

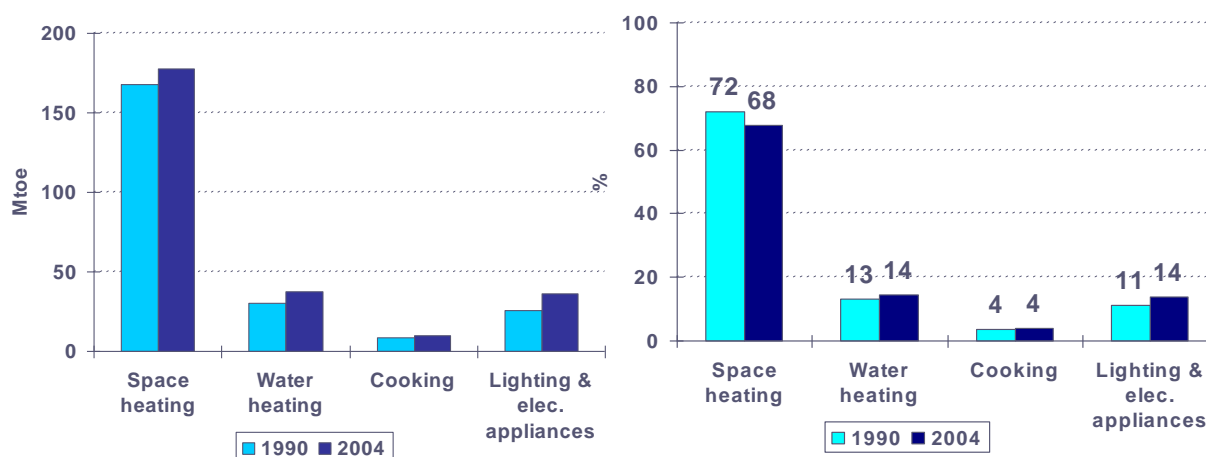
4. Energy efficiency trends in the household sector

4.1. Energy use pattern

Households consume 26 % of the energy used by final consumers in the EU-15 (260 Mtoe)⁵⁴. Space heating requires a declining share of the consumption (68 % in 2004 compared with 72 % in 1990) (Figure 4-1)⁵⁵. Excluding the southern European countries, space heating accounts for between 60 % (UK) and 75 % (Germany and the Netherlands) of household consumption. In Spain and Portugal, its importance is much lower (around 40 %).

About 14 % of overall consumption is due to water heating. Electrical appliances⁵⁶ and lighting play an increasing role, accounting for 14 % of the energy used by households and 62 % of their electricity consumption in 2004 (11 % and 58 %, respectively, in 1990).

Figure 4-1: Energy consumption by end-use in the EU-15



4.2. Trend in the average consumption per dwelling

No definitive trend in the average consumption per dwelling: a high degree of volatility has now resulted in a present level close to its 1990 value

The average energy consumption⁵⁷ per dwelling in the EU-15 was slightly under its 1990 level (by 3 %) in 2004. In fact, this consumption was marked by a reduction until 1996, mainly linked to a low progression of incomes⁵⁸ (0.7 %/ year), followed by a rise until 2000, driven by a rapid increase in the average income per household (almost 2 %/ year). There was then a rapid decrease after 2000 (-0.4 %/year), which corresponds to an economic slowdown and higher energy prices (+10 % between 1999 and 2004). Most countries follow a similar pattern, with an increase in the period 1995-2000 and a reduction since 2000. In Spain and Greece, however, the consumption per dwelling progressed throughout the entire period and has

⁵⁴ 26.3 % of the final consumption for energy uses in 2004 and 25.8 % in 1990 (under normal climate conditions).

⁵⁵ End-use shares calculated under normal climate conditions.

⁵⁶ Electrical appliances exclude the appliances used for thermal uses (electric heating and water heaters, as well as electric ranges and ovens).

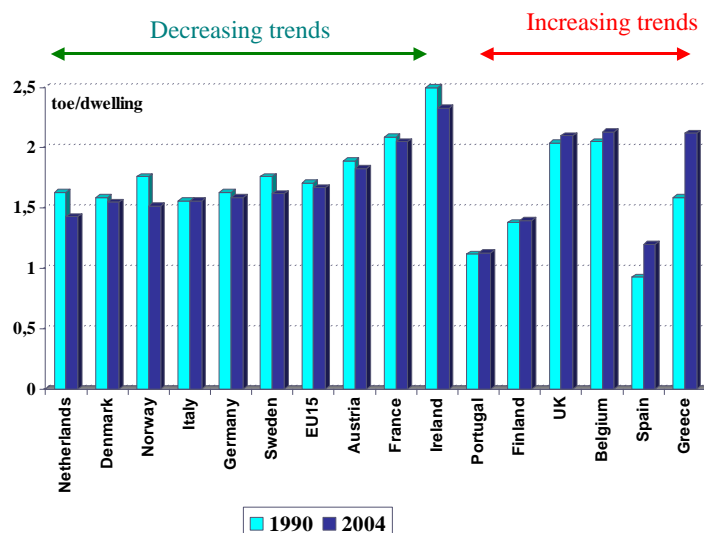
⁵⁷ All consumption figures are climate-corrected.

