Energy Efficiency Trends in the EU

Lessons from the Odyssee-Mure Project
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Project leader

¹ Alphabetic order of countries
Key Messages

Overall trends

- Energy efficiency improved by 12% at EU level between 2000 and 2010 (1.2%/year). There has been a net slow down in the energy efficiency progress since the economic crisis: 0.6%/year since 2007, compared to 1.5%/year between 2000 and 2007.
- The household sector has achieved the largest energy efficiency improvement, with a regular energy efficiency gain (1.6%/year). Gains for industry and transport of goods are only registered until 2007 (1.8%/year), with even a deterioration of energy efficiency after 2007. In transport, energy efficiency progress that was regular and rapid until 2007 (1.2%/year) started to slow down because of transport of goods.
- In 2010, the final energy consumption was 23 Mtoe higher than in 2000. This situation is the result of two main balancing effects: growth in the economic activity would have led alone to an increase of 86 Mtoe while energy savings contributed to 130 Mtoe; changes in lifestyle, modal shift in transport and the colder climate in 2010 contributed to increase the consumption (by 18, 4 and 32 Mtoe respectively) while structural changes in industry led to a decrease (-6 Mtoe).
- Without energy savings, final energy consumption would have been 130 Mtoe higher in 2010. Around 38% of the savings come from households, 28% from industry, 27% from transport and 7% from services.

Industry

- Energy efficiency improved rapidly between 2000 and 2007 in manufacturing industry (1.8%/year at EU level). Since 2007, there was no more progress with even a reverse trend in 2009 and 2010. The average trend in energy efficiency over 2000-2010 was 1.3%/year.
- Energy efficiency improved quite unevenly across countries over the period 2000-2010: from above 4%/year in Bulgaria, Poland and Estonia and between 2 and 4%/year in 5 countries. In 7 countries there was no improvement or a deterioration.
- A shift towards less energy-intensive branches contributed to reduce industrial energy intensity\(^2\) in most countries until 2008; these structural changes explain most of the reduction (over 60%) in 11 countries over the period 2000-2008 (among which Finland, Sweden, Romania, Austria, Germany, and France). On the opposite there was a shift towards energy-intensive industry in UK, Netherlands, Lithuania and Bulgaria, which had an opposite effect and lessened the energy intensity reduction.
- The reaction of countries to the industrial recession in 2009 was quite diverse, structural changes were generally significant but not all in the same direction: they explain 40% of the large decrease in the energy intensity of industry at EU level.
- In 2010, the rebound of industrial growth resulted in an increase of the energy intensity, driven both by structural changes to more intensive branches and lower energy performance (linked to structural changes within the branches and a progressive recovery with inefficient operations in the beginning of 2010); as a result, in 2010 energy efficiency in industry is not back to its historical trends.
- A large part of the decrease in CO\(_2\) emissions between 1990 and 2010 was achieved in 2009 (48% at EU level).

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\(^2\) Energy intensity calculated as the ratio energy consumption / value added.
Energy Efficiency Trends in the EU

Transport

- Despite deterioration in the efficiency of freight transport in 2009, the overall transport sector was 15% more energy efficient in 2010 than in 1990. Most of the gains come from cars, thanks to measures on new cars that have been clearly reinforced since 2007 (EU labelling for new cars and national fiscal measures).
- The energy efficiency of cars is improving on a regular basis (by 1%/year since 2000); in 2010, cars consumed on average 0.8 litre/100 km less than in 2000 at EU level, i.e. 7.1 litre/100 km.
- The specific CO₂ emission of new cars has decreased by 20% (or 2.2%/year) on average in the EU since 2000. The target of 140 gCO₂/km stipulated in the agreement between the European Commission and the association of car manufacturers was however only reached in 2010, instead of 2008.
- The annual distance travelled by cars has been steadily decreasing since 2000, which contributed to lower the energy consumption.
- Modal shift has a negative impact on energy savings as the share of public transport in passenger traffic is decreasing almost everywhere, despite policies to reverse that trend.
- At EU level, the growth in passenger traffic between 1990 and 2010 contributed to increase the energy consumption of passenger transport by 48 Mtoe. Energy savings, have partially offset this activity effect (27 Mtoe). The decreasing share of public transport contributed to increase the consumption by 8 Mtoe, which has offset one third of the energy savings. As a result of these opposite trends, the energy consumption of passenger transport has increased by 29 Mtoe from 1990 to 2010.
- The increase in freight traffic in tonne-km was responsible for a consumption increase of 30 Mtoe. Energy savings amounted to 10 Mtoe and have been completely offset by a modal shift from rail and water to road transport contributed to increase the consumption of freight transport by about 11 Mtoe at EU level between 1990 and 2010. As a result, the consumption increased by 31 Mtoe.
- In 2009, freight traffic dropped drastically (by 12%). However, because of a deterioration in energy efficiency linked to the economic crisis, the energy consumption of freight transport did not follow the reduction in traffic and only decreased by 5%.
- The transport sector is the only end-use sector in which CO₂ emissions continue to increase: emissions in 2010 were 21% above their 1990 levels.

Buildings

- Buildings consume 41% of total final energy consumption in Europe in 2010. It is the largest end-use sector, followed by transport (32%), and industry (25%).
- Final energy consumption of buildings has increased by around 1%/year since 1990 and by 2.4%/year for electricity at EU level.
- At EU level residential buildings represent around 76% of the building floor area, of which 65% for single family houses.
- Annual unit consumption per m² for buildings at EU level is around 220 kWh/m² in 2009, with a large gap between residential (200 kWh/m²) and non-residential (around 300 kWh/m²).

Households

- The energy consumption trend varies among European countries; two thirds reduced their average consumption per dwelling, and in particular some new Member States show a considerable decline.
In 2009, energy consumption decreased with the global economic crisis by 1.6% (at normal climate) as a result of a decrease of income (-3%) and despite a drop in energy price (-9%).

The fraction of energy devoted to space heating is decreasing, partly due to the relative growth in the consumption for electrical appliances. The highest fractions are not found in countries with severe winters but in countries with a moderate climate.

Energy use for space heating per m² is decreasing almost everywhere, except in a few countries with mild winters where winter comfort is improving.

About 25% of energy efficiency progress for space heating has been offset by dwellings becoming larger and a wider diffusion of central heating.

The effect of efficiency standards for new dwellings on space heating consumption is hampered by the often limited volume of new construction (below 1% of the building stock every year in most EU countries).

The Netherlands can be regarded as a benchmark for space heating as it shows the lowest specific energy use per m², thanks to the large diffusion of gas condensing boilers and a comprehensive thermal retrofitting of existing dwellings.

The amount of dwellings with solar water heaters is only a few percent. Some countries with a sunny climate, such as Cyprus and Greece, score much higher than comparable countries like Italy and Spain. Austria is the benchmark for countries with medium solar radiation.

Electricity consumption for appliances & lighting increased in most Member States except Bulgaria and Slovakia. The strongest growth is recorded for small appliances.

The energy efficiency of large appliances has improved quite a lot over the last 20 years but most of the gains has been offset by an increase in equipment ownership.

Services

At EU level, energy consumption in the tertiary sector increased significantly in the early 2000s, and was then rather stable until 2008. In 2009, it decreased by 2.3% because of the economic downturn.

The decrease in energy use per employee (-3% since 2000) is in strong contrast with the substantial increase in electricity consumption per employee (+16%), which is mostly due to the diffusion of cooling in summer (all southern countries) or to strong economic growth (eastern European countries) and a large diffusion of IT appliances.

However, for countries with a sustained high level of economic welfare, the electricity consumption per employee is either stable or even decreasing. This could signal that electricity use reaches a saturation level.
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1. Introduction

1.1. Objective of the brochure

The aim of this brochure is to provide an overview of past developments on energy use and energy efficiency trends in each end-use sector in the EU (industry, transport and buildings), as well as at the overall level. It summarises four sectoral reports on industry, transport, buildings and overall energy efficiency trends that are available on the ODYSSEE web site (www.odyssee-indicators.org). This should help policy makers and other parties involved in energy efficiency and CO₂ emission reduction to adapt current policies and to define new, effective policy measures. Although the main focus is on the improvement of energy efficiency, other drivers affecting the energy demand trend - such as industrial growth, structural changes, lifestyle changes, energy prices - are also considered.

This publication relies on data contained in the ODYSSEE database on energy efficiency indicators, with data on energy trends, drivers for energy use, explanatory variables and energy-related CO₂ emissions (Box 1).

Box 1: ODYSSEE database

The ODYSSEE database is used for the monitoring and evaluation of annual energy efficiency trends and energy-related CO₂ emissions. The energy indicators are calculated for the years from 1990 onwards (EU-15 countries) or from 1996 onwards (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:
  - Energy/CO₂ intensities which compare the energy used in the economy or a sector to macroeconomic variables (e.g. GDP, value added).
  - Unit energy consumption which compares energy consumption to physical indicators (e.g. specific consumption per tonne of cement, steel and paper).
  - 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 (e.g. adjustments for differences in structure i.e. adjusted to the same value added structure).
  - Benchmark/target indicators for energy intensive products (steel, cement, paper) to show the potential improvement based on countries with the best performance.
  - Diffusion indicators to monitor the market penetration of energy-efficient technologies.

ODYSSEE indicators are now used to monitor trends in energy efficiency in a harmonised way among countries. It contributes to support energy efficiency policy formulation and evaluation by the European Commission and EU Member States, in particular as part of the monitoring and evaluation of the Energy Services Directive. ODYSSEE indicators are more specifically used by the European Commission as well as by several international organisations, including:

3 The methodological issues and precise definitions of indicators and data are explained at the end of each sectoral brochure in a specific section, “Definitions and Glossary.”
• DG-Energy: the EC explicitly referred to the ODEX indicators in the Energy Service Directive as a way of contributing to the monitoring of the Directive in a so-called “top-down” approach. The EMOS (Energy Market Observatory) database includes about 40 ODYSSEE indicators. The Energy Demand Management Committee of ESD has proposed indicators similar to those used in ODYSSEE for the measurement of energy savings with top-down methods and a majority of Member States made use of such indicators to report their energy savings in the second NEEAP\(^4\) in June 2011.

• EEA (European Environmental Agency): uses data and indicators taken from the ODYSSEE database for their indicators factsheets as well as in different annual reports such as the Energy and Environment Report\(^5\) and the TERM report\(^6\). 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 for the collection of the data necessary to calculate the indicators similar to the ODYSSEE data template.

