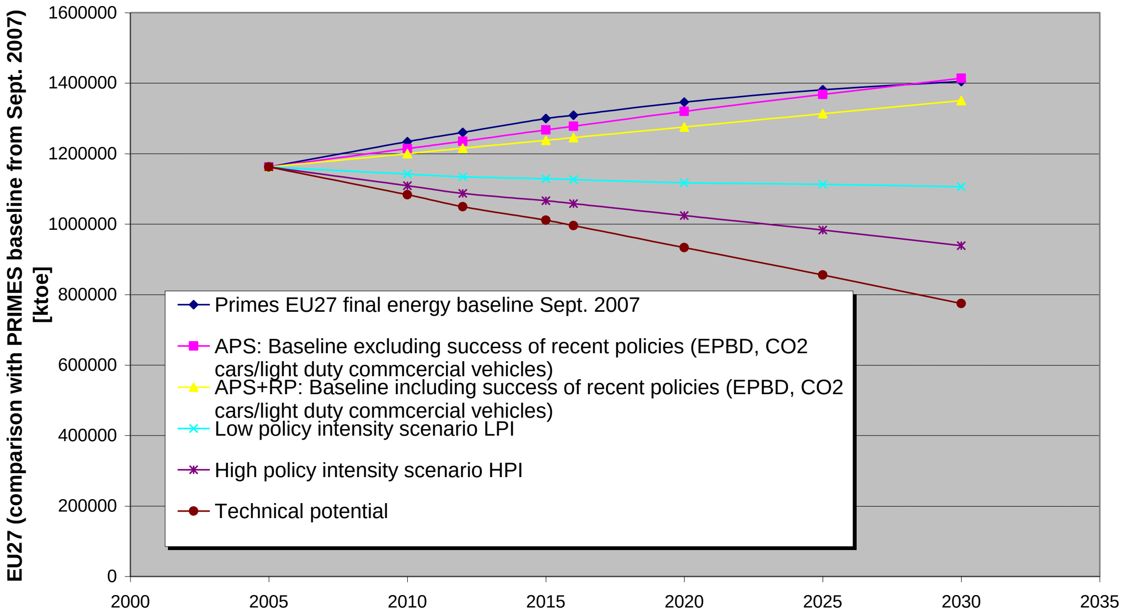
[48] Energy Savings Potentials in EU Member States, Candidate Countries and EEA Countries http://ec.europa.eu/energy/efficiency/studies/efficiency_en.htm

- **High Policy Intensity Scenario HPI** (which implies removing barriers to energy efficiency, a high policy effort to overcome the barriers and low discount rates for investments, options are economic on a life cycle basis).
- **Technical Scenario** (includes also more expensive but still fairly realistic options; no exotic technologies).

Energy price assumptions are conservative, for crude oil as the leading energy around 61 $2005 in 2020 (real prices), 63 $2005 in 2030 (real prices). The 61 $ in 2020 imply a price of 83$ in nominal terms in 2020 (assuming an inflation rate of 2 % annually), while the 63 $ in 2030 correspond nominally to 105 $ in 2030.

Final energy consumption is still on the rise in the APS+RP scenario. It stabilises in the LPI Scenario, while the HPI and the Technical Scenarios curb the final energy demand by 2020 as compared to the baseline (APS) (**Figure 4.9**).

