

Energy Efficiency Trends and Policies in the Household & Tertiary sectors in the EU 27

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Energy Efficiency Trends and Policies in the Household & Tertiary sectors in the EU 27

Lessons from the ODYSSEE/MURE project



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Didier Bosseboeuf
Project leader

Key Messages

This publication presents European trends for energy use, efficiency indicators and savings and the patterns for, and impact of, policy measures, mostly for the period 1997-2006. It relies on the following two tools:

- ✓ The **ODYSSEE** database on energy efficiency indicators, with data on energy trends, drivers for energy use, explaining variables and energy related CO₂ emissions, for the EU as a whole and for all member countries (www.odyssee-indicators.org).
- ✓ The **MURE** database with policy measures on energy efficiency implemented in EU countries and at EU level including the impact of the measures (www.mure2.com).

Both tools are used to support energy policy formulation by the European Commission, e.g. as part of the monitoring and evaluation of the Energy Service Directive.

Households

- In the period 1997-2006, the overall energy efficiency improvement was 0.8% per year. The rate has decreased somewhat since the nineties. Just over half of the countries realises less than the 1% requested in the Energy Service directive by the European Commission. The lack of progress cannot be attributed to lower energy prices because these prices increased. It is not due to the incorporation of new member states, as these countries realised above the EU average energy savings. Finally, the trend occurred despite a substantial increase in policy measures. Possibly causes are the liberalisation of the energy markets, which asked for new ways of policy making, and other societal problems displacing environment and energy savings as priority activities.
- Due to liberalisation of energy markets new policy measure types have emerged, such as White Certificates systems, Energy Performance Contracting and Energy efficiency Commitments. Within a prescribed overall target for energy savings it is left to the managers of these programs how (and sometimes when) the savings are realised.
- More and more policy measures are directly or indirectly the result of EU policy, such as the directives on Labels (electrical appliances), Energy Performance of Buildings (EPBD), Energy efficiency and Energy Services (ESD) and Ecodesign (energy using systems). After joining the EU the amount of new policy measures for new member states increased considerably.
- However, because EPBD, ESD and Ecodesign directives did hardly result in implemented policy measures up to 2007, EU policy cannot have had much effect on the energy savings analysed here for 1997-2007.
- Fuel use per household more or less stabilises with moderate economic growth and a reasonable amount of energy savings. However, in countries with high economic growth and/or lack of saving efforts fuel use keeps increasing.
- Electricity use per household increases despite energy savings, even for countries with low economic growth. In case of high economic growth (Ireland, Spain), taking up modern life styles (Eastern European countries) or introduction of air-conditioning (Italy, Spain) the electricity growth is substantial.

Services

- Energy use grows in the period 1997-2006, but there is no clear pattern. Some new member states and the southern EU-15 countries show very high growth rates, but other countries from both groups show a decrease in energy use.
- For energy intensity (toe per € value added) there is a clear division between the Eastern European countries and other EU countries. However, if a correction is made for power purchasing parity the intensities come much closer.
- The decrease in energy consumption per employee (-3%) is in strong contrast with that for electricity (+14%). Large increases in electricity use are probably due to the introduction of cooling in summer (all southern countries), to strong economic growth (Ireland) or more electricity consumption per employee (eastern European countries).
- The fuel consumption (including heat) per employee shows differences between countries that are partly explained by the winter climate, but there is no clear relation with the stage of economic development .
- New member states often lag behind as to the broadness of the package of policy measures. EU wide standards, financial support and information are most applied, energy taxes and voluntary agreements are hardly used.
- In total about 40% of all national policy measures is due to EU policy, e.g. transposition of EU directives. Up to 2006 most directives did not result yet in national policy measures; therefore EU policy cannot have had much effect on the energy savings analysed here for 1997-2006.
- The total impact of all policy measures is highest for EU-15 countries and not always related to the number of policy measures. The total impact is generally lower for new member states.
- The measure on standards, financial support and info/education all contribute about 25 % to total impact. Fiscal/tariffs hardly contribute to total impact.
- The fast growth in electricity use per employee mentioned earlier can be attributed to increased labor productivity (VA/employee), as shown by the observed relationship for countries.

