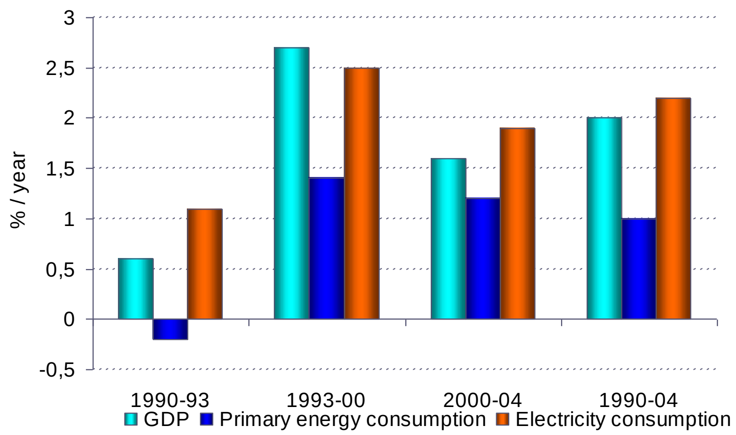
1. Overall energy efficiency trends

1.1. Energy consumption and CO_2 emissions trends

Rapid growth in primary and final energy consumption between 1993 and 2000

The primary and final energy consumption increased at approximately the same rate between 1990 and 2004 (1 %/year on average) in the EU-15 (**Figure 1-1**) and amounted to around 1500 Mtoe and 1000 Mtoe, respectively. However, the period 1993-2000 was characterized by faster growth in energy consumption (1.5 %/year) driven by a steady and rapid expansion of the economy (2.7 %/year for the GDP and 2.3 %/year for industry). This followed three years of low economic growth between 1990 and 1993 (0.6 %/year). Since 2000, there has once again been a net slowdown in economic activity and, in addition, an increase in the energy prices on the international markets[7], which has resulted in a lower progression of energy use. Electricity demand underwent a more rapid progression of around 2 %/year on average.

Figure 1-1: Energy consumption[8] and GDP in the EU-15



Buildings (households and service sector) absorb 39 % of the final energy consumption. The share of services is increasing, with very rapid growth since 2000 (almost 3 %/year). Energy use in transport rose the fastest over the period 1990-2004 (around 2 %/year) but has been slowing down since 2000 (1.3 %/year): its share in final consumption increased from 29 % in 1990 to 32 % in 2004. In contrast, the share of industry has fallen from 30 to 28 %. Agriculture contributes only 2 %.

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[7] Crude oil price (Brent) was 30$/bl on average in the period 2000-2005 compared to 17$ between 1990 and 2000.

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

1.2. Trends in primary and final energy intensities

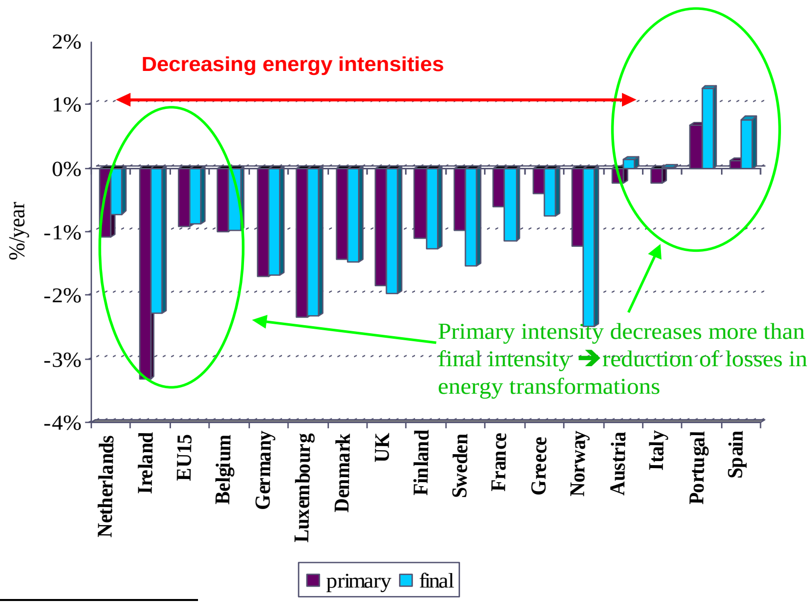
In the EU-15 as a whole and in 6 countries in particular, the primary energy intensity has decreased faster (or increased slower) than the final intensity because of energy efficiency gains in electricity generation

Over the period 1990-2004, the primary energy intensity decreased faster on average – or increased slower- than the final energy intensity in six countries (Ireland, the Netherlands, Italy, Austria, Portugal and Spain) as well as in the EU-15 as a whole (**Figure 1-2**). This tendency results from an overall improvement in the efficiency of power plants linked to the rapid penetration of gas-combined cycles, cogeneration and wind. For 4 countries, the variation is about the same (Luxembourg, Denmark, Belgium, Germany).