⁵⁸ The indicator of income used here is the average expenditure (i.e. private consumption) per household.

increased rapidly since 2000. In the Netherlands, Denmark, Sweden and Norway, this consumption has fallen steadily.

The average energy consumption per dwelling⁵⁹ was below its 1990 level in the majority of countries in 2004 (**Figure 4-2**); this unit consumption is presently in the range of 1.1 to 2.3 toe/year, with 6 countries having a unit consumption between 1.5 and 1.8 toe/dwelling; the EU-15 average stands at 1.7 toe/dwelling. Finland and the Netherlands stand out as the countries with the lowest consumption level (apart from southern European countries)

Figure 4-2: Unit consumption per dwelling (adjusted to EU climate)



Lifestyle changes and progress in energy efficiency are driving energy consumption in opposite directions

Does this stability in the energy consumption per household mean that there has been no improvement in energy efficiency and that the policy measures implemented have had little impact? Actually, the changes in the average energy consumption per dwelling result from a mix of different factors that have converse influences:

- genuine energy efficiency improvements brought about by more efficient new buildings and appliances and by retrofitting existing dwellings as well as most energy substitutions tend to lower energy consumption⁶⁰;
- improved living standards due to rising income result in larger dwellings, more appliances⁶¹ and increased heating (greater comfort)⁶² and are driving energy demand upwards.

The relative role of these factors will now be discussed for heating and electrical appliances.

⁵⁹The data shown in this graph are adjusted to the EU-15 average climate to improve the comparison. This is done by adjusting the space heating consumption to the same assumed underlying climate conditions.

⁶⁰ Substitutions between energies with different end-use efficiencies usually contribute to decreasing the amount of final energy required (e. g. substitutions to district heating, gas or electricity with the usual convention for measuring the electricity, i. e. without production and distribution losses); however, an increasing use of wood for heating, as observed in some countries in the framework of climate change policies, increases this consumption.

⁶¹ Increased ownership and multiple ownership for some appliances such as TVs and maybe larger appliances.

⁶² Diffusion of central heating and higher indoor temperature.

4.3. Space heating

The average amount of energy used per dwelling for space heating has not really decreased in the EU-15 since 1990: in 2004 it was only 6 % below its 1990 level (-0.5 %/year). This is all the more surprising since new buildings and new heating appliances are clearly more efficient than older ones. Such a trend is in fact, as explained above, the result of two opposing trends: increased comfort, larger dwellings, an increasing share of central heating and single family homes drive the demand upwards on the one hand and, on the other hand, more efficient dwellings and heating appliances contribute to lowering the demand.

The efficiency standards of new dwellings are regularly reinforced

Efficiency standards for new buildings are mandatory in all countries and are raised at regular intervals. For instance, building codes have been reinforced in 10 countries⁶³ since 2000, in 4 of them following the adoption of the new EU Directive on the Energy Performance of Buildings in 2001, known as "EPBD". This Directive, which came into force in 2006, harmonises the standards among EU countries and makes it mandatory to regularly reinforce these standards. Since the first oil shock in 1973/74, the standards for new buildings have been increased several times in most countries.

In 2003, new buildings were about 25 % more efficient than those built before 1990, but the impact of building regulations on household consumption is still limited

For the EU-15 as a whole, new buildings in 2005 consumed about 33 % less energy than dwellings built in 1990, according to the standards. Compared to dwellings built before the first oil shock in 1973/74, the theoretical progress achieved is around 60 %.

The impact on the total consumption of the household sector is only gradual and linked to the rhythm of construction: new buildings constructed since 1990 only represented 18 % of the total stock of dwellings in the EU-15 in 2005.

Actual savings are below these theoretical savings

A recent survey⁶⁴ showed that, according to the thermal insulation standards, new dwellings in Germany should consume 70 % less energy than those built before the first building regulations were introduced. In reality, the actual savings are only half this (35 %). This results from the combined effect of behavioural factors (such as higher indoor temperatures, more rooms heated, or a longer heating period over the year) and non-compliance with the building regulations. Similar results have been observed in Belgium.⁶⁵

⁶³ In 2006: in Denmark (25-30 % energy savings compared to the previous standards), Greece (20-25 %) and the UK (20 %); in 2005: in Italy and France (15 % each); in 2003: in Ireland (23-33 % savings) and Finland (20-30 %); in 2002: in Germany (30 %), the UK (25 %) and Portugal (7.5 %); in 2001: in France (15 % savings).

⁶⁴ See W. Eichhammer and J. Schleich; "Voluntary / Negotiated Agreements to Improve Energy Efficiency and to Protect the Climate", ADEME and FhG-ISI, April 2004 (www.worldenergy.org).

⁶⁵ Ministry of Economic Affairs, Gestion de la demande d'énergie, 2003 (p 65-79).