Figure 4.9 : Scenario development and comparison with the PRIMES baseline

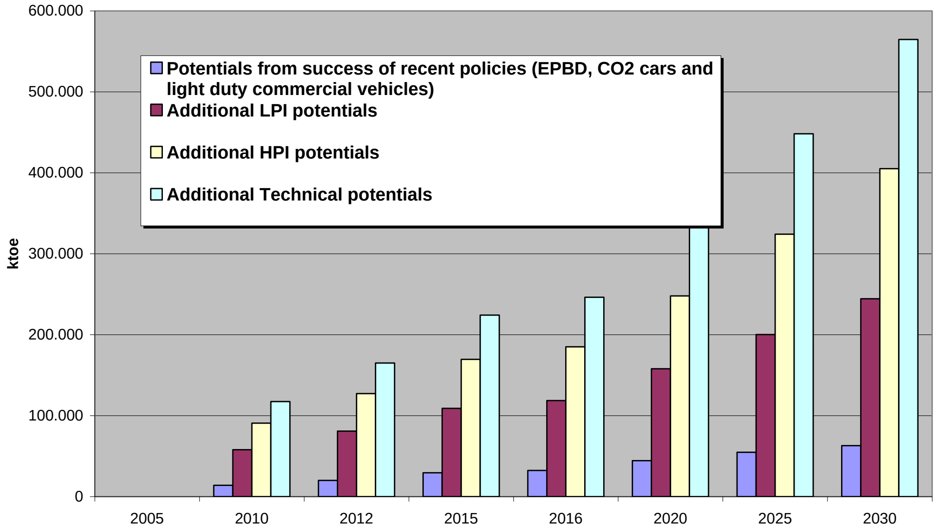


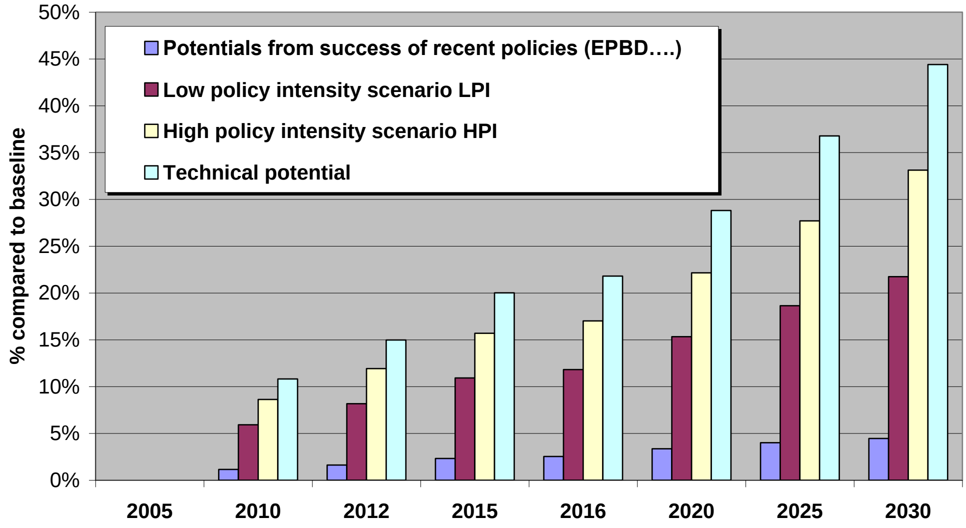
Source: Fraunhofer ISI/ENERDATA/ISIS/WI (2009)

In 2020 the **LPI/HPI/Technical potentials** may reach 158/248/336 Mtoe for the EU27 (15/22/29 % compared to APS). In 2030 this could be 244/405/565 Mtoe (respectively 22/33/44 % compared to APS). Potentials from the (still supposed) success of recent policies (EPBD, CO_2 standards for cars and light duty commercial vehicles) reach 44 Mtoe in 2020 and 63 Mtoe in 2030 (**Figure 4.10**).

At the short term (2010) transport, non-EU ETS sectors (in particular cross-cutting technologies such as electric motor applications) and electric applications in the residential/tertiary sectors may have the largest potentials (**Figure 4.11** and **Figure 4.12**). At medium term (2020) the contribution from the building sector (residential and tertiary) to the potentials grows larger. The contribution of the buildings to the potentials is largest in the HPI and Technical Potential scenarios and for the longer term up to 2030. This would imply an early mobilisation of these potentials through measures due to the longer lead times.