Innovative policy measures

Innovativeness regards the provision of *substantial energy savings (effective)*, at reasonable costs (*efficient*). Innovative measures should be *broad in nature*, in order to meet all conditions for implementing saving measures, and provide *lasting savings*, without too much *rebound effects* that erode initial savings, *tackle social problems* (energy poverty) and preferably attain *positive side effects*, such as a better indoor climate.

- Many policy measures aiming at dwellings or buildings fulfil few criteria for innovativeness. Also they do not constitute a coherent combination that addresses all conditions for implementing saving measures (availability of technologies, options known to users, barriers lifted and enough incentives)..
- For households the most innovative and effective measures are performance standards on dwellings and appliances, performance programs such as White

Certificate systems and broad action plans with a combination of measure types that addresses all conditions for implementation.

- Taxes on energy or CO₂, policy addressing energy poverty and policy measures on inspection and maintenance are innovative complementary policy measures.
- For the tertiary sectors about the same innovative policy measures are valid. Here Energy Performance Contracting using ESCOs is of importance because the whole process of implementing saving measures is in one hand.
- Finally an (proposed) Emission Trading Scheme (ETS) for energy users that do not participate in the European ETS provides a way to find the most cost-effective energy savings as part of the efforts to reduce emissions of greenhouse gasses.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	II
KEY MESSAGES	III
1. INTRODUCTION	1
1.1. Goal of the brochure	1
1.2. ODYSSEE and MURE	1
1.3. Contribution to EU policy evaluation	3
1.4. Scope of this brochure	4
1.5. Indicators, energy savings and policy effect	5
2. ENERGY EFFICIENCY AND POLICY MEASURES FOR HOUSEHOLDS	1
2.1. Key strategic issues	1
2.2. Trends for total household energy consumption	1
2.3. Unit energy consumption	5
2.4. Energy for space heating	8
2.5. Electricity for appliances	14
2.6. Savings by renewable energy technologies	17
2.7. Overall energy efficiency and CO₂ emission reduction	18
2.8. Policy measure developments	21
2.9. EU based policy measures	25
2.10. Policy impact and realised energy savings	33
2.11. Analysis of drivers and factors behind trends and differences	36
2.12. Observations and lessons learned	44
3. ENERGY USE AND POLICY FOR TERTIARY SECTORS	46
3.1. Key strategic issues	46
3.2. Trends for energy consumption	46
3.3. Energy intensity and unit consumption	49
3.4. Policy measure developments	55
3.5. EU based policy measures	58
3.6. Impact of policy measures	59
3.7. Analysis of drivers and factors behind trends and differences	61
3.8. Observations and lessons learned	64
4. INNOVATIVE POLICY MEASURES	66

4.1.	What are innovative measures?	66
4.2.	Innovative policy measure types for Households	70
4.3.	Innovative policy measure types for tertiary sectors	73
4.4.	Conclusions	75
5.	GLOSSARY OF CALCULATIONS ISSUES	76