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

For 5 countries (Greece, the UK, France, Finland, Sweden and Norway), the final energy intensity decreases faster than the primary energy intensity: this means that increasing losses in energy transformation offset part of the reduction in the final energy intensity. These higher losses may come from more rapid growth in electricity consumption for final end-users (compared to fossil fuels), which results in increased losses in the electricity sector[9], and/or changes in the electricity generation mix (towards less efficient technologies, such as nuclear). This phenomenon is particularly apparent in Norway, France and Greece, where about half of the final energy intensity decrease "disappears" at the level of primary energy intensity: in France, this is due to the increasing role of nuclear (from 36 to 43 % of the primary consumption); in Greece due to the increased penetration of electricity (from 15 to 20 %) which is produced from lignite with low efficiency; in Norway to increasing losses in oil and gas production and processing.

Figure 1-2: Variation of energy intensities in the EU-15 countries and Norway[10]



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

[10] Under normal climate conditions (1990-2004)

Energy intensities need to be adjusted before any comparison

The amount of energy required to generate one Euro of GDP varies quite a lot from one country to another. In order to make a more realistic comparison, the final energy intensity needs to be corrected to account for these national characteristics. Three types of adjustments are quantified in the ODYSSEE database:

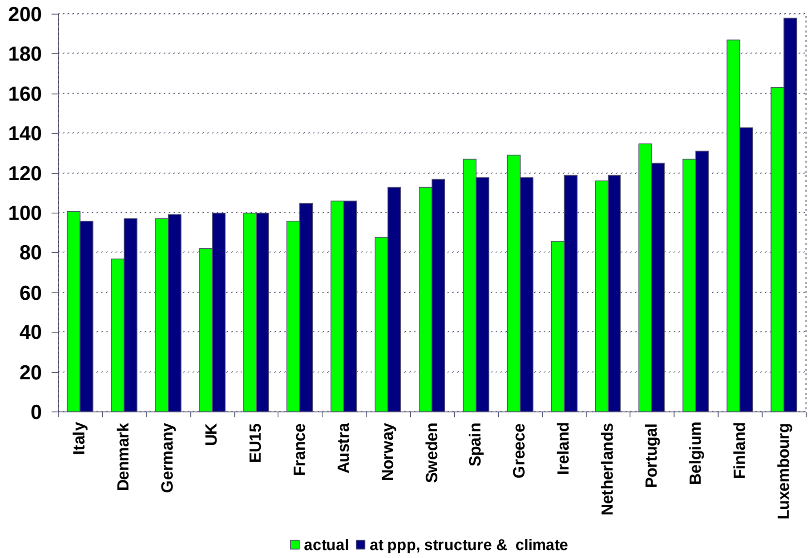
- adjustment of the GDP in purchasing power parities to account for differences in the general price level;
- adjustment in heating requirements to account for climatic differences
- and finally, adjustment in the "economic structure" to account for differences in the nature of the economic and industrial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

Figure 1-3 summarises the results of all the adjustments and ranks the countries according the value of their adjusted intensities. For countries with colder climates (e. g. the Scandinavian countries), with energy-intensive industrial activities (e. g. Finland and Greece), or with low general price levels (e. g. Portugal, Greece or Spain), the adjusted value is below the observed intensity. For Finland and Portugal, with respective energy intensities of 80 % and 40 % higher than the average, the adjustments significantly decrease their intensity level and bring them more in line with the other countries. For Italy, which is close to the EU average, the adjustments reveal that its performance is better than implied by the initial figure.

For most other countries (9 out of 16), the adjustments have the reverse effect and increase the intensity:

- For a first group of countries with an intensity level below that of the EU-15, the adjustments show that in fact they require more energy per unit of GDP than indicated by the observed intensity (Denmark, the UK, Ireland, Norway, France and Germany[11]).
- For a second group with an already higher than average intensity, the adjustments make them look slightly more energy-intensive (e.g. Belgium, Sweden and the Netherlands).

Figure 1-3: Adjusted final energy intensities (EU-15=100) (2004)



[11] Before the adjustment, Denmark, the UK, Ireland, Norway, France and Germany have respective final energy intensities of 23 %, 18 %, 14 %, 12 %, 4 % and 3 % lower than the EU-15.