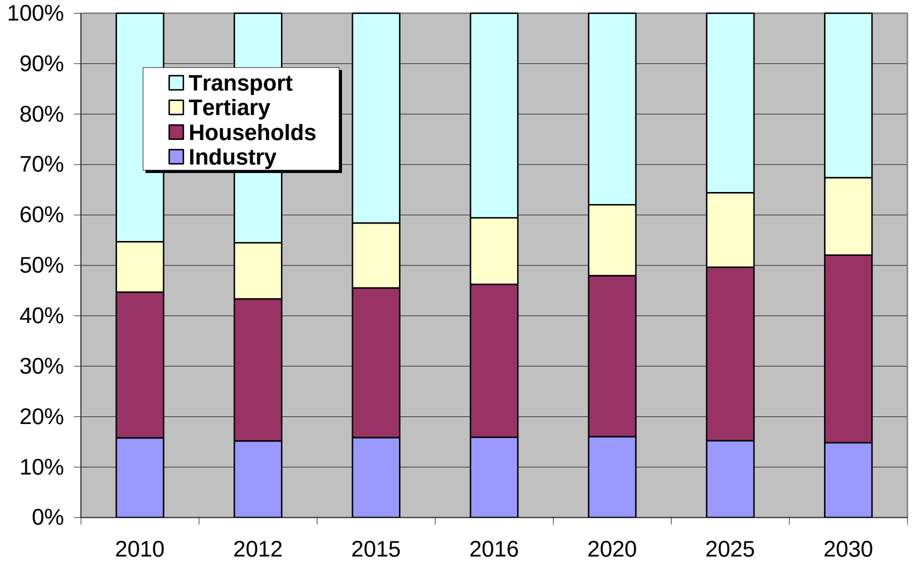
Figure 4.10 : Energy efficiency potentials in the different scenarios (ktoe and %, compared to APS)





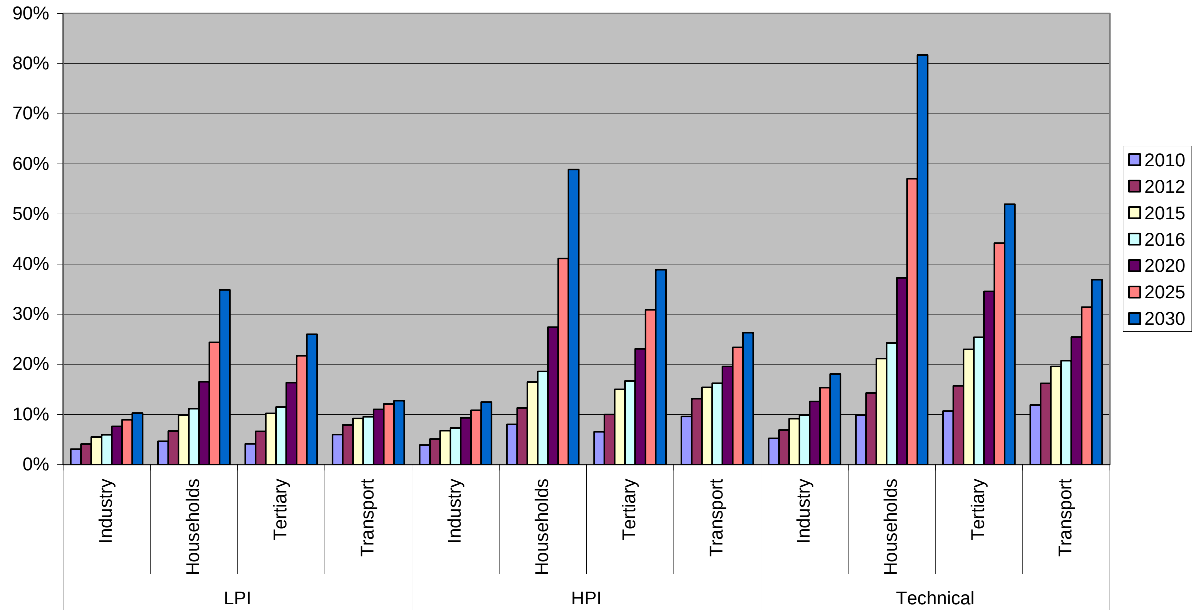
Source: Fraunhofer ISI/ENERDATA/ISIS/WI (2009)

Figure 4.11 : Sectoral contributions to the potentials over time in relative terms



Source: Fraunhofer ISI/ENERDATA/ISIS/WI (2009)

Figure 4.12 : Sectoral potentials over time compared to the APS (in %)