TABLE OF FIGURES

Figure 1-1: Final energy consumption household and tertiary sectors (EU-27)	4
Figure 1-2: From ODYSSEE energy savings to total savings and policy savings	6
Figure 2-1: Increase in household energy consumption before/after 2002	2
Figure 2-2: Energy consumption⁵ by energy carrier for households (EU-27)	2
Figure 2-3: Break down of household energy use for EU-countries (2005)	4
Figure 2-4: Final and primary energy consumption trends for households (EU-27)	4
Figure 2-5: Trend for population, households and income (EU-27)	5
Figure 2-6: Average energy consumption per household (climate corrected)	6
Figure 2-7: Average electricity consumption per household	7
Figure 2-8: Space heating fraction in household energy consumption	8
Figure 2-9: Energy use for space heating per dwelling	9
Figure 2-10: Energy use for space heating per m² floor area adjusted to the EU climate	10
Figure 2-11: Heating energy use: per dwelling, per m² and size effect (1997-2007)	11
Figure 2-12: Growth of dwelling stock between 1997 and 2007	12
Figure 2-13: Energy efficiency trend for space heating in dwellings (EU-27)	13
Figure 2-14: Electricity use per household with/without thermal uses (2004)	14
Figure 2-15: Yearly growth in electricity use per household for appliances & lighting (1997-2006)	15
Figure 2-16: Change in total electricity use for large/small appliances and lighting	15
Figure 2-17: Shares of large appliances in total appliance electricity use	16
Figure 2-18: Decomposition of change in electricity use of large appliances	16
Figure 2-19: Development of the fraction of dwellings with a solar water heater	17
Figure 2-20: Overall efficiency index ODEX of households for EU-27	18
Figure 2-21: Yearly energy efficiency improvement by country (1997-2007)	19
Figure 2-22: Decomposition of 1996-2007 variation in CO₂ emissions for EU 27	20
Figure 2-23: Number of policy measures and status for households (2006)	21
Figure 2-24: Policy measures per type for households (ongoing, 2006)	22
Figure 2-25: Yearly introduced new policy measures for households	23
Figure 2-26: Completed policy measures per type for households (1990-2006)	23
Figure 2-27: Policy measures targeted at dwelling related uses (2006)	24
Figure 2-28: EU policy influencing national policy measures for households	27
Figure 2-29: Penetration of labels A and A+/A++ for refrigerators (2006)	29
Figure 2-30: Penetration of labels A and A+ for washing machines (2006)	30
Figure 2-31: Market share of A/A+ labels for cold and washing appliances (EU)	30
Figure 2-32: Market penetration trend for refrigerators in the Netherlands	32
Figure 2-33: Market penetration trend for refrigerators in the UK	32
Figure 2-34: Policy measures per impact level for households (ongoing)	33
Figure 2-35: Total impact of household policy measures, split per type (2006)	34

Figure 2-36: Policy impact and overall energy efficiency increase for households	36
Figure 2-37: Penetration of central heating in dwellings (selected countries)	37
Figure 2-38: Contribution of fuel substitution to unit consumption per m²	38
Figure 2-39: Decomposition of change in heating energy use per dwelling (EU-27)	39
Figure 2-40: Energy consumption versus income, per household (PPP¹⁷, 2006)	40
Figure 2-41: Appliance electricity use versus income, per household (PPP¹⁷, 2006)	40
Figure 2-42: Trend in energy prices for households, weighted EU-27 average	41
Figure 2-43: Electricity use per household and price variations (1996-2004)	42
Figure 2-44: Income, energy price and average energy use per household (EU-27)	42
Figure 2-45: Average floor area of dwellings versus growth rate (1997-2006)	43
Figure 3-1: Increase in energy consumption of Tertiary sectors	47
Figure 3-2: Energy consumption by energy carrier for Tertiary (EU-27)	48
Figure 3-3: Final and primary energy use trends for Tertiary (EU-27)	49
Figure 3-4: Value added, employees and labour productivity for Tertiary (EU-27)	50
Figure 3-5: Energy intensity and change for Tertiary, per country and EU-27	51
Figure 3-6: Energy intensity trend for Tertiary, in EU-15 and new MS	51
Figure 3-7: Total energy and electricity use per employee for Tertiary (EU-27)	52
Figure 3-8: Fuel consumption per employee in 1997 and 2006 for Tertiary	53
Figure 3-9: Electricity use per employee and change, per country for Tertiary	54
Figure 3-10: Policy measures and status for tertiary sectors (2006)	55
Figure 3-11: Policy measure per type for tertiary sectors (ongoing, 2006)	56
Figure 3-12: Policy measures targeted at building related uses (2006)	57
Figure 3-13: EU policy influencing national policy measures for tertiary sectors	59
Figure 3-14: Total impact of policy measures, split per type, for tertiary (2006)	60
Figure 3-15: Value added versus electricity use, per employee, for services	61
Figure 3-16: Decomposition of energy use for services in Denmark (1997-2006)	62
Figure 3-17: Decomposition of change in direct CO₂ emissions for Tertiary (EU-27, 1996-2007)	63
Figure 5-1: Yearly HDD and (climate corrected) energy consumption (EU-27)	76
Figure 5-2: Energy use for space heating per dwelling (2000): statistics, climate corrected and for EU-27 climate	77
Figure 5-3: Energy intensity of new member states with/without PPP correction	78
Figure 5-4: ODEX-Households, yearly and 3-years moving average values	79
Figure 5-5: Ratio of dwellings to households (selected countries)	80