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

The final energy intensity at constant structure, although adjusted for the influence of changes in the structure of economic and industrial activities, is not sufficient to assess the results of policy measures dedicated to energy efficiency. Indeed, three factors influence this intensity:

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

These factors usually have contradictory influences on energy intensities: the first two factors contribute to curbing final energy intensities at constant structure, whereas the final factor often tends to increase these intensities, all other things being equal. The contribution of the last factor is all the more significant if the country is less developed: it probably plays a decisive role in Southern European countries. In order to clarify the role of energy-related factors (i.e. energy efficiency and energy substitutions) and better assess the actual results of energy efficiency policy measures, specific energy efficiency indicators, expressed as indices, have been developed in ODYSSEE to measure the achievements observed at the level of the main end-uses and appliances, the so-called **"ODEX**". This index aggregates the trends revealed by the detailed bottom-up indicators (in end-use and equipment) in a single indicator. It provides an alternative indicator for energy intensities (industry and transport) or unit consumption (per dwelling for households) to describe the overall trends by sector (**Box 1-1**).

Box 1-1: ODEX: the ODYSSEE energy efficiency index

In ODYSSEE, various indicators of unit consumption are calculated to depict the changes in energy efficiency at a detailed level by sub-sector (end-uses or transport mode). ODEX indicators aggregate sub-sector trends in a single indicator by main sector (industry, households, transport and services) and for the economy as a whole. They are calculated from the unit consumption indices by sub-sector based on the weight of each sub-sector in the total energy consumption of the sector[12]. As indices are used, it is possible to combine different units for unit consumption to provide the best proxy of energy efficiency, e. g. toe/dwelling, koe/m^2, or kWh/appliance for households. A decrease in the index means an energy efficiency improvement[13]. Presently, about 30 indicators are used in ODYSSEE **("ODEX 30")[14].**

[12] Energy efficiency gains are measured in relation to the previous year ("sliding ODEX") and not to a base year (e.g. 1990) to avoid having results influenced by the situation in the base year.
[13] A value of 85 in 2004, for instance, means a 15 % efficiency improvement compared to the base year (1990)
[14] Up to 7 modes in transport, 9 end-uses for households, 11 branches in industry, and 1 end-use in services. This covers around 80% of the final energy consumption.

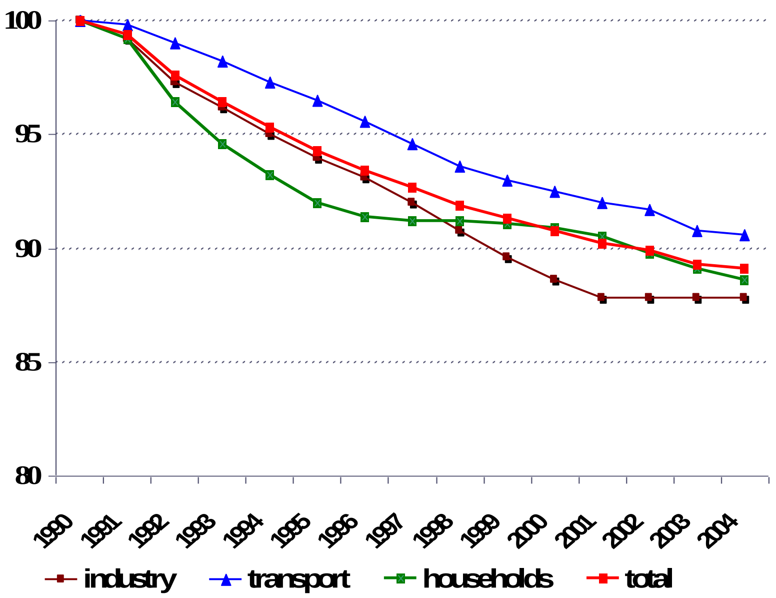
1.3. Energy efficiency progress in the EU-15

Energy efficiency in the EU-15 improved by about 11 % between 1990 and 2004, corresponding to 100 Mtoe energy savings in 2004

Energy efficiency policies and measures implemented since 1990 as well as autonomous technological progress have contributed to improving the energy efficiency of the EU-15 by 0.9 %/year on average between 1990 and 2004 (**Figure 1-4**). Without these energy efficiency gains, the final energy consumption of the EU-15 would have been 11 % higher in 2004. This represents energy savings of around 100 Mtoe for the EU-15.

Industry is the sector which achieved the largest energy efficiency improvement, with a regular energy efficiency gain of 1.2 %/year on average between 1990 and 2001 followed by a subsequent slowdown (to 0.5 %/year). Industry is 12 % more energy-efficient than it was in 1990. For households, no progress is observed from 1995 to 2000 (11 % of improvement since 1990)[15]. In transport, the progression is modest but regular: 9 % efficiency improvement.