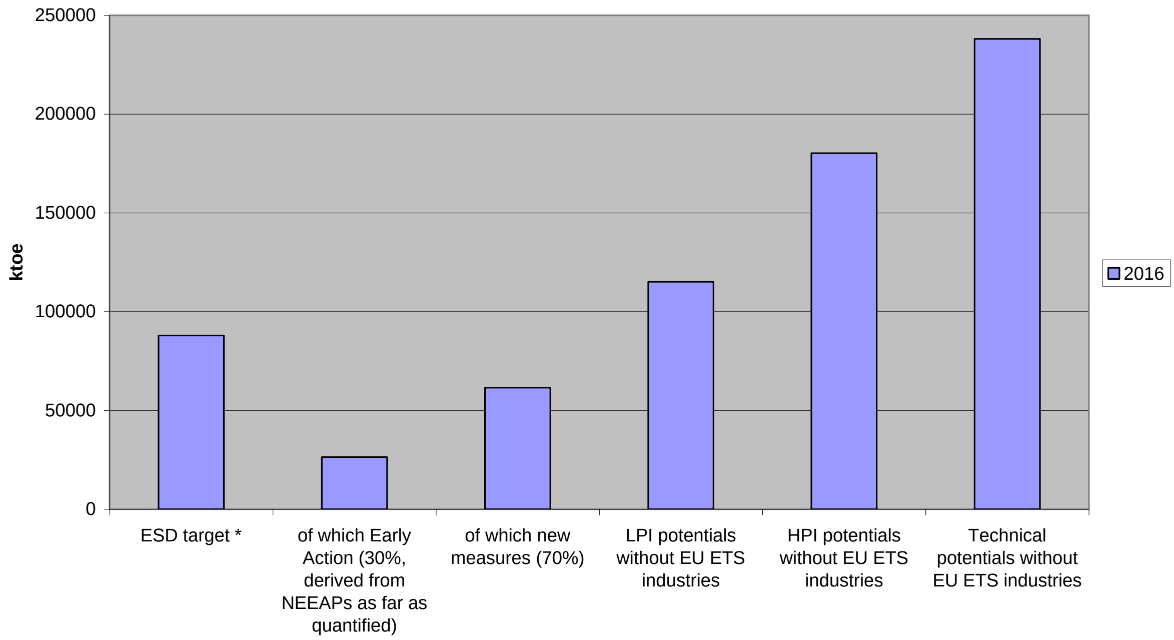
Source: Fraunhofer ISI/ENERDATA/ISIS/WI (2009)

For the comparison with the ESD targets in 2016 the following observations can be made:

- For the comparison with the 9 % target of the ESD, the target was calculated as average for the period 2001-2005 from Odyssee data, excluding EU ETS industries. It should be noted that the ESD target is calculated on a historic 5-years period while the potentials calculated here are calculated with respect to the Autonomous Progress Scenario.

- Potentials for this comparison are also without EU ETS industries. Potentials in non EU ETS sectors are considerably larger than for the EU ETS sector, especially for electricity
- If all proposed measures in the National Energy Efficiency Action Plans (NEEAPs) will be new measures than they represent an effort broadly in the range of the LPI scenario.
- Early action measures undertaken 1995 to 2007 are admitted under the ESD. They are not included in the potentials as calculated here. In fact, they are part of our baseline. If Early Actions represent 30 % which is rather realistic when looking at the NEEAPs then the new effort represents less than the LPI potentials. Some countries have even 50 % Early Action. This implies that between the new action and the HPI potentials there is still some gap open for further action in future NEEAPs. If there is in addition autonomous progress included in the actions than the effort is even less.

Figure 4.13 : Comparison of the potentials (excluding EU ETS industries) with the targets of the Energy Service Directive in 2016



*(calculated from the Odyssee Indicators by excluding EU ETS Industry on a sectoral basis and averaging 2001-2005)