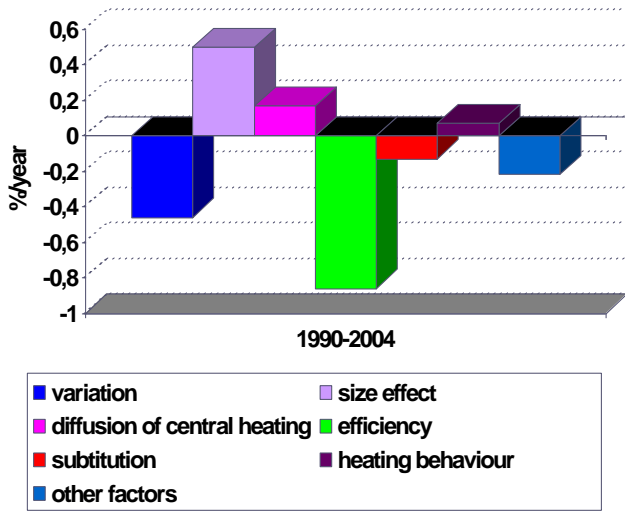
The increasing size of dwellings as well as the penetration of central heating offset part of the energy efficiency progress achieved

Dwellings are becoming larger as a result of increasing income and the preference for more space and single-family houses. The average size of dwellings is now 91 m² in the EU-15 which is 6 m² more than in 1990 (with a range of 75 to 110 m²). Over the period 1990-2004, dwelling size increased by approximately 0.4 m²/year (or at an average rate of 0.5 %/year). As a result, the average heating consumption per dwelling is decreasing at only half the rate of the consumption per m²: respectively -0.5 %/year and -1 %/year between 1990 and 2004. In other words, the increasing size of dwellings has offset about half of the energy efficiency progress achieved.

In the southern European countries, as well as in Ireland over the nineties, there is an increasing penetration of central heating, reflecting improved comfort in winter⁶⁶. It is estimated that the replacement of single room heating by central heating increases the energy required for space heating by about 50 % on average. All the rooms are well heated with central heating, whereas with room heating, a stove generally provides heat to the main room only. In the EU-15, the proportion of centrally heated dwellings increased from 71 % in 1990 to 80 % in 2004; this trend has, however, slowed down since 1998. Over the period 1990-2004, the penetration of central heating contributed to increasing the heating demand by 0.2 %/year.

If we exclude the influence of these two lifestyle factors responsible for increasing heating needs, we can approximate the improvement in energy efficiency as the balance with the actual variation (Figure 4-3). Energy efficiency for space heating can thus be shown to have improved by 1 %/year since 1990⁶⁷.

Figure 4-3: Drivers of the variation in heating consumption per dwelling in the EU-15



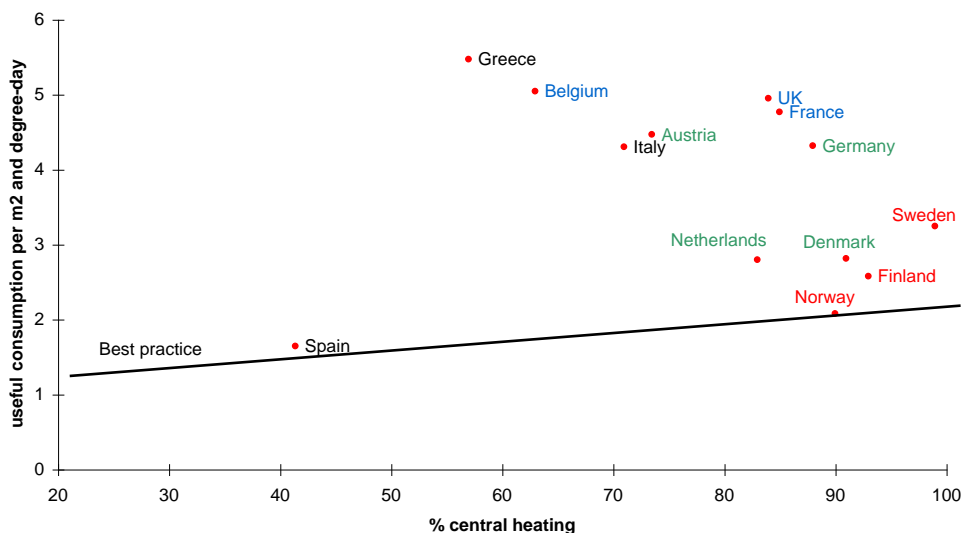
⁶⁶ Central heating includes district heating, block heating, individual boiler heating and electric heating.

⁶⁷ The energy efficiency indicator used is the average energy consumption per m² and per dwelling equivalent to central heating (to leave out the impact of the size and diffusion of central heating in useful energy (to assess the impact of fuel substitutions)). The effect of heating behaviour was estimated by assuming that technical progress cannot be reversed.

Heating requirements vary significantly among EU-15 countries

Heating demand, even corrected for differences in the climate and the fuel mix, varies significantly among EU-15 countries (**Figure 4-4**). Finland, Denmark and the Netherlands turn out to have the best performance (or the lowest demand) which could be considered a target for most other countries and for the EU-15 average.