LIST OF TABLES

Table 2-1: Implemented EU Directives by countries, per appliance and period ..	28
Table 2-2: National supporting measures to the EU label system	31
Table 2-3: Examples of high impact measures in the household sector	35
Table 3-1: Examples of high impact measures for tertiary sectors	60
Table 4-1: Criteria and selection of innovative policy measures	66
Table 4-2: Examples of policy measures using a new approach	67
Table 4-3: Influence of policy on conditions for implementing saving measures .	68
Table 4-4: Policy measures examples on (non) lasting saving measures	69
Table 4-5: Examples of policy measures with different rebound effects	70
Table 4-6: Policy measures in EU-countries with positive side effects	70
Table 4-7: Innovative policy measure types for households	71
Table 4-8: Innovative policy measure types for tertiary sectors	73
Table 5-1: Rating of data availability households, per end-use type and country	81
Table 5-2: Rating of data availability for services, per end-use type and country	81

LIST OF BOXES

Box 2-1: Countries with an extreme fuel mix and large changes for households ...	3
Box 2-2: Strengthening of standards for new dwellings	12
Box 2-3: Overview of household saving technologies	19
Box 2-4: Extreme policy measure choices per country for households	22
Box 2-5: Energy Performance of Buildings directive (EPBD)	25
Box 2-6: Ecodesign directive on energy using products	26
Box 2-7: Determination of the impact of policy measures	33
Box 3-1: Countries with an extreme fuel mix and large changes for Tertiary	48
Box 3-2: Extreme policy measure choices per country for Tertiary	56
Box 4-1: Mandatory Energy Efficiency Action Plans for Municipalities	67
Box 4-2: White certificate systems and other performance programs	72
Box 4-3: Energy Service Company (ESCO)	74

1. Introduction

1.1. Goal of the brochure

The aim is to provide insight into past developments for energy use, energy efficiency trends and related policy measures for households and tertiary sectors of EU-27 countries. This should help policy makers and other parties involved in energy efficiency and CO₂ emission reduction in adapting present policy and formulating new effective policy measures. The main issues in the analysis are energy efficiency improvement and the effect of various policy measures. However, energy trends including autonomous energy savings and the effect of other factors, such as the impact of economic growth, energy prices and behaviour, are also part of the analysis.

The period covered in this book (1997-2007) does not cover yet the 2008 oil price peak and the financial crisis and economic downturn. The material gathered provides a robust analysis of the situation before these events which is relevant for the expected back-to-normal trends. It constitutes also a sort of baseline scenario to the new policies (ESD, EPBD and stimulus plan and energy prices etc.) which will have impact soon.

1.2. ODYSSEE and MURE

This analysis is based on the ODYSSEE database on energy efficiency indicators and the MURE database on policy measures. The ODYSSEE database is used for the monitoring and evaluation of annual energy efficiency trends and energy related CO₂ emissions. The MURE database is used for the analysis of policy measures and the impact of policy measures. Both databases include the new EU member states and now cover the EU-27, Croatia and Norway.