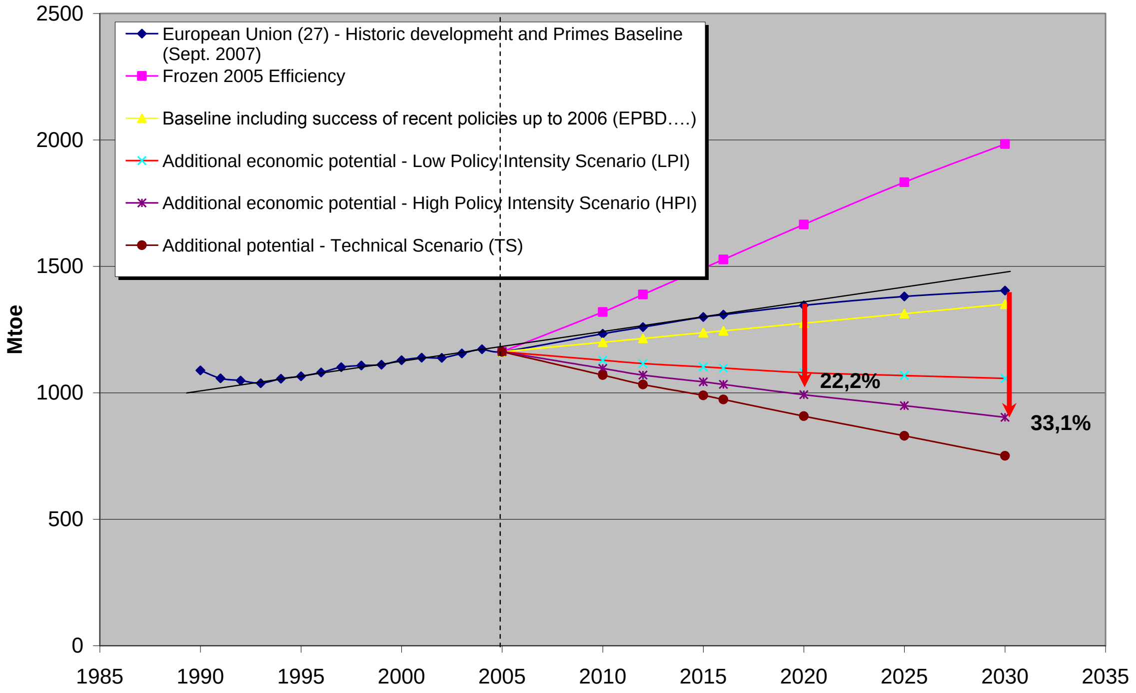
Source: Fraunhofer ISI/ENERDATA/ISIS/WI (2009)

For the comparison with the 20 % energy efficiency target in 2020 the following observations can be made:

- The 20 % target has so far been discussed as a primary energy target hence may include also the conversion sector and renewables (although it could also be specified as a final energy target converted to primary energy to avoid distortion between fuels and electricity). For this reason it can not be really compared here to the potentials calculated here, which are pure demand side potentials.
- Nevertheless, the comparison of the final energy potentials with the baseline in percentage points shows that the HPI reaches 22% in 2020. Therefore, the 20 %

reduction target is rather demanding but achievable if it is to be reached by demand side measures only. Possibly additional measures on the primary energy side and renewable, or measures which are currently more expensive (and which are in the technical scenario) will make it easier to reach this target.

Figure 4.14 : Comparison of the potentials (including EU ETS industries) with the 20% target for energy efficiency of the EU Commission



Source: Fraunhofer ISI/ENERDATA/ISIS/WI (2009)

4.7. Outlook: Mandatory energy efficiency targets and their interaction with other policy instruments

Energy efficiency has, in difference to renewables and climate policies, not been included in the Energy and Climate Package[49] from 2008 ("20-20" target on renewables and on CO_2 emission reduction)

In an unofficial document from the EU Commission[50] it was mentioned that by 2020 only a reduction of 11 % of primary energy may be achieved and therefore further measures were brought to the debate:

- Legally binding energy efficiency targets for the Member States of 20% by 2020. There is also the debate, in how far such legally binding targets need to be differentiated by Member State or by sector.
- A European building initiative to refurbish existing buildings by creating a new financing infrastructure, in particular based on national energy efficiency funds

49 http://ec.europa.eu/environment/climat/climate_action.htm

50 7 Measures for 2 Million new jobs – a low carbon eco-efficient & cleaner economy for European Citizens

- Smart cities: also here financing is a major issue
- Energy Saving in the utility sector: major innovations include here the preparation of mandatory energy efficiency objectives for the energy suppliers and the introduction of White Certificates.
- Energy efficiency in SMEs: This feature has an information component and aims to bring forward the market for Energy Service Companies ESCOs
- Behaviour and education: this component aims to raise awareness among citizens.
- International cooperation: this mainly concerns to include energy efficiency as an important prerequisite into financial support.

Although the debate on the revised energy efficiency action plan is delayed to 2010, it can be expected that important features discussed above could be part of the finally accepted energy efficiency action plan. The issue of mandatory targets for energy efficiency (and how to measure the target achievement) will, nevertheless, be an important field of debate.