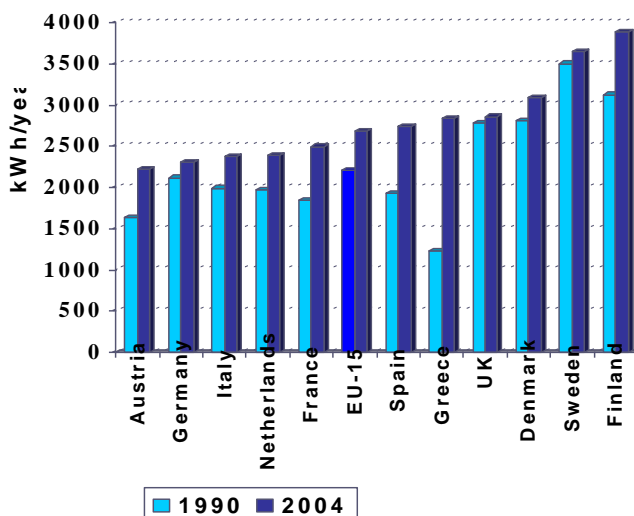
Figure 4-4: Heating requirement per m² in the EU-15⁶⁸



4.4. Electrical appliances and lighting

The average electricity consumption per household for electrical appliances and lighting varies quite a lot among countries. It is 2700 kWh/year on average for the EU-15, but exceeds 3500 kWh in Finland and Sweden. In Austria and Germany, it is significantly lower, around 2300 kWh (**Figure 4-5**).

Figure 4-5: Electricity consumption for electrical appliances and lighting in the EU-15



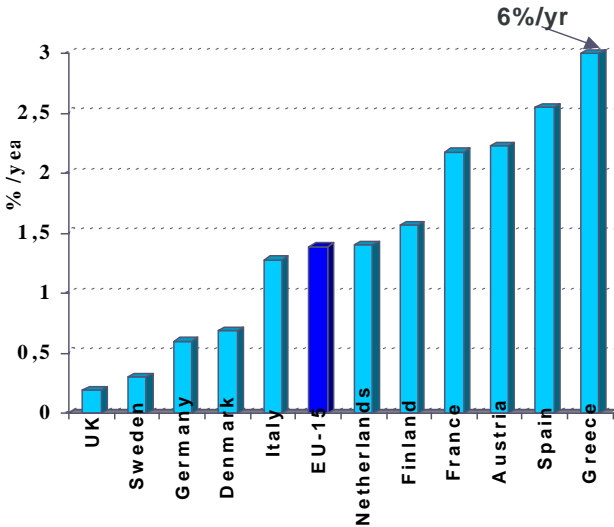
⁶⁸ Consumption expressed in useful energy per degree-days to correct for differences in heating equipment efficiency (which varies according to the fuel used) and climate; useful energy consumption is equal to final energy consumption multiplied by end-use efficiency.

Different trends among countries in the consumption progression per household

The average consumption per household for electrical appliances⁶⁹ and lighting is increasing at around 1.5 %/year in the EU-15, with wide variation among countries (**Figure 4-6**). The UK, Germany, Sweden and Denmark exhibit a very slow development, whereas France, Austria and Spain show a more rapid progression of between 2 and 2.5 %/year. Greece stands out with a growth of 6 %/year; its consumption jumped from 1200 kWh/year in 1990 to 2800 kWh in 2004. Since 2000, this consumption has been growing very slowly in Denmark, the Netherlands and the UK, and to a lesser extent in Finland. In contrast, consumption has accelerated in Austria, Spain, Sweden and the EU-15 as a whole.

The different trends observed in the consumption variation per household as well as in the consumption level can be partially linked to changes in household income, the impact of which will depend on the income level. Countries with high income and an equipment level close to saturation (e. g. the UK, Sweden or Denmark) will experience much slower growth than countries like Greece or Spain that have a higher potential for growth to match the equipment level of other countries. In addition, these countries are experiencing a rapid diffusion of air conditioning because of their climatic characteristics. To achieve a better understanding of these trends, a more detailed investigation by type of appliance is necessary. Due to data constraints, only the larger appliances can be looked at in more detail.

Figure 4-6: Electricity consumption trends for electrical appliances and lighting (EU-15)⁷⁰



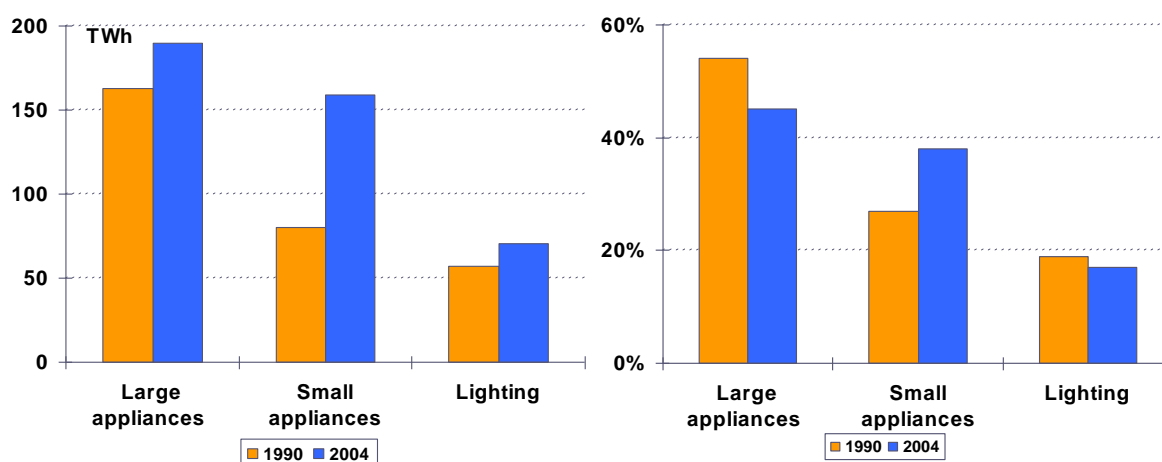
⁶⁹ Electrical appliances include large domestic appliances (refrigerators, freezers, washing machines, dish-washers, TV and dryers), and a variety of smaller appliances (radios, videos, irons, coffee machines, PCs, etc), as well as air conditioning.