Figure 1-4: Energy efficiency progress in the EU-15[16]



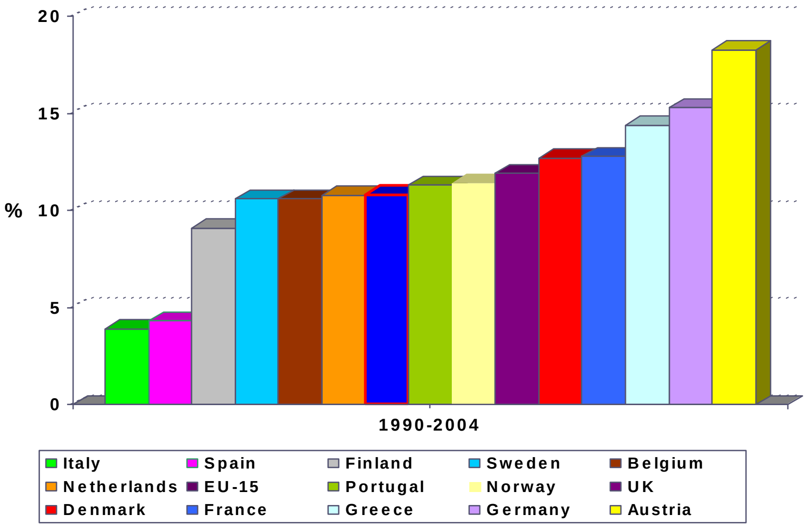
Compared to pure bottom-up evaluations, energy efficiency gains measured in ODYSSEE have a broader scope as they include all sources of energy efficiency improvements, whatever their driving factor: policy measures, price changes, autonomous technical progress or other market forces; in other words,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

[15] This result is surprising, as there has been construction of efficient new buildings over the period. However, there was more construction in countries with lower efficiency standards; at constant structure (i.e. constant distribution of construction among EU-15 countries, there was an improvement of 3% between 1995 and 2000 for new dwellings in the EU-15 as a whole; at actual structure there is a trend towards poorer performances (increase of the average specific consumption of new dwellings of 14% for the EU-15 as a whole)

[16] ODEX is calculated as a 3 years moving average to avoid short-term fluctuations (imperfect climatic corrections, behavioural factors, business cycles)….

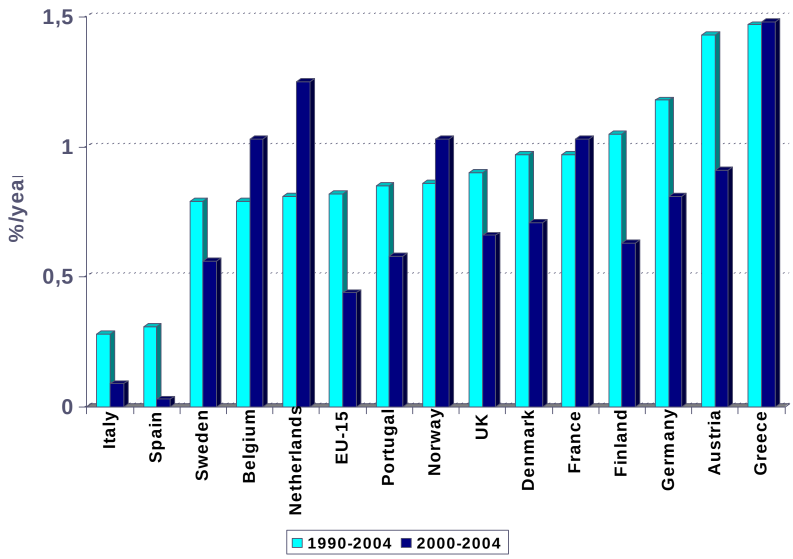
For most countries, the improvement in energy efficiency was around 10 % in the period 1990-2004, with 9 countries in a range from 10 to 15 % (**Figure 1-5**).

Figure 1-5: Energy efficiency progress in EU-15 countries and Norway[17]



The ODEX variation can be expressed as yearly variation in order to measure the annual progress in energy efficiency. In most countries, the rate of energy efficiency improvement (or rate of energy savings) is below 1 %/year; in almost all countries, there has been a slowdown in energy efficiency progress since 2000 (**Figure 1-6**).