Given the global increase in energy efficiency policy measures described in **section 4.2** but also of other policies for renewables and CO_2 emissions, with which energy efficiency measures are interacting, there is the legitimate question how this policy measures can best be brought into synergy rather than reducing mutually its impact.

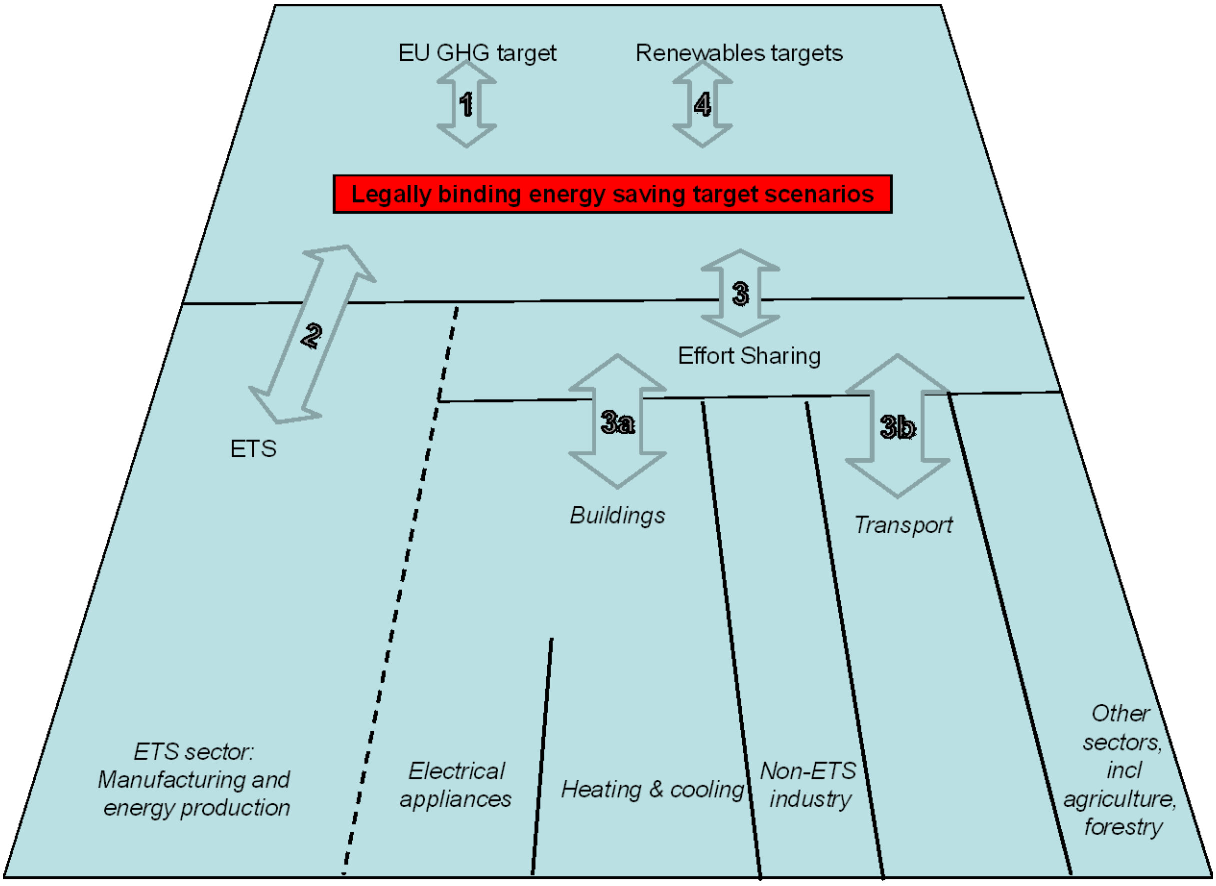
Figure 4.15 shows this interacting policy landscape between GHG targets, renewables targets, the EU ETS and the energy efficiency world.