1.2. Content of the brochure

This report aims to review the trends observed in terms of energy use, energy efficiency and CO\(_2\) emissions, at the level of all end-use sectors together (chapter 2) and in each end-use sector (industry in chapter 3, transport in chapter 4 and buildings in chapter 5). The analysis will mainly focus on the overall EU trends\(^7\); the differences between countries will also be highlighted, so as to pinpoint the countries with the most interesting trends. The analysis will cover the period 2000-2010, with a focus on the two recent years 2009, to underline the impact of the economic crisis, and 2010 as the most recent year with detailed data available.

This brochure summarises four sectoral brochures available on the ODYSSEE web site\(^8\) that provides more indicators and in depth analysis, as follows:

• Overall Energy Efficiency Trends in the EU
• Energy Efficiency Trends in the Transport sector in the EU
• Energy Efficiency Trends in Industry in the EU
• Energy Efficiency Trends in Buildings in the EU

\(^7\) EU will refer to the EU 27 all along this brochure.
\(^8\) http://www.odyssee-indicators.org/publications/publications.php#trends
2. Overall trends

2.1. Energy consumption trends

Slight decrease of the energy consumption between 2006 and 2009

In the EU, the primary and final energy consumption are slightly below their 2000 level in 2010 (Figure 1). After a slight progression until 2006, they have been decreasing until 2009. Since 1990, the progression has been much slower than the GDP (0.1%, against 1.8%/year for GDP). This trend was probably influenced by the rapid increase in international energy prices\(^9\) as well as the energy efficiency and climate policies implemented by the EU Commission and by national governments.

Final energy consumption decreased slightly (-0.1%/year) from 2005 to 2007 despite a rapid expansion of the economy (+3.3%/year for the GDP). In 2009, primary and final consumption decreased by 5.7%, which was stronger than the GDP contraction (-4.3%). In 2010 the energy consumption increased again with the economic recovery (+2%) and despite a rapid progression of energy prices (+7%) (by respectively 1.5% and 0.9% for the primary and final consumption).

Figure 1: Energy consumption and GDP in the EU\(^{10}\)

\[^9\] In 2011, the price of oil and natural gas was around four times higher than in 2000.

\[^{10}\] Energy consumption at normal climate (i.e. with climatic corrections) calculated by Enerdata from Eurostat, excluding non-energy uses.
Until 2008, the trends by country show a large decoupling between the primary energy consumption and GDP (Figure 2). In most countries, high economic growth was possible with a low progression in energy consumption (below 1%/year for 12 countries) or even a reduction in some countries (Portugal, Germany, UK). In 2009 in most countries (18), the primary consumption decreased more than the GDP. In 2010, in 12 countries the primary consumption increased more rapidly than the GDP, whereas it has been decreasing in 4 southern countries (Portugal, Greece, Croatia, Cyprus) and Ireland.

**Figure 2:** Primary energy consumption and GDP in EU countries

Source: Odyssee
Decreasing share of industry to the benefit of transports

Buildings (households and service sector) absorb around 40% of the final energy consumption in 2010 (Figure 3). The share of industry in the final consumption has decreased significantly, from 34% to 25% between 1990 and 2010 while transport increased its contribution from 26% in 1990 to 32% in 2010. The sector mix between countries is quite diverse with a share of industry ranging from around 25% for example in Cyprus, Malta, Luxembourg or Denmark to more than 45% such as in Finland.

**Figure 3: Final energy consumption by sector in the EU**

![Figure 3: Final energy consumption by sector in the EU](image)

Source: Odyssee

Decrease of the final consumption in most sectors since 2000

Since 2000, the consumption has been decreasing in industry and for households. Electricity consumption increased by 1.4%/year, mainly driven by demand in services (+2.8%/year).

**Figure 4: Final energy consumption trends by sector in the EU**

![Figure 4: Final energy consumption trends by sector in the EU](image)

Source: Odyssee

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11 Final energy consumption measured under normal climate conditions, excluding non-energy uses.
2.2. Trends in primary and final energy intensities

Primary and final energy intensities have been decreasing at a similar rate in the EU, by about 1.6% / year since 1990 and slightly less since 2000 (around 1.5% / year); in 2010, these intensities were 30% below their 1990 values (Figure 5).

**Figure 5:** Primary and final energy intensities in the EU

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

Since 2000, the primary energy intensity decreased faster on average than the final energy intensity in half of EU countries (Figure 6). This trend results from an overall improvement in the average efficiency of power generation linked to the penetration of gas-combined cycles and renewables.

**Figure 6:** Variation of primary and final energy intensities in EU countries

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12 The energy intensity is the ratio between the energy consumption and the GDP measured in constant prices; all indicators are measured at normal climate.
For the other countries, the final intensity has decreased faster than the primary intensity as higher losses in energy transformation have offset more than one third of the reduction in the final energy intensity. These higher losses may come from an increasing share of electricity in the final consumption (e.g. France and Belgium), which results in increased losses in the power sector, and/or changes in the electricity supply (change in the power mix towards less efficient technologies, or less imports (e.g. Finland and Sweden). In The Netherlands, the increasing share of non energy uses explains the greater reduction of the final intensity.

**In most countries and at EU level, structural changes towards less energy-intensive branches contributed to the energy intensity decrease.**

In the EU as a whole, the contribution of services to the GDP has increased from 64% in 2000 to 67% in 2010. This trend has contributed to decrease the final energy intensity, as services require on average 7 times less energy to create one unit of GDP than industry. In the same way, the greater contribution of less energy intensive branches in industry also contributed to decrease the final intensity. Over the period 2000-2010, these structural changes explain 20% of the final intensity reduction\(^{13}\) (Figure 7). In 2010 however, structural changes had a reverse effect because of a strong rebound of industrial growth (3.9% against 1.6% for services). 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 7: Impact of structural changes on the final energy intensity (2000-2010)**

Structural changes had a significant impact on the intensity reduction in Ireland, Sweden and Portugal, where they contributed to more than 2/3 of the overall decrease, and to a lesser extent in Luxembourg, Belgium and Denmark (between 40 and 50%). In Spain and Austria, they offset the impact of an increase in sectoral intensities. In Spain, Portugal and

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\(^{13}\) The effect of structural changes is given by the difference in the variations of the observed final energy intensity and a fictive final intensity at constant structure.
Luxembourg, the high growth in services explains most of this trend, whereas in Belgium, Denmark and Austria, structural changes in industry are the main driver.

In Lithuania, Latvia and Finland, structural changes had a negative impact on the energy intensity reduction (the actual intensity has decreased less than the intensity at constant structure). In Lithuania and Finland, the main reason is the faster growth in industry than in services (2 points decrease in the share of services in the GDP).

2.3. Energy efficiency progress in the EU

Net slow down in energy efficiency progress since 2007 with even a reverse trend in industry since the economic crisis

Energy efficiency has improved by 1.2 %/year on average between 2000 and 2010 at the EU level (Figure 8). There has been a net slow down in the annual energy efficiency progress since the economic crisis: the annual gain has dropped from 1.5%/year between 2000 and 2007 to 0.6%/year between 2007 and 2010, mainly in the productive sectors (industry and transport of goods).

Figure 8: Energy efficiency progress in the EU (ODEX)\textsuperscript{14}

![Energy efficiency progress in the EU](image)

Source: Odyssee

The household sector has achieved the largest energy efficiency improvement, with a regular energy efficiency gain of 1.6 %/year between 2000 and 2010. Gains for industry are only registered until 2007 (1.8%/year). After 2007 the trend is reverse with an increasing index (no more savings afterwards): this is linked to the economic crisis and to the facts that factories do not operate at full capacity and therefore with lower efficiency. For transport, there was a regular and rapid progress until 2007 (1.2%/year), and a net slow down in efficiency improvement since then, because of a deterioration of the energy efficiency of transport of

\textsuperscript{14} The ODEX is calculated as a 3 year moving average to avoid short-term fluctuations (imperfect climatic corrections, behavioural factors, business cycles). It is calculated for households, industry, transport and services.
goods, for the same reason as in industry (lower load factor of trucks, increased empty running): the overall energy efficiency gain registered for transport since 2000 is 0.9 %/year.

Compared to bottom-up evaluations, energy efficiency gains measured in ODYSSEE have a broader scope and include all sources of energy efficiency improvements: policy measures, price changes, autonomous technical progress, other market forces, etc.

**Around half of countries with an energy efficiency improvement above 1%/year**

The improvement in energy efficiency is higher or close to 2 %/year for 5 new member countries: Poland, Romania, Bulgaria, Latvia and Slovenia (Figure 9). For 12 other countries this improvement is above 1%/year (1.2%/year for the EU average). In three countries (Luxembourg, Spain and Portugal), no energy efficiency gains could be measured with the indicators used. These results should be obviously considered carefully because the energy efficiency gains are dependent on the time period and in many countries the economic crisis has deteriorated energy efficiency. This is, for instance, the case of Spain where energy efficiency started to improve in 2004 but the economic crisis stopped that trend from 2007 onwards.

**Figure 9: Energy efficiency progress by country**

[Figure showing energy efficiency progress by country]

Source: Odyssee

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15 This is, for instance, the case of Spain where energy efficiency started to improve in 2004 but the economic crisis stopped that trend from 2007 onwards.
16 Services are not included in the analysis by country due to the difficulty of grasping energy saving with existing data.
About 130 Mtoe of energy savings in 2010

In 2010, energy savings reached 130 Mtoe for the EU as a whole in comparison to 2000. In other words, without energy savings, final energy consumption would have been 130 Mtoe higher in 2010. There was no real progression of energy savings since 2008, as a direct result of the economic crisis, as underlined above. Around 38% of the savings come from households, 28% from industry, 27% from transport and 7% from services (Figure 10).

Figure 10: Energy savings in the EU

Source: Odyssee

2.4. Explanatory factors of final energy consumption variation

The variation of the final energy consumption between two years can be decomposed into several effects for each end-use sector\(^{18}\), as follows\(^{19}\):

- An activity effect due to an increase in the economic activity, measured by the value added in industry and agriculture, by the number of employees in services, by the number of dwellings for households, and by the traffic of passengers and goods in transport;
- A structural effect due to a change in the structure of the value added in industry among the various branches, or due to modal shift in transport;
- A lifestyle effect due to an increase in the household equipment ownership and to larger homes;
- Energy savings, measured from ODEX;
- A climatic effect in the households and tertiary sectors, as the consumption is at real climate\(^{20}\), measuring the effect of different winter severity between the two years;

\(^{17}\) Energy savings in services have not been accounted for due to data limitations.

\(^{18}\) Industry, transport (including international air transport), households, tertiary and agriculture.