The **ODYSSEE database** (www.odyssee-indicators.org) regards developments for the end-use sectors households, industry, transport and tertiary and the national level. The energy indicators are calculated for the years from 1990 on (for EU-15 countries) or from 1996 on (for all member states). The inputs for the indicators are provided by national energy agencies or institutes according to harmonised definitions and guidelines. Historically, ODYSSEE indicators focused on energy trends at sectoral level. But new types of indicators, e.g. on energy performance of new dwellings or diffusion of efficient technologies, have been added more recently to enable a complementary monitoring of policy measures. ODYSSEE encompasses the following types of indicators:

- **Energy/CO₂ intensities** relate the energy used in the economy or a sector to macroeconomic variables (e.g. GDP, value added).
- **Unit consumption indicators** relate energy consumption to physical indicators (unit consumption per dwelling, per m²); specific consumption of electrical appliances, ...

- **ODEX** aggregates energy efficiency indices by sector and for the whole economy, to evaluate energy efficiency progress (see methodological issues).
- **Adjusted indicators** allow the comparison of indicators across countries (adjustments for differences in climate, general price level, fuel mix).
- **Benchmark/target indicators** by sector show the potential improvement based on countries with the best performance (based on adjusted indicators).
- **Indicators of diffusion** enable to monitor the market penetration of energy efficient technologies (efficient lamps, condensing boilers) and practices (label A for electrical appliances) as well as of end-use renewables (solar water heaters).

The amount of *energy savings* is calculated from the (relative) energy efficiency improvements and the energy consumption involved.

The **MURE database** (www.mure2.com) provides an overview of the most important energy efficiency policy measures for EU-27, Croatia and Norway. Per policy measure the following is specified:

- Sector: households, industry, transport, tertiary and cross-sector
- Status: completed, ongoing or planned
- Period: year of introduction and (for completed policy measures) end year
- Type: legislative/normative (e.g. standards for new dwellings), legislative/informative (e.g. obligatory labels for appliances), financial (e.g. subsidies), fiscal (e.g. tax deductions), information/education, co-operative (e.g. voluntary agreements) and taxes (on energy or CO₂ emissions)
- Semi quantitative impact: low, medium or high impact, based on quantitative evaluations or expert estimates
- Other properties: targeted energy users, actors involved, etc.

For each policy measure a detailed description is available which contains, if available, a quantitative impact in terms of energy savings and/or CO₂ emission reduction.

The database excludes long term R&D measures, measures to improve supply side efficiency and greenhouse gas reduction measures without a direct link to energy efficiency. All policy measures from 1990 to the current year are available. Important policy measures introduced before 1990 and planned policy measures are also available. Information about these measures is collected by national energy agencies or institutes, according to harmonised guidelines which have been established centrally.

1.3. Contribution to EU policy evaluation

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

- DG TREN made explicit reference to the ODEX indicators in the Energy Service Directive (ESD) as a way of monitoring realised energy savings by a so-called “top-down” approach. The EMOS database (Energy Market Observatory) includes about 20 indicators from ODYSSEE
- DG ENV is using CO₂ emission data and indicators similar to the ones used in the ODYSSEE for monitoring the demonstrable progress in GHG abatement within its climate change task force
- EUROSTAT also relied on ODYSSEE indicators when designing its own list of priority indicators. Regular cooperation takes place in the form of exchanging data and harmonised methodologies. This cooperation will be reinforced during monitoring of the ESD
- EEA (European Environmental Agency) uses in their yearly TERM report¹ a data set and indicators taken from the ODYSSEE database and the indicators were used in the fourth pan-European environment assessment report (UNECE)
- JRC Ispra and IPTS are also using ODYSSEE data for different studies for the Commission, including the SRS system for energy efficiency monitoring
- IEA uses ODYSSEE to construct the European part of their indicator database for OECD countries
- WEC (World Energy Council) and the Energy Charter Secretariat regularly rely on ODYSSEE indicators in publications and workshops
- Some models used by the European Commission, such as PRIMES and POLES, also employ ODYSSEE data.