⁷⁰ Average variation over the period 1990-2004.

Large electrical appliances represent a decreasing share of the electricity consumption

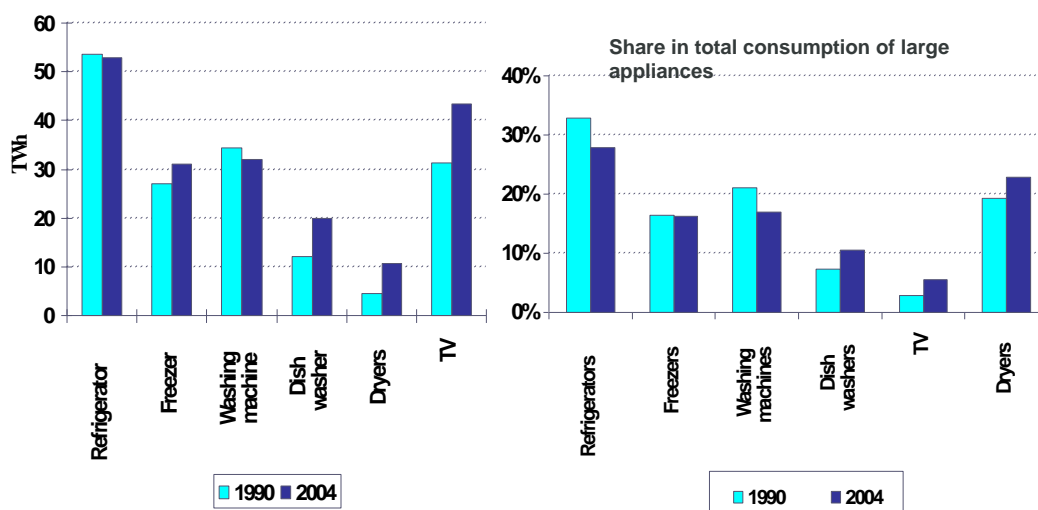
The six large appliances targeted by the EU Directives on labelling, the EU mandatory efficiency standards (cold appliances) and voluntary agreements with equipment manufacturers (washing machines, dishwashers) account for a decreasing share of the total consumption for electrical appliances and lighting⁷¹ (**Figure 4-7**). Their share dropped from 54 % in 1990 to 45 % in 2004. In contrast, the various small appliances have an increasing share in this consumption with 38 % in 2004 compared to 27 % in 1990. The share of lighting has decreased slightly from 19 to 17 %.

Figure 4-7: Household electricity consumption by type of appliance (EU-15)



Among the large appliances, cold appliances (refrigerators and freezers) play a decreasing role: from 50 % in 1990 to 44 % in 2004 (**Figure 4-8**). Their electricity consumption has increased only slightly since 1990 as a result of reaching saturation levels in household ownership and because of the efficiency progress made in this field. Indeed, these appliances were the first to be targeted by the EU labelling scheme and later by the Directive on minimum efficiency standards.

Figure 4-8: Electricity consumption of large appliances (EU-15)



⁷¹ i. e. electricity consumption without thermal uses.

A regular decrease in the specific consumption for large electrical appliances since 1992

If we leave out all the small appliances and lighting and focus on the 6 largest appliances⁷², their average annual consumption per household has decreased slightly by 2 % between 1990 and 2004 and is close to 1200 kWh/year. This trend results from two opposite influences:

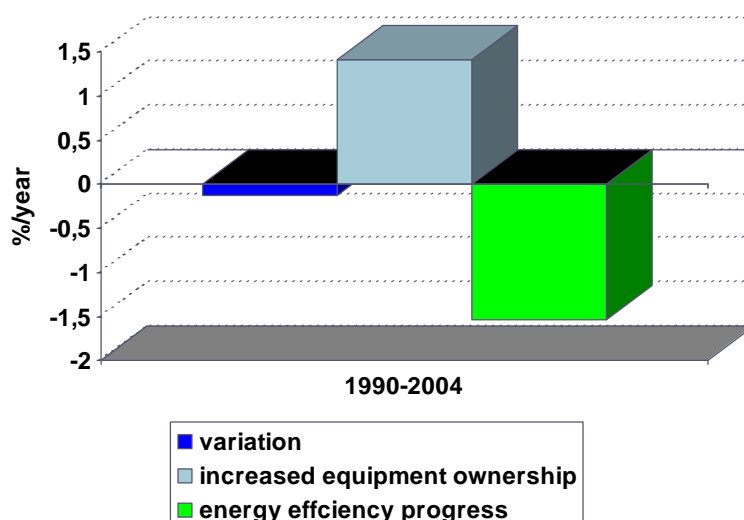
- more households are now equipped with each of these large appliances and there is multiple ownership of some appliances (mainly TVs). The biggest growth has been in dishwashers (from 22 % in 1990 to 45 % in 2004) and dryers (from 15 to 27 %)⁷³;
- change in the annual consumption per appliance (kWh/year/appliance).