\(^{19}\) The methodology is presented in a report available on the ODYSSEE web site “Interpretation of the energy savings for ESD end-use and sub-sectors in relation with the energy consumption variation”.

\(^{20}\) Measuring the effect of different winter severity between the two years.
- A residual effect ("other effects") capturing behavioural changes for heating and change in the valorisation of products in industry (ratio value added over production).

In 2010, the final energy consumption in the EU was 16 Mtoe higher than in 2000 (Figure 11). This trend is the result of two balancing effects:

- On one hand, the growth in the economic activity effect (86 Mtoe), demography or more dwellings (36 Mtoe), changes in lifestyle (18 Mtoe), modal shift in transport (4 Mtoe) and climate difference (32 Mtoe) contributed to increase the energy consumption by around 110 Mtoe;
- On the other hand energy savings (130 Mtoe), as well as, to a lesser extent, structural changes mainly in industry (6 Mtoe), contributed to decrease the energy consumption.

**Figure 11:** Drivers of final energy consumption variation between 2000 and 2010 (EU)

Source: Odyssee

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20 Real climate correspond to the consumption indicated in energy statistics (i.e. actual consumption), as opposed to the consumption at normal climate used before for the indicators. Here it seems more relevant to decompose the actual consumption.
3. Industry

3.1. Energy use pattern

In 2010 final energy consumption of the industrial sector\(^{21}\) was 12% below its 2000 level\(^{22}\), with very contrasted trends over the period: it slightly increased between 2000 and 2004 (0.5%/year), then decreased by 1.8%/year from 2004 to 2008 (Figure 12). In 2009, it dropped dramatically with the global economic crisis, by almost 15%, which was slightly higher than the drop in production (-14%). In 2010, the significant rebound of the activity (4.6%) was followed by a progression of the energy consumption twice faster (around 9%).

For electricity, the trends are different until 2007. From 2000 to 2007, the electricity consumption of industry has regularly increased by around 1.2%/year. This progression was however slower than the industrial activity, as the industrial production index has increased by 1.7%/year over the same period. In 2009 and 2010, the electricity consumption followed changes in industrial activity.

Figure 12: Energy consumption trends in industry in the EU

Electricity and gas are the dominant energy sources in industry

Natural gas and electricity are the dominant sources of energy for industry in 2010 with respectively 32% and 31% of the market. Electricity has experienced a rapid growth (+8 points between 1990 and 2010), partly linked to substitution of fuels by electricity\(^ {23}\). Natural gas market share has only marginally increased (+1 point). The contribution of oil has

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\(^{21}\) Industrial energy consumption includes manufacturing industry, construction and non-energy mining; it excludes the energy used for non-energy uses (e.g. gas or naphtha used as feedstock in petrochemicals).  
\(^{22}\) Compared to its 1990 level, the consumption is 20% below in 2010.  
\(^{23}\) If electricity share had remained constant, the electricity consumption would have been 23% lower than the level observed in 2009 (see brochure industry).
Energy Efficiency Trends in the EU

decreased from around 16% to 13%, while hard coal and lignite have nearly halved their market share from 21 to 12%. Heat from district heating accounts for around 5% of the total. The share of wood and wastes has increased by 4 points reaching 7% in 2010, linked to the high growth of the paper sector.

Reduction in the consumption of steel and chemicals; growth for pulp and paper

The chemical industry is now the main energy consuming branch with 17% of total energy consumption of manufacturing industry in 2010 in the EU, followed by steel with 16% (Figure 13). Steel and chemicals energy consumption are respectively 40% and 20% lower in 2010 than in 1990. In contrast, the pulp and paper industry registered a strong growth of its consumption (+36%) which now represents 13% of industrial consumption (+6 points compared to 1990). The share of all energy-intensive branches (steel, chemicals, cement, glass/ceramics and pulp and paper) in industrial consumption slightly increased from 66% in 1990 to 69% in 2010.

Figure 13: Energy consumption trends by industrial branch in the EU

Electricity consumption has increased in most industrial branches between 1990 and 2008, except in chemicals, non ferrous and textile. In 2009, it decreased in all branches (by 14% for total manufacturing and by 23% for steel). In 2010, it rebounded in all branches (+7% for total manufacturing) and was only 5% higher than in 1990. Paper has become the second largest electricity intensive branch after chemicals and ahead of machinery. Electricity has a market share above 50% in three branches: non ferrous (57% in 2010), machinery and transport vehicles (51%).

The breakdown of consumption by sector varies widely across countries: pulp and paper play the dominant role in Finland and Sweden (more than 50% of the consumption 201024),

24 The values are given for 2008, which is the last year before the strong changes due to the crisis: the shares for 2009 and 2010 would not reflect a normal situation.
whereas it is chemicals in the Netherlands (around 40%), non metallic minerals in Croatia, Portugal and Estonia (respectively 36%, 32% and 30% of the consumption), primary metals (mainly steel) in Slovakia, Norway, Luxembourg, and Belgium (respectively 48%, 45%, 37% and 30% of the consumption) and food in Ireland.

3.2. Overall energy efficiency trends

Energy efficiency has improved by 1.3%/year in industry in the EU since 2000.

Energy efficiency progress in manufacturing industry is measured with ODEX that is calculated from specific energy consumption indices of 11 individual branches. Energy efficiency improved by 1.3%/year in manufacturing industry in the EU since 2000 and by 1.7% on average since 1990 (+30 % for the ODEX) (Figure 14). In 2008 there was no more progress and in 2009 and 2010 there was even a reverse trend because of the economic crisis (a growth of 0.5% for the index in 2009 and +0.2% in 2010). Energy efficiency improvements already slowed down before the recession (1.9 %/year from 1998 to 2007 compared to 2.2%/year from 1990 to 1998).

Figure 14: Energy efficiency index in manufacturing industry in the EU

The specific energy consumption of almost all branches decreased with quite diverse trends across the branches: chemicals (-53 % between 1990 and 2010), machinery (-31%), steel (-27 %), cement (-17 %) and paper (-11 %). For chemicals, part of the variation is probably due to structural changes within the branch, which cannot be removed due to a lack of

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25 Specific consumptions are expressed in toe per ton produced for steel, cement, and paper and in toe per unit of production index for other branches. ODEX better reflects the energy efficiency development than the usual energy intensity to value added, even cleaned for structural changes, as it relies on physical indicators.

26 The variation of the index includes changes in the process mix from oxygen to the electric arc process.

27 Variation in the energy consumption per ton of cement reflects energy efficiency improvements as well as the effect of changes in process mix and the increasing use of clinker additives.
disaggregated data (e.g. increasing share of less energy intensive chemicals, such as pharmaceuticals)\textsuperscript{28}.

In 2009 the specific consumption of steel, cement and paper increased in most of the countries which reflects a loss of efficiency. Indeed, during a year of recession, such as in 2009, the consumption does not follow the reduction of activity, mainly for two reasons:

- the end-use process equipment, such as boilers, furnaces or motors do not operate at full capacity and are significantly less efficient;
- part of the consumption is not linked to the level of production.

In a recovery year (e.g. 2010), there is a rapid efficiency improvement with the increase rate of utilisation of equipment: this was well observed for steel but not for paper and cement.

Expressed in Mtoe, energy savings in industry reached 38 Mtoe in 2010 compared to 2000; in other words without these savings energy consumption would have been higher by 38 Mtoe in 2010. In 2008, and especially in 2009, there was a deterioration in energy efficiency ("negative savings") due to the economic recession (Figure 15).

**Figure 15:** Energy savings in industry\textsuperscript{29} in the EU

![Energy savings in industry](image)

Source: ODYSSEE

Energy efficiency improved quite unevenly across countries over the period 2000-2010: from above 4%/year in Bulgaria, Poland and Estonia; in a range of 2 to 4% in 12 countries (e.g. UK, Denmark, Slovenia, The Czech Republic, The Netherlands or Romania). In 6 countries (Finland, Latvia, Slovakia, Ireland, France and Portugal) energy efficiency improved by less than 1%/year (Figure 16).

As for the EU as a whole, the economic crisis in 2009 had a negative impact on energy efficiency with a reverse trend in several countries (e.g. Ireland, Latvia, Finland, Hungary) or a slowdown in the other countries.

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\textsuperscript{28} See further explanation in the brochure on industry indicators.

\textsuperscript{29} Savings calculated for manufacturing industries, based on ODEX
**Figure 16:** Energy efficiency trends in industry in EU countries\(^{30}\) (%/year)

![Energy efficiency trends in industry in EU countries](chart)

Source: ODYSSEE

### 3.3. Benchmarking of energy performance in steel, cement and paper\(^{31}\)

This section compares the level of performance of the various countries through benchmarking indicators, taking into account the specificities of the production process. The benchmarking has been done for 2008 instead of 2009, as 2009 was an unusual year due to the economic crisis.

**The specific energy consumption per tonne of steel depends on the process mix**

As the oxygen process requires 2 to 3 times more energy than the electric process\(^ {32}\), it is important, when comparing the average energy consumption per tonne of crude steel among countries, to take into account the “process mix” (i.e. the relative share of the two processes). Figure 17 compares the specific consumption per tonne of steel in relation to the share of electric steel in total crude steel production. The vertical distance from the world benchmark (shown by a red line), which is based on the best available performance, shows the technological improvement possible at the given process mix of the country\(^ {33}\).

Benchmarking of countries should be done at similar rate of penetration of the electric process: for countries in a range of 10-25% share of electric steel, Hungary and Japan are benchmark countries; for countries in a range of 30-35% electric steel, Germany and

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\(^{30}\) Based on ODEX.

\(^{31}\) The analysis includes non-EU countries using data collected by IEA.

\(^{32}\) The conversion of electricity for the electric process is made in final energy terms on the basis of the calorific value of electricity.

\(^{33}\) The distance to the 100% electric process shows the potential theoretically open to process substitution. In reality, this might be more restricted due to the limited substitution possible between oxygen steel and electric steel, linked to the availability of iron scrap, the quality requirements of the steel produced and the obsolescence of existing plants.
Belgium represent the benchmark countries; for the range of 60-80%, the best country turns out to be Italy. For a full penetration of electric steel (i.e. share of 100%), Greece has the best performance. On the opposite the Netherlands has the best performance for oxygen process.