For example, there is a whole debate arising from main stream economics schools which argue that beyond the comprehensive policy of the emission trading scheme there is no need and no further room for other policy instruments because every kWh saved which has not been considered when the cap was fixed will lead to an increase of emissions in the ETS because the emissions are caped: a kWh saved outside the ETS will lead to reduced emissions from electricity producer and will provide an opportunity for another emitter in the ETS to increase it's emissions up to the cap. Only a further reduction of the cap together with saving programmes aimed at electricity savings will definitely lead to a reduction of emissions. This question is not without foundation, given the fact that more and more overlapping policies are developed to fulfil more and more interacting policy targets (Öko-Institut, DIW, Fraunhofer ISI, 2009). However these interactions are complex and may considerably deviate from the theoretically expected performance of an instrument such as the ETS. Particular arguments in favour of instruments in addition to the ETS are the existence of barriers beyond[51] the internalisation of external costs (which is the main target of the ETS), the fact that the ETS is a partial system covering only part of the energy users (as shown above, 50 % of the energy users in industry are not covered by the system), and that the prices in the ETS are highly volatile and may dissuade long-term

[51] One example of such non-economic barriers occurs in the case of electric motors which are not directly sold but integrated into machines (investor-user dilemma). Policies to target intermediary such as wholesalers of motors and OEMs (Originally Equipment Manufacturers) become relevant to overcome the barriers.

investment in energy efficiency or renewables despite signals that prices could increase over time up to 2020. One further problem at present is also the economic crisis which leads to a smaller demand and falling prices for the allowances.

Figure 4.15 : Policies interacting with possible mandatory energy efficiency targets



Source: European Climate Fund (2009)

The debate schematised above for the ETS, will also arise once stringent and in particular mandatory, energy efficiency targets are considered, or once a scheme of White Certificates would be introduced. White certificates may interact with the ETS but they may also interact with existing regulation for energy efficiency, for example with policies for existing buildings. Once a White Certificate scheme is introduced, there could be at each time a debate if further regulation is introduced which could reduce the benefits of the White Certificate scheme, although it may be better adapted to tackle non-economic barriers. The integrity of an existing instrument could be a strong argument not to introduce a new instrument, because existing instruments tend to develop their own "lobby" who believes that this particular instrument is the most suitable one.

On e crucial problem that appears here is that there is a considerable time lag for strong energy efficiency policies compared to the rather successful supply side measures for renewables or the development of the EU ETS. In fact, the policies discussed now could have been more easily developed ten years ago with supply measures than adapting to the evolving energy demand measures, while now, energy efficiency policies have to cope and face already existing policy instruments and targets and need to find a suitable path to get implemented.

Annex 1: Glossary

ODEX: ODYSSEE energy efficiency index

In ODYSSEE, various indicators of unit consumption are calculated to depict the changes in energy efficiency at a detailed level by sub-sector (end-uses or transport mode). ODEX indicators aggregate sub-sector trends in a single indicator by main sector (industry, households, transport and services) and for the economy as a whole. They are calculated from the unit consumption indices by sub-sector based on the weight of each sub-sector in the total energy consumption of the sector. Energy efficiency gains are measured in relation to the previous year (sliding reference) and not to a fixed base year (e.g. 1990) to avoid having results influenced by the situation in the base year. As indices are used, it is possible to combine different units for unit consumption to provide the best proxy of energy efficiency, e. g. toe/dwelling, koe/m^2, or kWh/appliance for households. **Box A1** details the calculation of ODEX in the case of industry.

Box A1 : Example of ODEX calculation: case of industry

Energy efficiency index of industry (ODEX) is a weighted average of the specific consumption index of 10 manufacturing branches; the weight being the share of each branch in the sum of the energy consumption of these branches in year t and the sum of the implied energy consumption from each underlying industrial branches in year t (based on the unit consumption of the sub-sector with a moving reference year). The 10 branches considered in the calculation are: chemical, steel, non ferrous, cement, other non metallic, paper, food, machinery, transport equipment and textile. For steel, cement and paper, energy savings are calculated using specific consumption per tonne produced; for the other branches, the indicator used is the ratio on energy consumption related to production index.

The variation of the weighted index of the unit consumption between t-1 and t is defined as follows:

$$I_{t-1}/I_t = \sum EC_{i,t} .*(UC_{i,t} / IUC_{i,t-1})$$

with : energy share EC i (consumption of each branch i in total industry consumption);

unit consumption index UC i (ratio : consumption related to production index or ratio : consumption related to physical production of steel, cement and paper)

t refers the current year, t-1 to the previous year

The value at year t can be derived from the value at the previous year by reversing the calculation: It /It -1= 1/(It -1/It)

ODEX is set at 100 for a reference year and successive values are then derived for each year t by the value of ODEX at year t-1 multiplied by It /It -1.