The specific consumption of most large appliances is decreasing

The specific consumption of most of these appliances has been decreasing quite rapidly since 1990, in a range of 20 to 30 %⁷⁴ with the exception of TVs. As a whole, the energy efficiency of large electrical appliances improved by 20 % between 1990 and 2004⁷⁵ as measured by the trends in specific consumption. The actual energy efficiency gains may be even greater since other factors may have offset some of these gains, e. g. size increases⁷⁶ (more combi-refrigerators compared to simple refrigerators, larger TVs, etc), as well as a higher intensity of use (mainly for TVs and dishwashers).

As the average consumption for large appliances per household decreased by only 2 %, the deviation to the variation of the energy efficiency index (20 % versus 2 %) is due to the increasing diffusion of large appliances; in other words, increased appliance ownership offset almost 90 % of the technical efficiency gains (**Figure 4-9**).

Figure 4-9: Variation in the consumption per dwelling for large appliances (EU-15)



⁷² Refrigerators, freezers, washing machines, dishwashers, dryers and TVs.

⁷³ There is also a diffusion for freezers, but this was of lower amplitude (from 40 to 52 %).

⁷⁴ 20 % for refrigerators, 25 % for freezers and washing machines and 30 % for dishwashers.

⁷⁵ Efficiency index for large appliances calculated by weighting the progress achieved by each appliance by their weight in the total consumption for these appliances.

⁷⁶ The size may also decrease with the trend towards smaller households.

The share of the most efficient cold appliances is increasing

The European Directives on labelling aim at influencing consumers to buy the most efficient appliances. For refrigerators, the share of category A and A+ increased from 2.5 % in 1994 to 39 % in 2002 and 58 % in 2004 (Figure 4-10 and Figure 4-11); in the Netherlands, it is even above 70 % and around 60 % in Germany and Belgium⁷⁷. For washing machines, the increase in the share of A and A+ appliances has been even more rapid, from about 1 % in 1996 to 59 % in 2002 and 73 % in 2004. Again, the Netherlands have the leading position with a market share of nearly 100 % for A and A+, followed by Germany and Belgium (around 90 %).

Figure 4-10: Progression of class A and A+ in the EU-15 in the sales of new appliances

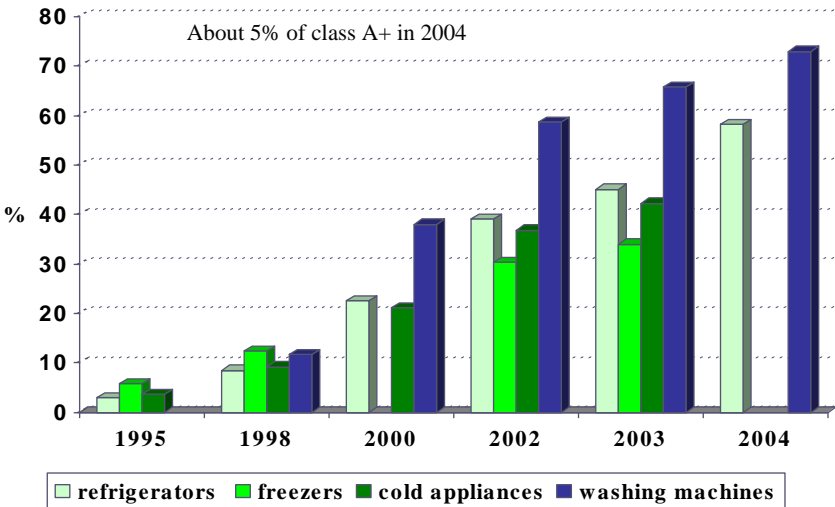
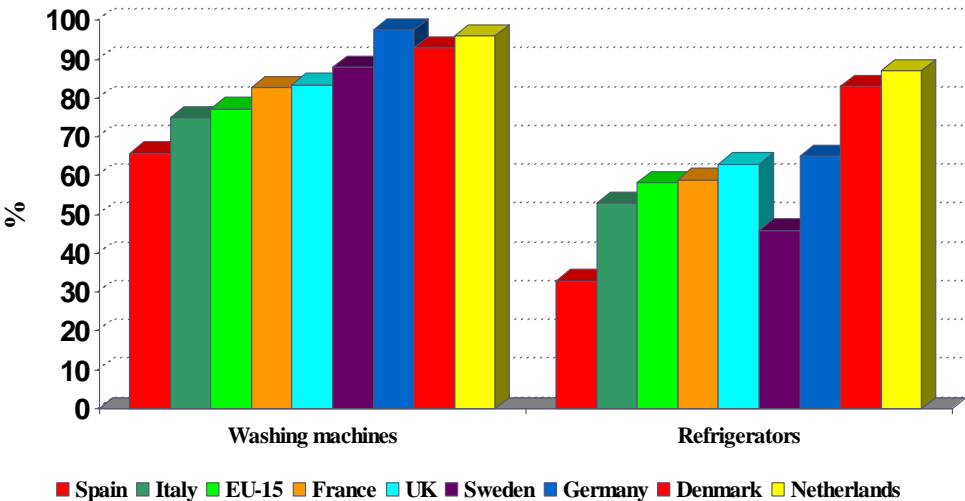


Figure 4-11: Market share of class A and A+ in selected EU-15 countries (2004)



⁷⁷ Source : own calculation from GfK, STEM .