**Figure 17: Energy consumption per tonne of steel** and process mix

The energy performance of pulp and paper depends on the production of pulp

To explain the differences observed among countries it is necessary to take into account how the paper is produced. Paper is produced from raw pulp or from recycled paper. Pulp production is an energy-intensive activity. The pulp used in a given country may be produced in the country itself or be imported from other countries. If it is imported, this means that the energy consumption for pulp production has taken place in the exporting countries. Therefore, the energy performance of the paper industry of a given country is linked to the share of pulp produced in the country in relation to the paper production: the higher this ratio, the higher the specific consumption per tonne of paper (Figure 18). Energy efficiency performance can only be benchmarked among countries with a similar ratio of pulp/paper production. In countries exporting a large production of pulp (i.e. Finland, Sweden and Norway), Norway has the best performance: this may be due to a higher penetration of electricity use (around 60% in Norway, compared to 30% in Finland and Sweden), partly linked to a higher production of mechanical pulp versus chemical pulp.

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34 Differences among countries may also arise from the fact that the energy consumption covers the whole iron and steel industry, not only the steel plants but also sintering, rolling mills, reheating furnaces.

35 Pulp paper represents chemical and mechanical paper pulp.
Figure 18: Specific energy consumption in the pulp and paper industry

Source: ODYSSEE

For cement, comparisons of energy efficiency are more relevant taking into account the share of clinker produced in relation to the cement production.

The energy performance of cement production is shown in Figure 19. Distance to the red line (which represents the actual world best practice) indicates the potential of energy savings. For countries with a similar share of clinker, the country with the lowest values represents the benchmark: for instance, Germany for countries in the range 70-80%.

Figure 19: Energy consumption per tonne of cement produced

Source: ODYSSEE

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36 Specific energy consumption is measured by the ratio between energy consumption and physical production (tonne of paper).
3.4. Decomposition of the energy consumption variation

Energy savings and structural effects have contributed to decrease industrial consumption between 2000 and 2008

The energy consumption of industry in the EU has decreased by 13 Mtoe over the period 2000-2008 and by 46 Mtoe during the recession year 2009. To understand these trends, the variations observed have been decomposed into four effects:

- An activity effect, measuring the effect of the variation of the value added, assuming the same energy intensity as in the base year (2000);
- Structural changes, measured by the change in the structure of the industrial value added by branch;
- Energy savings, measured by the ODEX;
- Changes in the value of products calculated as a residual effect.

The decrease of the energy consumption from 2000 to 2008 is due the combination of two contrasted factors: on the one hand, the increase in the value added (by 1.4% year on average) contributed to raise the energy consumption by 38 Mtoe ("activity effect"), while, on the other hand, energy savings and structural effects contributed to reduce the consumption by 42 Mtoe and 12 Mtoe respectively. As a result, total energy consumption of industry decreased by 13 Mtoe (Figure 20).

In 2009, the strong drop in activity explains most of the consumption reduction

In 2009, recession year, the energy consumption has decreased by 46 Mtoe. The strong drop in activity (-13%) explains most of the energy consumption decrease; energy savings were negative and contributed to increase the consumption (by around 8 Mtoe). In 2010, most factors contributed to the consumption growth; few savings are meanwhile observed.

Figure 20: Decomposition of industry’s energy consumption variation in the EU

![](image)

Source: ODYSSEE

37 Changes in value of products can be also be measured by change in the ratio value added to production index.
38 The balance is due to change in the value of product.
3.5. **CO₂ emissions trends in industry**

Direct CO₂ emissions from industrial combustion of fossil fuels (oil, natural gas and coal) have decreased in all countries since 1990 except in Portugal, Norway, Ireland, Austria and Spain[^39] (Figure 21).

**Figure 21:** CO₂ emissions of industry from fuel combustion in EU countries

A large part of the decrease in CO₂ emissions was achieved in 2009 (48% of the variation between 1990 and 2010 at EU level). In countries such as Portugal, Bulgaria, Norway, Denmark, Sweden, Finland, Poland and Italy, the large decrease of CO₂ emissions in 2009 explained more than 60% of the total reduction in CO₂ emissions since 1990 (Figure 22).

**Figure 22:** Variations of CO₂ emissions of industry from fuel combustion in EU countries

[^39]: Emissions do not have the same boundaries as energy consumption: indeed emissions from the combustion of fuels used for own generation of electricity are included in industry but excluded from the energy consumption.
In the EU as a whole, indirect CO2 emissions corresponding to the emissions in power generation induced by the electricity purchased by industry\(^40\), are of the same magnitude as direct emissions in 2009 (Figure 23). There exist large differences among countries in the share of indirect emissions depending on energy mix for utility power generation (16% in France, 53% in Germany).

**Figure 23:** Share of direct and indirect CO\(_2\) emissions in EU countries (2009)

\[^{40}\text{Indirect emissions are based on an allocation of emissions of the electricity sector to industry in proportion of its share in electricity consumption.}\]**
4. Transport

4.1. Energy consumption

Decrease of transport consumption since 2007 with a sharp drop in 2009.

The energy consumption of the EU transport sector\(^{41}\) increased very rapidly between 1990 and 2000 (2%/year) (Figure 24). Between 2000 and 2007, there has been a net slowdown (1.5%/year) linked to the sharp increase in oil prices, and thus in motor fuel prices, the slowdown in air traffic, and national measures in certain countries\(^{42}\). The consumption has then been decreasing since 2007 (-1.3%/year over 2007-2010 on average), with a sharp drop in 2009 (-2.5%).

In Germany, consumption has been falling since 2000 (-0.8%/year on average); in France and UK, there has been almost no growth since 2001. In Spain and Italy, there has been a significant change compared to historical trends after 2007 with the economic recession.

In New Member Countries, there has been a rapid growth until 2008 (>4%/year), followed by a rapid decrease twice higher than for the EU average (-3.5%/year over 2008-2010).

The sector’s energy consumption has increased by 84 Mtoe since 1990, with trucks and light vehicles accounting for almost 40% of that growth, cars for about one-third and air transport (both domestic and international) for about 25%.

Figure 24: Trends in the energy consumption of transport in the EU

![Graph showing energy consumption trends](image)

Source: ODYSSEE

\(^{41}\) Transport consumption includes international air transport following Eurostat definition.

\(^{42}\) For instance, motor fuel tax increases in Germany and the UK, enforcement of speed limits via automatic speed control devices in France.
Road transport represents about 80% of total transport consumption

Road transport represents around 80% of the total EU transport consumption (ranging from 63-98%). There was a strong decrease of the energy consumption of road transport in most EU countries in 2009 with the economic recession (-1.7% for the EU as a whole) and a slight reduction in 2010.

Half of the energy consumption for cars and 30% for trucks

Cars account for about half of the sector’s total consumption (Figure 25). The share of cars is declining (48% in 2010 compared to 53% in 1990), whereas that of road freight transport (trucks and light-duty vehicles) is slightly increasing (30% in 2010 compared to 28% in 1990). Light-duty vehicles have the fastest consumption growth among road vehicles (1.6%/year compared to 0.9%/year for cars). The share of buses and two-wheelers is steady since 1990, at 4% of the total transport consumption.

Domestic and international air transport consumption increased the most rapidly (2.8%/year since 1990)\(^43\); air transport went from accounting for 10% in 1990 to 14% in 2010 of the energy consumed by the sector. Rail and domestic water transport accounted for about 4% of total transport energy demand (with 2% each). Passenger transport represents about two third of the total consumption and grows less rapidly than freight transport.

Figure 25: Consumption of transport by mode in the EU

![Graph showing transport consumption by mode](image)

Source: ODYSSEE

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\(^{43}\) Total air transport consumption increased at the rapid rate of about 5% per annum between 1990 and 2000, until in 2001 the sector was struck by a crisis.
The importance of cars varies greatly among countries

The share of cars in the energy consumption of transport varies from around 35% in Norway, Greece or Romania to above 55% in Germany and Hungary. These differences stem from the level of car ownership (low in Romania) and the importance of other transport modes, namely air transport (high in UK and the Netherlands), domestic water transport (high in Greece, Norway and the Netherlands) and road freight transport.

Reduction of the high dependence on oil in certain EU countries

Oil products make up the bulk of the sector’s consumption (95% on average in the EU, ranging from 91% to 100%): on average alternative fuels (electricity, compressed natural gas (CNG) and biofuels) supplied 5% of the consumption in 2010 and their share is progressing rapidly (2% in 2000).

Four countries have a high share of alternative fuels in road transport: Austria (9%), Portugal (6.5%), France (6.5%) and Germany (6%), compared to 4.9% for the EU as a whole (Figure 26). That good performance is mainly explained by the rapid penetration of biofuels, and especially of biodiesel, following the prompt implementation of the EU Directive on biofuels.

Figure 26: Share of biofuels and natural gas in road transport (2010)

Source: Enerdata estimates from national data, Eurostat/AIE and Observ’ER

Diesel makes up more than 60% of road transport consumption

Diesel consumption has grown quickly in the EU, by 3.3%/year between 1990 and 2010. As a result, diesel replaced motor gasoline as the sector’s leading energy source in 1998. Its market share now totals 63% of road transport consumption, compared to 52% in 2000 and 42% in 1990. The market share of diesel is particularly high in Belgium, Austria, France, Spain, and Portugal (between 70 and 80%).
Transport energy consumption is now growing at a slower rate than the GDP

Since 2000, there has been a decoupling of the energy consumption of transport from the GDP; from that year onwards the growth in the energy demand for transport has been slower than the growth in GDP. As a result, the ratio of transport energy use per unit of GDP has decreased at an average rate of 0.8%/year in the EU between 1999 and 2010. This trend is mainly explained by the fact that passenger transport, which is responsible for two-thirds of the consumption, has been increasing at a slightly slower rate than the GDP, and by the high oil prices.

4.2. Energy efficiency and CO\textsubscript{2} trends for cars

Acceleration of the reduction in the specific consumption of new cars since 2007

In the EU, the fuel consumption of new cars\textsuperscript{44} has been decreasing since 1995 (Figure 27). Between 1995 and 2010 the average specific consumption of new cars in the EU was almost 2 litres less than in 1995 (reduction from 7.7 l/100 km to 5.6 l/100 km\textsuperscript{45}). From 2000 to 2007 that reduction has slowed down because of the saturation of new diesel cars at 5.9 l/100 km. From 2007, it has decreased again significantly for all types of fuel, mainly because of national policies promoting low emission cars.

Since more than 90% of the cars on the road in 2010 had been produced after 1995\textsuperscript{46}, the energy efficiency gains achieved in new cars had a direct impact on the average performance of the car fleet. As a result, the average specific consumption of the car fleet decreased from 8.6 l/100 km in 1990 to 7.1 l/100 km in 2009 (Figure 27).

\textsuperscript{44} The energy efficiency progress of new cars is usually assessed using an average “test specific consumption” measured through a fuel consumption test for all new cars sold each year.