The MURE database provides the following services to European and international policy monitoring and evaluation:

- Structuring the format for reporting measures in the National Energy Efficiency Action Plans to be submitted by the EU member states to the Commission
- Input for IEA database on Energy Efficiency Policies and Measures, with regard to Europe (<http://www.iea.org/textbase/effi/index.asp>)
- The MURE simulation tool, attached to the database, has been used by the EU Commission as an aid to assess saving potentials when evaluating the National Energy Efficiency Action Plans submitted in 2007.

¹ TERM monitors indicators tracking transport and environment integration in the European Union.

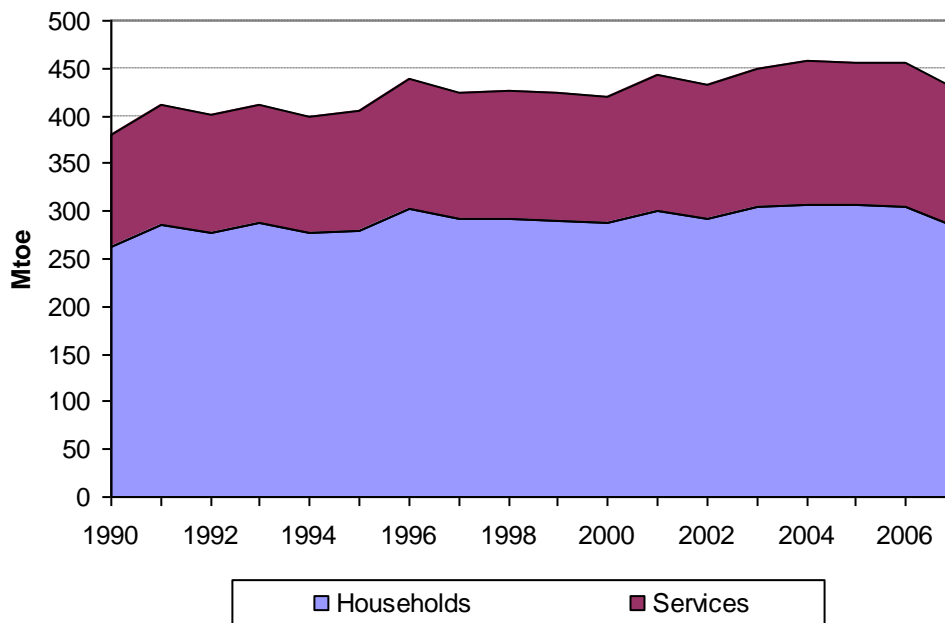
1.4. Scope of this brochure

The analysis in the ODYSSEE/MURE project regards different end-use sectors and overall energy use. This brochure reports on the sectors households and tertiary².

Sectors covered

The main part of energy use analysed regards households, which consume 17% of total primary energy consumption in the EU-27 (see **Figure 1-1**). Tertiary energy consumption is equal to 8% of EU-27 primary energy consumption.

Figure 1-1: Final energy consumption household and tertiary sectors (EU-27)



Period of analysis

For new member countries (reliable) data are only available since 1996, thus the analysis for EU-27 countries can only start then. However, the winter in 1996 was very cold and the correction for yearly variations in temperature during the heating season appeared not quite satisfactory. In order to depart from a trustworthy base year the analysis starts in 1997. The observation period will generally be 1997-2007, unless at the time of writing not all data were complete.

Subjects of analysis

The results for households are presented in Chapter 2 and that for tertiary sectors in Chapter 3. Per sector the analysis regards the following subjects:

- **General trends for energy use and emissions:** actual energy use and CO₂ emission per sector, split into energy carrier of subsector. Also energy use corrected for yearly varying climate is presented.