4.5. Overall energy efficiency trends

In the household sector, energy efficiency improved by 11 % between 1990 and 2004 in the EU-15

Energy efficiency⁷⁸ improved by 11 %, i. e. 0.9 %/year in the household sector between 1990 and 2004 (**Figure 4-12**). Most of the progress was achieved before 1996. The gains were much slower over the rest of the period. Large appliances experienced the biggest energy efficiency improvement: 20 % since 1990 (1.5 %/year). For space heating, progress was rapid until 1995 but no further progress was achieved between 1996 and 2001. In most countries energy efficiency increased by around 1 %/year, which corresponds to the target of the Energy Service Directive⁷⁹ (**Figure 4-13**).

Figure 4-12: Energy efficiency progress for households in the EU-15

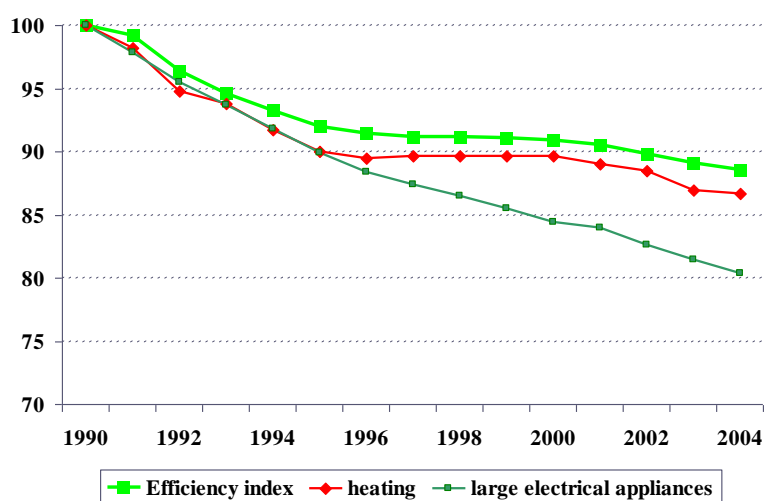
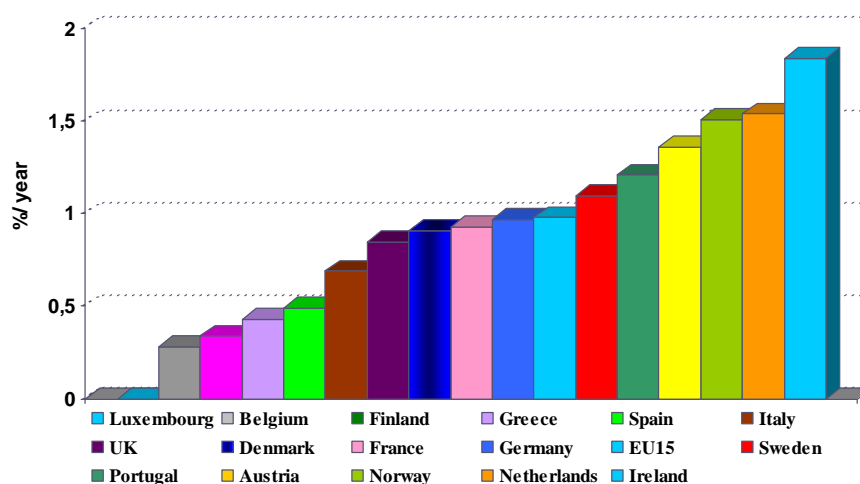


Figure 4-13: Energy efficiency trends by country in the household sector



⁷⁸ The energy efficiency index was calculated by weighting the energy efficiency gains for 8 end-uses/appliances: heating (toe/m²), refrigerators, freezers, washing machines, dishwashers and TVs (kWh/year), water heating, cooking (toe/dwelling). For small appliances and lighting, energy savings are difficult to assess and have been neglected.

⁷⁹ This comparison to the ESD target is purely indicative as ODEX measures total savings and ESD aims at accounting only those energy savings linked to policy measures (excluding autonomous technical trends, for instance).

All the energy efficiency progress is offset by lifestyle changes

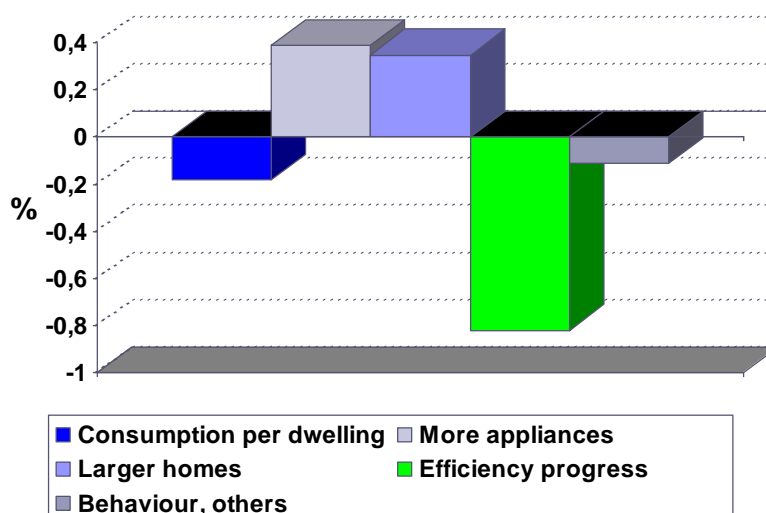
In 2004, the average energy consumption per dwelling was only 3 % below its 1990 level, whereas the energy efficiency index was 12 % below. This means that lifestyle changes have offset almost all the energy efficiency improvements achieved.