\textsuperscript{45} From 7.9 to 6 l/100 km for new gasoline cars and from 6.7 to 5.2 l/100 km for new diesel cars.

\textsuperscript{46} Every year new cars represent about 8%, on average, of the total car fleet in the EU.
The specific consumption of new cars differs among countries in 2010: a difference of about 1 l/100 km can be seen between Denmark, France and Portugal, on the one hand, that are around 5 l/100km, and Sweden, Germany and Finland, on the other hand, that are around 6 l/100km (Figure 28). The high share of diesel cars, which have a lower specific consumption than gasoline cars for a given type of car, largely explains the good performances of France for instance, where diesel cars made up more than 70% of new registrations. This is true too in the cases of Belgium and Portugal, with diesel shares between 70% and 80% (EU average around 55%).

**Diverging trends in the reduction of the specific consumption of new cars**

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47 Test values for new cars.
48 Data on new cars come from the reporting by car manufacturers to the European Commission. They are processed to get national averages (done by EEA since 2009). Until 2008, data were available by country in l/100km; since 2009 data are only available in gCO2/km.
49 Data only available until 2008 for Croatia, Cyprus, Latvia, Lithuania, Luxembourg, Malta, Poland, Czech Rep., Romania, Slovakia and Slovenia, and until 2009 for Estonia, Greece and Hungary.
Between 1995 and 2010, the reduction in the specific consumption of new cars ranges between 1.4 and 3.2%/year depending on the country (2.1%/year on average for the EU) (Figure 29). From 2007, the rate of reduction significantly increased in most countries, as a result of the labelling of new cars, of national fiscal measures increasing taxes on inefficient cars and also of high motor fuel prices.

**Since 2008, there has been a clear trend towards smaller new cars**

Until 2007, there had been a shift to heavier and more powerful cars in most countries: the average power of new cars sold in the EU-15 increased by 50%, from 64 to 96 kW, between 1995 and 2007\(^{51}\). Therefore, over that period, the actual technical progress achieved was even more pronounced than is suggested by the changes in the test specific consumption of new cars. Between 2007 and 2010, this average horsepower decreased by 14% to 83 kW; the reduction was very significant almost everywhere and has to be linked to recent measures (car labels, incentives to purchase efficient/low emission new cars; CO2 taxes, etc.) and to the high oil price.

**Figure 29: Trends in the specific consumption of new cars in the EU**

![Chart showing trends in specific consumption](chart.png)

Source: estimation ODYSSEE from ACEA, KAMA, JAMA, EU Commission, EEA T&E

**In 2010, the specific CO₂ emission of new cars was below 140 g/km in 10 countries**

The average specific CO₂ emissions of new cars sold in the EU decreased from 186 g/km in 1995 to 140 g/km in 2010; that corresponds to an average reduction of 1.9%/year or 25%. However, the reduction was not in line with the target of 140 g/km to be reached in 2008 as stipulated in the agreement between the European Commission and the associations of car manufacturers; this level was reached with 2 years delay, in 2010. In 2010, ten countries had an average specific CO₂ emission below 140 g/km for new cars. There exist significant differences among countries in the average specific CO₂ emissions of new cars, with a range of 22% between Denmark and Latvia (Figure 30).

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\(^{51}\) For more detail see the transport indicators brochure.
In 2010, 60% of new cars in the EU had specific CO\textsubscript{2} emissions below 140 g/km, and 30% were even below 120 g/km. The share of car emitting between 100 and 120 gCO\textsubscript{2}/km has increased by 25 points in four years.

**Diverse trends in the decrease of the car fleet's average specific consumption**

The average specific consumption of the car fleet has decreased steadily in all EU countries although to varying degrees ranging between 0.5-2.3%/year (1.3%/year at EU level) (Figure 31). In 2010, cars consumed 0.8 litre/100 km less than in 2000 at EU level, i.e. 7.1 litre/100 km. The fall was more rapid than the EU average in Austria, Romania, Norway, Italy, Slovenia, UK, Greece and Germany. This continuous improvement stems from the oldest and less efficient cars being replaced by new ones and the increasing share of diesel vehicles in the car fleet.
Figure 31: Variations in the average specific consumption of cars\textsuperscript{52}

\begin{figure}[h]
\centering
\includegraphics[width=\linewidth]{figure31.png}
\caption{Variations in the average specific consumption of cars.}
\end{figure}

The average specific consumption of the car fleet ranged between 6.1 l/100 km (Italy, UK) and 8 l/100 km (Sweden, Denmark, Ireland) in 2010, with an EU average around 7.2 l/100 km. There is no real correlation between the average specific consumption of the car fleet and the average fuel price: the average car size and horsepower and the share of diesel are probably the most important factors behind the differences observed.

The average amount of energy consumed by a car over one year (in toe per car) does not only depend on the technical performance of the car (in litres/100 km), but also on the annual distance travelled (km/year).

\textsuperscript{52} Specific consumption expressed in (l/100 km).
The annual distance travelled by cars has been decreasing since 2000

The annual distance travelled by cars varies greatly among countries, from a minimum of around 8000 km to a maximum of 17000 km. The EU average stands slightly above 12000 km/year.

In most EU-15 countries and in the EU as a whole, the average annual distance travelled by cars increased until 2000 and has been decreasing since then, mainly because of the large increase in motor fuel prices since 2000. There was a reduction of about 800 km at EU level between 2000 and 2010 (Figure 32). In Finland, UK and Czech Republic, the decrease was quite significant (around 2000 km). In Greece, Denmark and Ireland the reduction was around 1000 km. In most of those countries and in the EU as a whole, this reduction has offset the increase at the beginning of the nineties, and the average distance travelled has returned to the same level as in 1990.

In most new Member States, except the Czech Republic, an opposite trend can be observed, with a regular rise in the distance travelled linked to disaffection for public transport. During the 2009 crisis, the annual distance travelled by car has however decreased almost everywhere.

**Figure 32:** Variation of the average annual distance travelled by car

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8000 km corresponds to the average of the 3 lowest countries (Poland, The Czech Republic and Romania with very similar values) and 16500 km to the average of the 5 highest values, also with very similar values (Denmark, Ireland, Finland, Slovenia and Latvia).
Technological savings for cars averaged 1.7 Mtoe/year since 2010 in the EU

Energy savings for cars can be measured according to the reduction in the energy used by car per passenger-km\(^54\). These savings may stem from improvements in their technical performance, from changes in driving behaviour (“eco-driving”), from changes in the average car size or horsepower, or from an increase in car occupancy (“car pooling”\(^55\).

“Technological savings” resulting from the decrease in the average specific consumption per car in l/100 km are estimated at 26 Mtoe for the EU in 2010 (compared to 1990), i.e. about 16% of the total consumption of cars; in other words, without these savings, the consumption of cars in 2010 would have been 26 Mtoe above its actual level or 16% higher. This corresponds to an average annual savings of 1.4 Mtoe/year (Figure 33). Fuel switching from gasoline to diesel contributed to an increase of energy consumption by about 0.4 Mtoe/year between 1990 and 2010. Changes in car occupancy, which is a behavioural factor, had a small effect.

**Figure 33:** Energy savings from cars in the EU

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\(^{54}\) This is the definition used to monitor the Energy Services Directive (ESD).

\(^{55}\) See transport brochure
Energy savings have helped moderate the energy consumption increase

Between 1990 and 2010, the increase in the total stock of cars should have raised the energy consumption of cars by 76 Mtoe or 3.8 Mtoe/year, of which 26 Mtoe (or 1.3 Mtoe/year) are due to an increase of the population in age of driving^56 (“demographic effect”) and 50 Mtoe (i.e. 2.5 Mtoe/year), are due to an increase in the number of cars per inhabitant (“equipment rate effect”), all other things being equal. These two effects were partially offset by an increased efficiency of the car stock (“technical efficiency effect”^57) (-37 Mtoe; 1.8 Mtoe/year) and by the decrease of the average annual distance travelled by car (“distance effect”), resulting in a net increase of just 27 Mtoe or 1.3 Mtoe/year in the energy consumption of cars (Figure 34). In 2009, the global economic crisis implied a net reduction in total consumption, mainly because of very slow growth in the car stock.

**Figure 34:** Decomposition of cars’ energy consumption variation in the EU

Source: ODYSSEE

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**4.3. Passenger transport: modal shift**

Energy efficiency improvements for passenger transport can come from more efficient vehicles, as seen above for cars, as well as from a shift of part of the traffic by car with public transport (rail, metro, buses) that are less energy intensive modes. Indeed, all countries are implementing national and local measures to change the present modal split that is dominated by cars.

On average, cars require four times more energy to transport one passenger-km than public transport (rail transport and buses), and five times more energy than rail transport alone (trains, metros and tramways).

^56 The population in age of driving is considered as the population older than 20 years.

^57 This effect is based on toe/100km, i.e. including substitution compared to previous Figure 33.
The share of public transport is decreasing almost everywhere

The share of public transport in passenger traffic is decreasing in most countries and in the EU as a whole (Figure 35). At EU level the share of public transport decreased by two points between 1995 and 2010, from 19% to 17%. The strongest reduction in the share of public transport took place in new member countries from Central and Eastern Europe. Only seven countries show a different trend and have reversed the increasing role of cars: Belgium with the largest progression (+4 points), followed by UK (+3 points), France and Italy since 2000 (+2 points), and three countries with smaller increases (Sweden, Denmark and Germany).

The declining role of public transport should slow down or reverse in other countries and at EU level in the future, as many government and local authorities are developing or planning new public transport infrastructures, the impact of which is slow given the long lead time in that area.

**Figure 35**: Share of public transport in total passenger traffic in EU countries

Source: ODYSSEE

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58 Traffic measured in passenger-km (2009 for Estonia and Luxembourg; 2008 for Belgium, Ireland and Croatia; 2007 for Lithuania)
The decline in the share of public transport has offset 1/3 of the energy savings.

At EU level, the growth in passenger traffic between 1990 and 2010 contributed to increase the energy consumption of passenger transport by 48 Mtoe. Energy savings, due to reductions in the specific consumption per unit of traffic, have partially offset this activity effect and contributed to reduce the consumption by 27 Mtoe. The decreasing share of public transport contributed to increase the consumption by 8 Mtoe, which has offset one third of the energy savings. As a result of these opposite trends, the energy consumption of passenger transport has increased by 29 Mtoe from 1990 to 2010 (Figure 36).

**Figure 36:** Drivers of energy consumption variation for passenger transport in the EU

![Figure 36](image)

Source: ODYSSEE

### 4.4. Freight transport

**Lower efficiency of road freight transport since 2000**

Freight transport by road absorbs almost 80% of the energy consumption of total freight transport. The energy efficiency of overall freight transport is assessed through an indicator of energy consumption per tonne-km.