Figure 1-6: Energy efficiency progress in EU-15 countries and Norway (%/year)

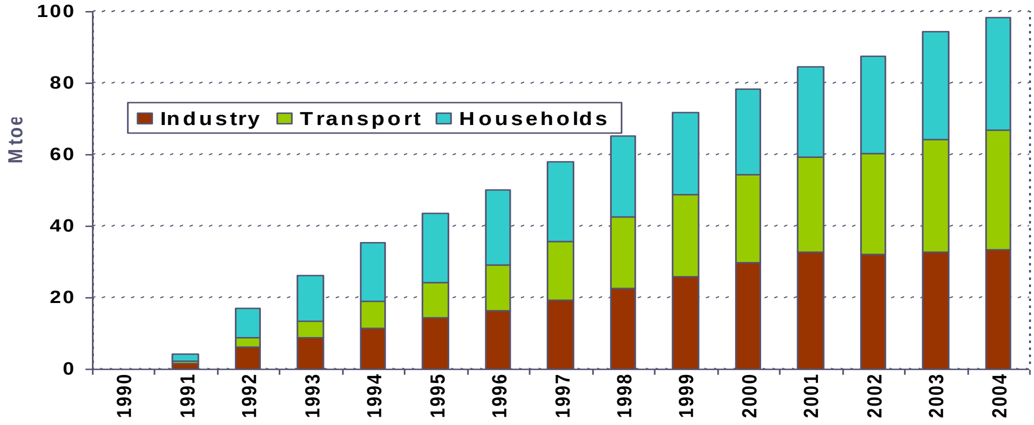


About 100 Mtoe cumulated energy savings since 1990

[17] For Ireland and Luxembourg, the results are not shown since the values obtained are not relevant. They are influenced by large structural changes in industry that cannot be fully accounted for.

Energy savings can be directly derived from the ODEX indicator since this also represents the ratio between energy consumption and a fictive consumption that would have occurred without the savings[18]. In 2004, the cumulated energy savings were 100 Mtoe for the EU-15 as a whole; this is equivalent to 11 % of the final energy consumption that year. In other words, without energy savings, final energy consumption would have been 100 Mtoe higher in 2004. Energy savings since 1990 are more or less evenly distributed among sectors (**Figure 1-7**).

Figure 1-7: Energy savings in the EU-15 [19]



1.4. CO_2 indicators[20]

Total CO_2 emissions from energy use were 5 % above their 1990 level in 2004. After dropping until 1994, they have increased steadily since then (0.7 %/year on average). Over the period 1990-2004, CO_2 emissions from energy use have risen much slower than the rise in economic activity: almost six times less (5 times less for the emissions of final consumers).

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

Total CO_2 emissions per unit of GDP, the "CO_2 intensity", decreased more rapidly than energy intensity: by 1.6 % /year and 0.9 % /year, respectively, on average between 1990 and 2004 (**Figure 1.16**). This gap is due to switching to energy with lower CO_2 emissions factors: the average emission factor of one toe decreased by 10 % over the period from 2.35 to 2.12 tCO_2/toe. In other words, the energy used tended to contain less and less carbon; this phenomenon is usually referred to as the "decarbonisation" of the economy. These switches explain almost half the reduction in the total CO_2 intensity (45 %), the rest (55%) is linked to the reduction in energy intensity.

[18] If for instance the energy consumption is equal to 50 Mtoe and ODEX = 80, the energy savings can be calculated as follows =50* ((100/80)-1) = 12.5 Mtoe.
[19] Energy savings in services have not been accounted for due to data limitations.
[20] This section deals with CO_2 emissions from energy combustion. The indicators are not expressed under normal climate conditions (i. e. with climate corrections) to comply with the official definition of CO_2 inventories. CO_2 emissions of final consumers include the emissions of auto producers.

1.5. Conclusions

- The energy efficiency of final consumers improved by 11 % on average in the EU-15 between 1990 and 2004. This resulted in energy savings of about 100 Mtoe. The performances achieved by the various countries range from 4 to 20 %.

- Energy efficiency improvements, for the EU-15 as a whole, as measured with ODEX, seemed to be below the ESD target for many countries; however, the definitions of energy savings are not directly comparable.

- In most countries and sectors, there has been a slowdown in energy efficiency progress since 2000, which is partly explained by the slower economic growth (business cycle effect).

- The decoupling between energy use and economic activity is continuing: since 1990, energy consumption has been growing at almost half the rate of the GDP.

- Structural changes in the economy had a marginal influence on the energy intensity reduction of final consumers and explain about 14 % of this reduction from 1990 to 2004.

- CO_2 emissions are slightly above their 1990 level: they have increased almost six times less rapidly than the GDP between 1990 and 2004. Almost half this reduction is due to fuel substitutes with lower emission factors.