To measure the impact of lifestyle factors on the average consumption per dwelling, three main influences were quantified:

- increase in the average size of dwelling;
- the diffusion of electrical appliances and central heating, i. e. the influence of increased appliance ownership;
- behaviour related to increased comfort (mainly an increasing use of hot water).

Larger homes and an increasing number of appliances each contribute to raising the consumption per household by about 0.4 %/year (**Figure 4-14**). These two factors almost completely offset the progress made in energy efficiency.

Figure 4-14: Drivers of the energy consumption per household in the EU-15



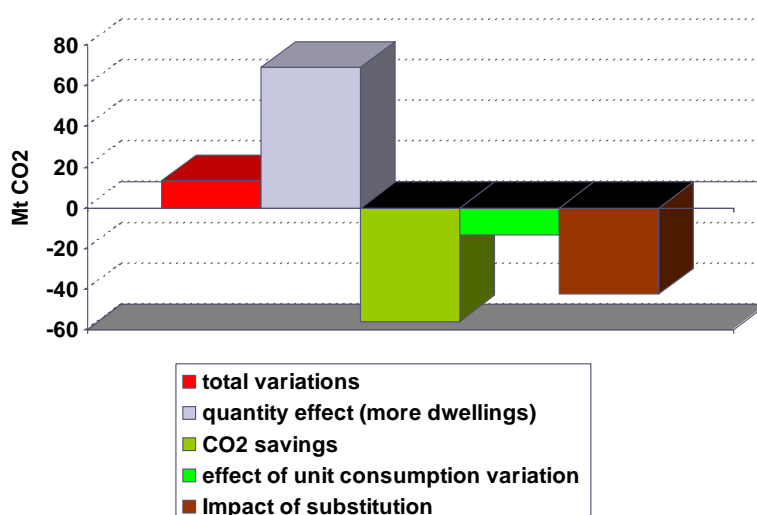
4.6. CO₂ emissions

Significant CO₂ savings limited the increase in CO₂ emissions

In 2004, the direct CO₂ emissions of households were 3 % above their 1990 level (increase of 13 Mt). This result was achieved despite an increase in the stock of dwellings and the number of household appliances owned, two developments that would have implied, all other things being equal, an increase of 69 Mt CO₂. This lower level of emissions was made possible by a reduction in the average emission per dwelling of about 10 % between 1990 and 2004 that resulted in CO₂ savings of around 56 Mt CO₂ most of which is linked to energy substitutions (81 %) (**Figure 4-15**).

This reduction in the average CO₂ emissions per dwelling was much larger than the 3 % decrease in the unit energy consumption per dwelling (in toe per dwelling)⁸⁰ because of switches to fuels with a lower CO₂ content (e.g. gas, heat and biomass) and an increasing use of electricity, the emissions of which are not included in the household sector. CO₂ savings from fuel switching and increased electricity use amounted to 42 Mt CO₂⁸¹.

Figure 4-15: Variations in CO₂ emissions from households in the EU 15⁸²



⁸⁰ All the figures given here are not corrected for climate variations.

⁸¹ If indirect emissions at the level of electricity generation are included, the variation is still the same.

⁸² 1990-2001 in Mt CO₂.

4.7. Conclusions

- Between 1990 and 2004, the energy efficiency progress in households was assessed as 0.9 %/year in the EU-15 (12 % over the period). This is partly the result of the policy measures implemented (EU directives and national measures such as building standards and financial incentives) which have raised the energy performance of new buildings and electrical appliances.
- In 2004, the amount of energy consumed by households was only slightly below the 1990 level. The main reasons for this rather surprising trend are that, at the same time as energy efficiency improved, increased income and/or lifestyle changes resulted in larger homes, greater heating comfort and ever more appliances, even if the numbers of the larger appliances have now reached saturation levels. Larger homes and a growing number of appliances each contributed to increasing the consumption per household by about 0.4 %/year (or 5 % over the period 1990-2004). These two factors together almost completely offset any energy efficiency progress achieved.
- In the medium- and long-term, these lifestyle factors should play a less determining role because of saturation effects for some equipment (e. g. central heating, most of the large electrical appliances), a slowdown in the progression of the average size of dwellings⁸³ and the increasing impact of new efficient buildings and appliances on the existing stock.
- Denmark and the Netherlands are among the countries with the best results in the household sector and should be considered as benchmarks by other countries (lowest heating requirement per m², large diffusion of A and A⁺ appliances and of condensing boilers).

⁸³ This phenomenon can already be seen in recent years and will be reinforced by the decreasing size of households and the increasing cost of housing