Until 2007, the energy consumption per tonne-km dropped, which means that the efficiency of road transport of freight has been improving regularly (by around 0.7%/year) (Figure 37). Between 2000 and 2007, energy efficiency improvements were driven both by an increase in the efficiency of vehicles (measured by the ratio toe/km) and by a more efficient management of freight transport (as shown by the increase in the ratio tonne-km/vehicle)\(^59\). The later trend is the result of higher load factors, a reduction of empty running, and possibly a shift to larger trucks, which can be explained by a rapid growth in the volume of traffic

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\(^{59}\) This was also the case between 1993 and 1998.
(nearly 5%/year in tonne-km). However, with the economic crisis in 2008 and 2009, the energy consumption per tonne-km drastically increased: even if the efficiency of vehicles (in terms of l/100 km) did not change, the fall down in traffic led to a less efficient operation of the vehicle fleet, as shown by the sharp decrease in load factors60.

**Figure 37:** Change in the unit consumption of road freight transport in the EU61

![Graph showing change in unit consumption of road freight transport in the EU](image)

Source: ODYSSEE

**The share of efficient transport modes (rail and water) is generally decreasing**

In most countries the share of efficient transport modes (rail and water) is decreasing; in other words, the trend is moving in the opposite direction in which policy makers plan for it to move (Figure 38). The greatest reduction can be seen in new member countries, especially in Poland, Slovakia and Bulgaria. The share of rail and water transport has slightly increased or remained stable in seven countries. Sweden appears as a good benchmark for all the other countries as it is both among the countries with the highest share of rail and water transport (it ranks fifth with a 46% share) and among the countries where this share is progressing. In 2010 the share of rail and water varied greatly among countries, ranging from less than 10% in Greece and Ireland to above 50% for The Netherlands, Estonia and Latvia.

The modal shift from rail and water to road transport contributed to increase the consumption of freight transport by about 11 Mtoe at EU level between 1990 and 2010. The increase in freight traffic in tonne-km was responsible for a consumption increase of 30 Mtoe. Energy savings, linked to a reduction in the specific consumption per unit of traffic amounted to 10 Mtoe and have limited the increase of the total energy consumption to 31 Mtoe (Figure 39). With the economic crisis in 2008-2009, there was an opposite trend: activity decreased and implied a reduction in total consumption, while energy savings reversed (“negative savings”) because of an increase in the energy consumed per tonne-km, as explained above.

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60 The load factor is measured by the ton-kilometre per vehicle; in a period of economic growth, this ratio is stable or increases. However, in a period of recession, such as over 2007-2009, it decreases because each truck is on average less loaded and empty running is increasing.

61 Unit energy consumption measured in goe (gram oil equivalent)/tonne-km.
Figure 38: Share of rail and water in total freight traffic in EU countries

![Graph showing the share of rail and water in total freight traffic in EU countries from 2000 to 2010.](image)

Source: ODYSSEE

Figure 39: Breakdown of energy consumption variation for freight in the EU

![Graph showing the breakdown of energy consumption variation for freight in the EU from 1990 to 2010.](image)

Source: ODYSSEE

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62 In Latvia, the high share of railway in freight transport is due to international transport.
63 A positive "modal shift effect" means that the share of road in total freight traffic is increasing (shift from rail-water to road): this offsets energy savings.
4.5. Overall energy efficiency trends

Regular improvement of 1%/year in the energy efficiency of transport in the EU

The energy efficiency of transport in the EU improved by 15% between 1990 and 2010 (around 0.8%/year), as measured according to the ODEX indicator. Greater progress was achieved in the energy efficiency of both cars and airplanes than in the rest of the sector (Figure 40). Energy efficiency progress slowed down for trucks and light vehicles since 2005, with even a loss of efficiency since 2008 because of the economic crisis.

Figure 40: Energy efficiency progress in transport in the EU

[Graph showing energy efficiency progress in transport in the EU, with trends for overall (excl air), cars, trucks & light vehicles, and air transport]

Source: ODYSSEE

In eleven EU countries the rate of energy efficiency progress is above 1%/year

In eleven EU countries, and in Norway, the rate of energy efficiency progress was above 1%/year since 2000, i.e. above the target of the Energy Services Directive (Figure 41). In six countries the efficiency of transport decreased because of road freight transport: in other words, the negative savings for freight transport have offset the savings registered for cars.

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64 Only the trends of the main modes are shown in the graph. ODEX is calculated as a 3-years moving average (see glossary and definition).
4.6. CO₂ emission trends in transport

CO₂ emissions in the transport sector have increased by 21% since 1990

The transport sector is driving total CO₂ emissions from energy use: CO₂ emissions from transport have increased by 21% between 1990 and 2010, whereas in all other sectors these emissions are far below their 1990 levels (reduction of 32% in industry and 10% in households, services and agriculture)\(^66\). As a result, transport represents a growing share of the total emissions of final consumers (i.e. excluding the power sector): 42% in 2010 compared to 32% in 1990. Since 2000, the increase of emissions from transport has slowed down (0.2%/year compared to 1.6%/year over 1990-2000).

Road transport of freight is driving CO₂ emissions from transport

Road transport represents 90% of total emissions from transport. The emissions from road freight transport increased by nearly 36% between 1990 and 2010 and made up 35% of the sector’s emissions (compared to 31% in 1990)\(^67\) (Figure 42); this is the main source of the sector’s rapid growth in emissions. Emissions from cars have increased by 15%. Although emissions from domestic air transport\(^68\) have increased by 17% since 1990, they represent less than 3% of the total.

\(^{65}\) Countries with an increase in the ODEX indicator are shown as having no energy efficiency progress: for these countries, negative savings for trucks, due to non technical factors, have more than offset energy savings for cars.

\(^{66}\) Source: EEA inventory (2010). CO2 represent 99% of the sector’s greenhouse gas emissions.

\(^{67}\) Source: ODYSSEE estimates.

\(^{68}\) Emissions from international air transport are not included in countries’ emissions, in accordance with the UNFCC methodology.
Figure 42: Variation of CO2 emissions from transport in the EU

![Graph showing CO2 emissions from transport in the EU from 1990 to 2010.]

Source: EEA for total emissions and ODYSSEE for the emissions by mode

Almost half of the increase in CO2 emissions have been offset by CO2 savings

The increase in the traffic of passengers and freight should have increased CO2 emissions by 318 Mt CO2 between 1990 and 2009. Savings in CO2 amounted to 150 Mt and were almost exclusively due to the reduction in the specific emissions of road vehicles per unit of traffic. These savings limited the increase in CO2 emissions to 167 Mt and have offset almost half of the CO2 emission increase since 1990 (Figure 43). Around 40% of the savings come from trucks and light vehicles and 30% from cars.

Figure 43: Decomposition of the variation of CO2 emissions in transport in the EU

![Graph showing the decomposition of CO2 emissions in transport between 1990 and 2009.]

Source: ODYSSEE

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Direct emissions as in the CO2 inventory; adding the indirect emissions from the sector’s electricity consumption would not really change the picture since electricity use is not important in that sector.
5. Buildings

5.1. Overview of the buildings sector

Buildings consume about 40% of total final energy requirements in Europe (2010). The building sector is one of the key consumers of energy in Europe, where energy use has increased a lot over the past 20 years.

A wide array of measures has been adopted at EU level and implemented across individual Member States to actively promote a better energy performance of buildings. In 2002, the Directive on the Energy Performance of Buildings (EPBD)\(^{70}\) was adopted and recast in 2010 with more ambitious goals. More recently in the Energy Efficiency Plan 2011\(^ {71}\), the European Commission states that the greatest energy saving potential lies in buildings\(^ {72}\).

Total energy consumption of the building sector has increased by around 1%/year since 1990, mainly in non-residential buildings (1.5%/year for non residential buildings compared to 0.6%/year for households). Electricity consumption has increased more rapidly, by 2.4%/year since 1990 (+60%). This increasing trends is rather marked for non residential buildings, with an increase of 3.3%/year, while the rate of progression for households was twice lower (1.7%/year) (Figure 44). Understanding energy uses in the buildings sector is complex because of a lack of reliable data on the energy consumption by end-use in service sector buildings in most countries (e.g. heating, cooling, lighting, IT equipment and appliances), and because of the large variety of building categories in this sector.

**Figure 44:** Electricity trends in the building sector

![Electricity trends in the building sector](source: Eurostat)

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\(^{72}\) Related documents MEMO 11-149.

The total floor area of buildings represents around 24 billion m$^2$ in the EU, of which around $\frac{3}{4}$ for residential buildings. Single family houses represent 65% of residential floor space, against 35% for apartments. At EU level the average floor area is around 87 m$^2$ per dwelling.

Retail and wholesale trade represent the largest proportion of non residential buildings with 28% of non residential floor space. Office buildings are the second largest category with around $\frac{1}{4}$ of the non-residential floor space, followed by education (around 20%), hotels and restaurants (11%), hospitals (7%), sport facilities (4%) and others buildings (11%)\textsuperscript{73}.

At EU level, the annual unit consumption per m$^2$ for buildings is around 220 kWh/m$^2$, with a large gap between residential (200 kWh/m$^2$) and non-residential buildings (295 kWh/m$^2$) (Figure 45). This unit consumption is lower in countries with a warm climate (e.g. Spain or Bulgaria) compared to colder countries, such as Finland, Poland, or Estonia (factor 2 difference between these two groups of countries).

**Figure 45: Energy consumption in buildings per m$^2$ in 2009 (normal climate)**

![Energy consumption in buildings per m$^2$ in 2009 (normal climate)](image)

Source: ODYSSEE

The average electricity consumption per m$^2$ is around 70 kWh/m$^2$ for the EU average, with most countries in the range 40-80 kWh/m$^2$. It is much higher in Nordic countries, due the use of electricity for space heating (130 kWh/m$^2$ in Sweden and Finland and around 170 kWh/m$^2$ in Norway.

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\textsuperscript{73} Survey from BPIE (Buildings Performance Institute Europe) (2011).
5.2. Households

5.2.1. Energy consumption trends

Energy consumption per dwelling is below its 1997 level in most countries

Energy consumption per dwelling is heterogeneous among countries: from 0.5 toe/dwelling in Malta to almost 2 toe/dwelling in Belgium (Figure 46). However, even for countries with similar climate, significant discrepancies exist (e.g. 1.5 toe/dwelling for The Netherlands compared to 2 toe/dwelling for Belgium).