A decrease in the index means an energy efficiency improvement: a value of 87 in 2007 (with 1990=100), for instance, means a 13 % efficiency improvement since 1990. Presently, up to 30 indicators are used in ODYSSEE: up to 7 modes in transport, 9 end-uses for households, 11 branches in industry, and 1 end-use in services. This covers around 80% of the final energy consumption. The rest of the consumption is not covered with ODEX as it is impossible to measure energy savings with top-down indicators as these indicators are increasing, instead of decreasing, because of other drivers (usually the diffusion of new endues and appliances): this is the case for the miscellaneous electrical appliances for households or of electricity uses in the service sector. This means that the possible energy savings in these subsectors are not accounted for.

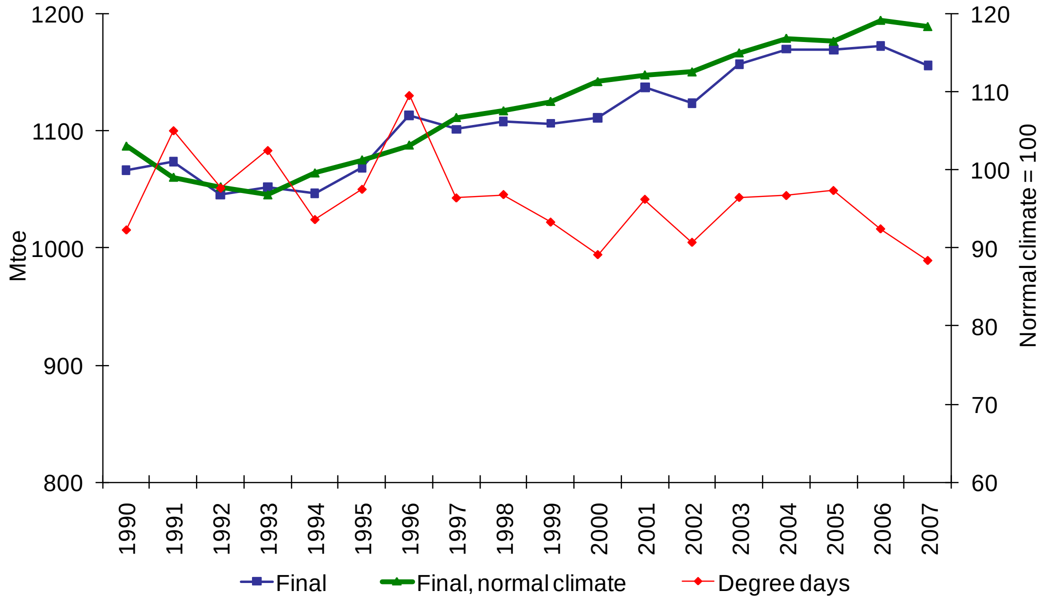
Climatic corrections

Over the period 1990-2007, 14 winters were warmer than usual and 3 were colder. Some years were marked by large climatic variations compared to the previous year[52] (**Figure A1-1**): climatic corrections are necessary before any interpretation can be made.

In ODYSSEE, climatic corrections are carried out for all countries using the same methodology, even if climate-corrected national data exist (e.g. France, Denmark). They are only applied to a certain proportion of the space heating consumption (90 %) to account for the fact that some losses are not dependent on the number of degree-days. The correction is done for each country in a linear way on the basis of the ratio between the normal degree- days (defined as the last 30 years average) and the real degree- days.

[52] This was particularly true for 1991 (17 % colder than 1990), 1993 (5% colder than 1992) and 1996 (13 % colder than 1995). The year 1990 was an unusually warm year (11 % warmer than normal).

Figure A1-1: Impact of climatic variation on the final energy consumption



Final energy intensity at constant structure

The final energy intensity at constant structure is the theoretical intensity that would result if all sectors grew at the same rate as the GDP, i.e. if no change took place in the GDP structure. It is calculated at constant GDP structure using the observed values of sectoral intensities. The calculation is carried out at the level of about 15 branches including the main sectors (industry, agriculture, services, transport and residential) and industrial branches (mining, construction and about 10 manufacturing branches).