Energy consumption per dwelling is below its 1997 level in about 80% of the countries in 2009, with a strong reduction (above 2%/year) in several new member countries (Romania, Poland and Estonia), while there is an increase in Cyprus, Greece, and to a lesser extent in Finland, Hungary and Croatia.

Figure 46: Household energy consumption per dwelling

[Graph showing household energy consumption per dwelling]

Source: Odyssee

In 2009, there was a strong reduction of the average energy consumption per dwelling compared to 2008 in most countries (Figure 47): it reached 3% at EU level compared to an average decrease of 1.1%/year over 2000-2008. There was a very large contraction (close to 5% or above 5%) in 12 countries (mainly Denmark, Malta, Greece, UK, Spain, Denmark). In 2010, there was again a strong reduction in Denmark, Austria, UK, Ireland, Czech Rep and Cyprus (above 5%), that is not explained by economic trends, except for Ireland. In 2010, there was a progression in some countries, such as Netherlands, Belgium, Norway, Poland and Greece that are difficult to explain.

74Unless otherwise specified, all indicators on total energy use or on heating shown in the report are temperature corrected, i.e. at normal climate.

75At normal climate; 2007 for Lithuania and 2008 for Malta. The number of dwelling corresponds to the number of permanently occupied dwellings and excludes vacant dwellings and summer houses.

76It may be due to the large climate variation between 2009 and 2010.
Since 2000 the strongest increase is for electricity

Natural gas is the dominant source of energy for households in the EU with 39% of the market, up from 29% in 1990. Electricity ranks second and its share is also increasing rapidly (from 19% in 1990 to 25% in 2009). Oil is slowly being phased out at EU average (from 22% in 1990 to 15% in 2009), but remains significant in island countries. The share of wood grew from 8 to 11% over the period, with a very uneven role among countries. Coal has almost disappeared (except in a few countries, 3% in 2009 down from 13% in 1990). Heat from district heating represents 8% of the total at EU average although it plays an important role in many new Member States. Since 2000 the strongest penetration was for electricity (from 21% to 25%), while the share of gas almost did not change.

Decreasing share of space heating and greater use for appliances and lighting

At EU level, space heating is the predominant end-use (67%), but its share is slightly declining since 2000. Water heating ranks second and has a stable share (13%). Electrical appliances and lighting absorb an increasing share of the consumption because of the multiplication of new electrical appliances (+3 points). Air conditioning still represents a marginal share of dwelling consumption, even if it reaches 5% of household consumption in Bulgaria and Cyprus. The declining share of space heating can be explained by greater energy efficiency improvements for space heating than for other uses, because of building regulations and the diffusion of more efficient heating appliances.

The total consumption for heating is 3% lower in 2009 than in 1997 (- 7 Mtoe). This contrasts with the increasing trend observed before. For the other uses it is either stable (water heating and cooking) or in strong progression (+4% or 12 Mtoe for electrical appliances and lighting).
5.2.2. Space and water heating

Steady improvement in space heating efficiency at EU level, by 1.1%/year

Energy efficiency trend for space heating is measured from the decrease in annual energy use per m². Over the period 1997-2009, the energy used per m² decreased in all countries, except in Greece and Hungary\(^77\) (Figure 48): the reduction was around 1.4%/year for the EU as a whole (i.e. almost 15%). This reduction is mainly linked to more stringent standards for new dwellings, to the diffusion of more efficient heating appliances and to the retrofitting of existing dwellings. The reduction was quite significant in The Netherlands, Ireland and France, as well as in some new member countries (e.g. Romania, Latvia, Estonia and Poland)\(^78\) thanks to a combined effect of higher energy prices and energy efficiency improvements. The Netherlands has one of the lowest levels of energy consumption per m² and is at the same time among the countries with the largest improvements\(^79\).

**Figure 48:** Energy use for space heating per m² floor area

[Graph showing energy use for space heating per m² floor area from 1997 to 2009 for different countries.]

Source: Odyssee

**New dwellings are 30 to 60% more efficient in 2009 than in 1990**

All EU countries have developed thermal regulations for new dwellings, some of them as far as the seventies. These standards, directly or indirectly, require a maximum heating consumption per m² for new buildings. Since 1990, these standards have been upgraded between 3 and 5 times in most countries: as a result, new dwellings built in 2009 consumed

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\(^77\) In Greece this trend may be due to progress in comfort.

\(^78\) Latvia, Estonia and Poland realised the strongest decrease in absolute terms (around 7-8 koe/m² or 80-95 kWh/m²), while Romania registered the highest relative improvement (~40%).

\(^79\) This is due to extensive insulation measures in existing dwellings, a large diffusion of gas condensing boilers and a low share of detached single family dwellings.
on average for the EU 40% less than dwellings built in 1990 (range of 30% to 60% depending on the countries).

The low volume of construction limited the impact of standards on new dwellings

The effect of buildings standards on heating efficiency improvement space is restricted by the often limited volume of construction. In most EU countries, new dwellings built each year only represent less than 1% per year of the total stock of dwellings.

The introduction of new dwellings with better insulation contributed to a decrease of the average energy consumption per dwelling that depends on the number of standards upgrades, their severity and the volume of construction: 11% for Ireland, 16% for Sweden, 27% for Denmark, around 35% for France and Netherlands, and around 50% for Germany and Slovakia (Figure 49). This approach overestimates the impact of building regulations as it is well known, but not well quantified, that the actual specific consumption of new dwellings is higher than this theoretical consumption, because of non-compliance and rebound effects. The other factors responsible for the decrease of the average unit consumption per dwelling are the retrofitting of existing dwellings and the introduction of new more efficient heating appliances (namely, condensing boilers and heat pumps).

Figure 49: Effects of building standards (1990-2009)

Source: Odyssée

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80 Rebound effects account for the fact that, in well insulated dwellings, occupants tend to have a higher indoor temperature than in less insulated dwellings.

81 The impact on the average specific consumption for space heating of standards on new dwellings has been modeled assuming that the unit consumption of new dwellings is equal to the standards.
One fourth of the efficiency increase offset by comfort

Energy efficiency progress contributed to decrease the space heating consumption per dwelling by 1.4%/year on average for the EU since 1997. Larger dwellings and the diffusion of central heating in the south of Europe have contributed to increase the consumption respectively by 0.3% and 0.1%/year on average) (Figure 50): they have offset the equivalent of 25% of the energy efficiency gains. Heating behaviour had a significant impact at EU level on space heating consumption (-0.3%/year) since 1997.

**Figure 50:** Decomposition of change in heating energy use per dwelling in the EU

![Graph showing decomposition of change in heating energy use per dwelling in the EU](image)

Source: Odyssee

Benchmarking of heating consumption

Comparison of heating energy use per dwelling should take into account countries specificities in terms of climate, dwelling size, fuel mix and comfort. Thus, in Odyssee, the comparison is based on an indicator of useful energy consumption, per m² and degree-days\(^ {82}\), that is related to the penetration of central heating\(^ {83}\). The Netherlands is the country with the best performance among countries with a large diffusion of central heating: its specific consumption for space heating, in useful energy per m² and degree-day, is 40% lower than for France, the least efficient country\(^ {84}\) (Figure 51). Finland, Denmark and Sweden are 30% more efficient than France.

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\(^{82}\) The useful energy enable to adjust for differences in the energy mix and thus in the heating appliance efficiency; the indicator is expressed per m² to adjust for differences in dwelling size and per degree-day to correct for differences in climate.

\(^{83}\) Countries like Spain or Bulgaria have a much lower diffusion of central heating: all other things being equal, their specific consumption will be lower than in countries where most dwellings have central heating, as the level of comfort is not the same.

Large diffusion of solar water heaters in southern countries and Austria

About 85% of dwellings have solar heaters in Cyprus, 35% in Greece, 17% in Austria, and 11% in Malta (Figure 52). The larger progression is observed in Greece (+15 points), followed by Malta and Austria (+9). Austria is the benchmark for most countries with medium solar radiation (24% of dwellings equipped in 2009). In most EU countries there exist financial incentives (subsidies or soft loans) and fiscal incentives (tax credit) to encourage households to install solar water heaters in their dwellings and even more recently regulations making mandatory the installation of solar heaters in new construction (e.g. Spain and Portugal).

Figure 52: Diffusion of solar water heaters and solar radiation

Source: Odyssee
5.2.3. Trends and patterns of electricity uses

Largest growth in electricity use in southern and new member countries

Electricity consumption increased at a rate above 2%/year in half of the countries between 2000 and 2008 (1.7%/year for the EU average) (Figure 53). The progression was particularly rapid in 5 countries, above 4%/year, of which 3 southern countries (Greece, Spain and Cyprus), because of the diffusion of AC, and 2 Baltic countries (Estonia and Latvia), because of a high economic growth and a catch up in household appliances ownership. On the contrary, this consumption decreased in Slovakia or had a very low progression in Norway, Denmark, Sweden and Bulgaria, which is partly due to substitution of electricity with fuels for thermal uses.

There is a strong impact of the 2009 crisis in 20 countries and at EU level, with a sharp decrease of the electricity consumption in 12 countries. In 2010 electricity consumption continues decreasing in 5 countries only.

Figure 53: Trends in household electricity consumption

![Trends in household electricity consumption](image)

Source: Odyssee

Large electricity consumption for some countries is due to space heating

Average electricity use per household in EU is about 4000 kWh per year. For most countries the largest part of electricity use concerns electrical appliances and lighting; it is above 60% at EU level and in most countries (Figure 54). Thermal uses are substantial (around or above 50%) in Norway, Estonia, Sweden, France, The Czech Republic and Ireland. Electrical appliances include the large appliances (cold and washing appliances), IT equipment (TV, PC, etc.) and all other small appliances. The share of AC is still low in southern countries (10-15% in Cyprus, Croatia and Bulgaria).
Figure 54: Average electricity consumption per dwelling (2009\textsuperscript{85})

Among EU countries there are significant discrepancies in the electricity consumption for electrical appliances\textsuperscript{86} and lighting: in a range from 1000 kWh (Estonia, Romania) to 4000 kWh (Finland, Sweden) (Figure 55).

Figure 55: Electricity consumption per dwelling for electrical appliances & lighting

\textsuperscript{85}Total for Norway:16000 kWh. 2008 for Spain, Romania and Slovenia; 2007 for Lithuania.

\textsuperscript{86}Electrical appliances include large cold and washing appliances, IT equipment and other appliances.
Different trends for the consumption per household for electrical appliances and lighting, and strong impact of the crisis

At EU level, the unit consumption for electrical appliances and lighting increased by 1.7%/year since 1997 (Figure 56) with a very unequal progression across countries:

- decreasing trends for Bulgaria and Slovakia, countries with a rather low consumption level (about 2000 kWh) as well as for Denmark and UK, countries with higher consumption level (about 3000 kWh);
- moderate progression in Sweden and Germany, countries with an already high electricity use;
- rapid growth in southern countries, such as Cyprus and Greece.

During the 2009 crisis, the consumption for electrical appliances and lighting has substantially decreased in some countries, by around 10% in Ireland and Croatia and around 4% in Denmark, UK, The Netherlands and Hungary.

Figure 56: Trends in electricity use per household for appliances & lighting

Source: Odyssee

Growth of electricity consumption concentrated on small appliances

The breakdown of appliances consumption shows that the strongest growth is recorded for small appliances (6.5%/year on average) (Figure 57). These small appliances more than doubled their share of the total consumption for appliances and lighting, from 18% in 1990 to 39% in 2009. The consumption of large appliances recorded a moderate growth and their share declined from 62% to 44%. Lighting has a rather stable share (about 20%).

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87 1997-2008 for Spain, Slovenia, and Romania; 1997-2007 for Lithuania
Figure 57: Change in total electricity use for large/small appliances and lighting

Source: Odyssee

Clothes dryers and dishwashers drive electricity consumption upwards

Televisions, clothes dryers and dishwashers increased their share over the period 1990-2009, due to higher penetration rates (Figure 58). Refrigerators and washing machines registered a decline, mainly due to substantial electricity savings and ownership saturation.

Figure 58: Shares of large appliances in total appliance electricity use

Source: Odyssee
Increased penetration of efficient new appliances

The diffusion of new efficient large appliances had a direct impact on their average efficiency: in 2009, almost 90% of refrigerators, washing machines and dishwasher’s sales corresponded to an efficiency class equal or above A class (Figure 59). On average, about 30% of new refrigerators sold in 2009 were in the highest efficiency class (labels A+ or A++) compared to less than 10% in 2005. This share reached around 40% in The Netherlands and 45% in Germany in 2009.

**Figure 59: Market share of label A, A+, A++ for cold and washing appliances in the EU**

Because of the diffusion of more efficient new appliances, the average specific consumption of all large appliances except TV has been decreasing steadily since 1990 (Figure 60): efficiency improvements have reached almost 40% for washing machines and dishwashers, and around 30% for freezers, refrigerators and dryers. For TV, the increase is due to the diffusion of larger TVs. Large appliances are on average 25% more efficient than in 1990, with some countries registering very strong progress (Germany, Sweden, the Netherlands): ~2%/year. There is a slight reduction in the progress achieved since 2000 (1.6%/year over 1990-2008 and 1.3%/year since 2000 at EU level).
Energy efficiency of large appliances is offset by more appliances

Almost all the energy efficiency gains over have been offset by an increase in equipment ownership (Figure 61). As a result, electricity consumption per household for large appliances is only slightly lower in 2009 than in 1997.
Decrease in the specific consumption for lighting since 2002

The lighting consumption per dwelling has been decreasing since 2002 at EU level and in more than half of the countries thanks to the diffusion of CFL (Figure 62). The unit consumption for lighting is quite diverse among EU countries: from 200 kWh for Slovakia and Bulgaria up to 900 kWh/year for Sweden (around 450 kWh at EU level). The unit consumption level depends not only on the lamps efficiency (i.e. the CFL penetration), but also on the number of lighting points per dwelling (Figure 63).

**Figure 62: Electricity consumption per dwelling for lighting**

![Figure 62: Electricity consumption per dwelling for lighting](image)

Source: Odyssee

**Figure 63: Lighting consumption per dwelling and number of lighting points**

![Figure 63: Lighting consumption per dwelling and number of lighting points](image)

Source: compiled by Enerdata from various sources, of which Remodece, JRC-Ispra
The efficiency of new air conditioners is improving rapidly

The average consumption per dwelling for air conditioning is increasing as this end-use is spreading in Southern countries88 (Italy, Spain, Malta, Cyprus and Greece) (Figure 64). New air conditioners are 30% more efficient in 2009 than in 2002 in the EU when labelling was introduced; this is mainly due to the increasing share of units with variable speed drive (from 4% in 2002 to 50% in 2009)89. Thanks to these efficiency improvements, the electricity consumption growth was lower than the progression in air conditioning ownership.

Figure 64: Consumption per dwelling for air conditioning

Source: Odyssee

5.3. Energy efficiency and savings trends for households

Household energy efficiency has improved by 10% at EU level since 2000

Energy efficiency improvement, as measured with ODEX90, shows an improvement of 27% since 1990 (or about 1.6%/year) (Figure 65). The efficiency improvement for heating, hot water and large appliances reaches about 10% since 2000. Since 1990 heating and large appliances efficiency improvement reached 1.8%/ and 1.4%/year respectively. These energy savings are largely due to the deployment of technologies that reduce energy demand (e.g. double glazing, insulation), convert fuels more efficiently (e.g. high efficiency boilers) or use electricity more efficiently (e.g. labels A, A+ and A++).

88 It is already above 50% in Spain, Malta, Cyprus and Greece
89 Almost 90% of new air conditioners are reverse cycles models (up from about 50% in 2002)
90 ODEX is an index weighting the energy efficiency progress for a set of 8 end-uses and appliances (heating, water heating, cooking, refrigerators, freezers, washing machine, dishwashers and TV.)
Some new Member States show very high energy efficiency improvement

Yearly energy efficiency improvements are not homogeneous among European countries: Romania, Slovenia and Poland had the highest efficiency improvement (above 2.5%/year), while Croatia, Greece and Hungary did not improve really their energy efficiency during the same period (Figure 66)\textsuperscript{91}. Most other new Member States also do better than the EU average improvement. This energy efficiency improvement for the EU is now higher than the 1%/year requested in the Energy Services Directive (ESD) by the European Commission, and more than half of countries are above the ESD requirement.

Figure 66: Yearly energy efficiency improvement by country (2000-2009\textsuperscript{92})

\textsuperscript{91} Low performances may be due to the fact that it is difficult to separate out for the indicators available changes in lifestyle that contribute to increase consumption from energy efficiency gains.

\textsuperscript{92} 2000-2008 for Spain, Luxembourg, Czech Rep, Romania, Slovakia, Slovenia and 2000-2007 for Lithuania.
5.4. CO2 emissions trends for households

Energy savings and fuel switching reduced direct CO₂ emissions in the EU

Between 1997 and 2009 emissions of EU households decreased by 91 Mt, from 503 to 413 Mt (-18%)\(^{93}\) (Figure 67). This result was achieved despite an increase in the stock of dwellings and appliances, that would have implied, all other things being equal, an emission increase of about 76 Mt. The reduction in the level of emissions was made possible by efficiency improvements and switches to fuels with a lower or zero CO₂ content (e.g. gas, heat, biomass and electricity\(^{94}\)), which contributed to reduce emissions by 167 Mt, equally split between energy efficiency and fuel substitutions.

**Figure 67:** Decomposition of 1997-2009 variation in CO₂ emissions in the EU

[Graph showing decomposition of CO₂ emissions]

Source: Odyssee

5.5. Energy use in the tertiary sector

No clear pattern for direction of energy consumption trend in countries

Energy consumption in the tertiary sector increased in almost all countries in the period 2000-2008, in a range of 2 to 5% /year for most countries. In 2009, because of the economic downturn, energy consumption decreased in almost all countries and at EU level (-2.3%).

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\(^{93}\) All the figures given here are not corrected for climate variations.

\(^{94}\) The emissions from electricity are not included in the household sector.
Figure 68: Energy consumption trends in the tertiary sector

Gas and electricity account for nearly 80% of energy consumption in services

The share of electricity has increased a lot due to the greater use of electricity, especially for information/communication technologies and air conditioning, from 31% in 1990 to 43% in 2009 at EU level. Gas met 33% of the energy consumption in 2009, up from 27% in 1990. On the other hand, the contribution of oil has decreased from 25% to 14% and coal has disappeared in most countries.

More than half of the energy is consumed in the trade sector and offices

The distribution of energy consumption by service sub-sector is quite homogeneous (Figure 69). The most important sectors are the trade sector and private and public offices, both with 26% of the total.

Figure 69: Energy consumption by subsector in services (2008)
Space heating represents a high share of the total energy consumption of services. It accounts for more than 70% in Germany and for 60% in France. However, its share is decreasing (-10 points for Germany and Finland, -7 points for Sweden) thanks to energy efficiency improvements (insulation of buildings, efficiency of boilers, etc.) and because of the high growth of specific electricity end-uses.

At EU level less energy is used per employee but substantially more electricity

Total energy consumption per employee increased until 2003 and decreased since then (Figure 70). The overall decrease (-0.2%/year) is in contrast with the substantial increase in electricity consumption per employee (+0.6%/year). At EU level, almost 800 extra kWh per employee were used in 2009 compared to 1997 (from around 3960 to 4730 kWh/employee). These developments suggest that increased productivity of labour is accompanied by more electricity using appliances and systems.

Figure 70: Total energy and electricity use per employee for tertiary in the EU

Source: Odyssee

Large use of electricity for space heating in Scandinavian countries

Norway, Sweden and Finland use by far the largest amount of electricity per employee (more than twice the EU average), which has to do with electric heating (Figure 71). Most countries use between 4,000 and 7,000 kWh per employee. Electricity consumption per employee is increasing in most countries. Large increases can be observed for all southern countries, because of the penetration of air conditioning. The high growth for eastern European countries is linked to their fast economic growth.
**Figure 71:** Electricity use per employee, per country in the tertiary sector

Source: Odyssee

**Fuel substitution also important for lower CO\textsubscript{2} emissions**

Tertiary represents 8% of CO\textsubscript{2} emissions in the EU in 2009. From 1996 to 2009, the direct CO\textsubscript{2} emissions have decreased by 16% (Figure 72). The value added has increased by 34%, which would have implied an increase of 68 Mt CO\textsubscript{2} (see activity effect). The reduction of CO\textsubscript{2} emissions by energy efficiency and fuel substitution has more than offset the effect of economic growth. About \(\frac{3}{4}\) of these reductions are linked to a switch to natural gas and the increased use of electricity. However, if the indirect CO\textsubscript{2} emissions from electricity production are also taken into account the emissions increase substantially.

**Figure 72:** Decomposition of change in CO\textsubscript{2} emissions\textsuperscript{95} for tertiary in the EU (1996-2009)

Source: Odyssee

\textsuperscript{95} It refers to direct CO\textsubscript{2} emissions