² Often referred to as Service sectors or in short “services”

- ***Average energy use***: trends for drivers for energy use, such as number of households and dwellings (sector households), or production and employees (sector tertiary). These are used to determine average energy use: total energy use per household, energy use for space heating per dwelling and total energy use per Euro value added or employee.
- ***Indicators***: mainly unit consumption indicators and diffusion indicators (see section 1.2).
- ***Overall efficiency development (ODEX)***: aggregated efficiency trend per sector or parts, e.g. space heating (see chapter 5).
- ***Policy measure developments***: patterns (number and type) and dynamics (new or completed) of energy efficiency measures, differences between countries and EU (related) policy measures.
- ***Impact of policy measures and efficiency improvement***: relative impact (high, medium or low) of policy measures, the total impact of policy measures targeted at specific end-uses, the trend for total impact in time and the overall impact of policy measures per sector. This last one is traded against the efficiency improvement based on the ODEX indicator.
- ***Analysis of factors explaining trends***: trade-off between trends for energy indicators and explaining factors, e.g. increase in income or higher energy prices. Comparison between EU countries as to the values for indicators and explaining variables, e.g. differences in GDP level, structure of energy use and saturation in energy use.
- ***Conclusions and observations***: based on the forgoing conclusions are drawn as to observed important trends and changes, possible explanations and consequences for policy formulation.

Innovative policy measures

The analysis in chapter 4 regards both households and tertiary sectors and is based on a set of criteria for innovativeness. For each criterion, sets of innovative policy measures are presented, followed by an overall set of innovative policy measure types.

1.5. Indicators, energy savings and policy effect

This section highlights the relation between ODYSSEE indicators and total or policy related energy savings. Other methodological issues are dealt with in chapter 5.

From indicators to energy savings

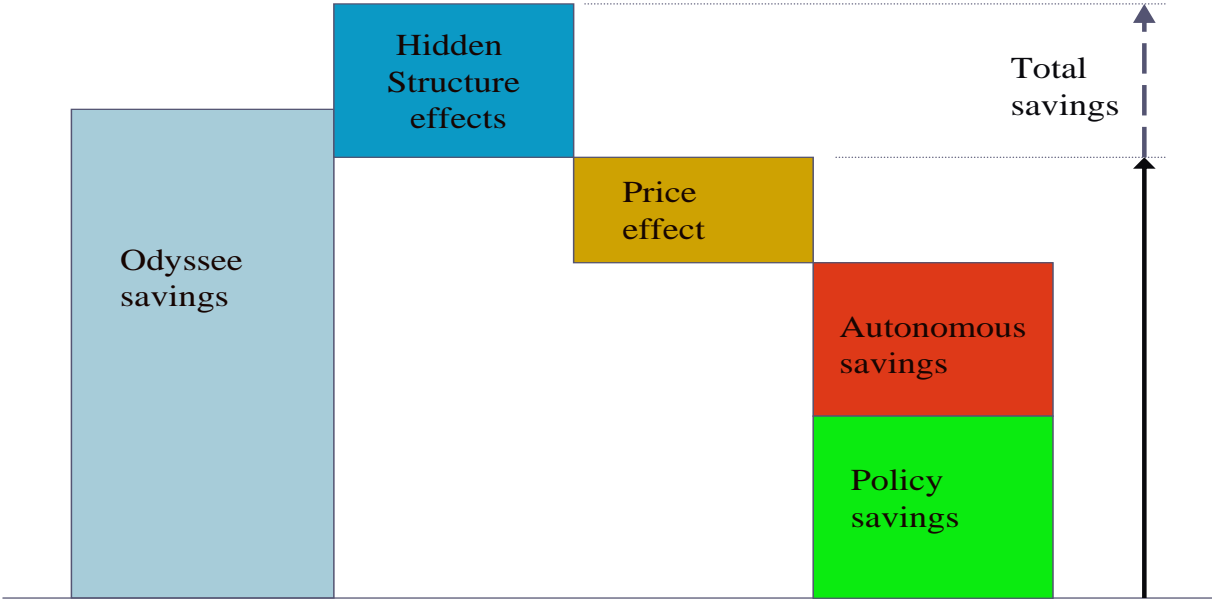
The indicator values found in the ODYSSEE project are used to determine realised energy savings. For instance, energy savings for space heating are calculated from the decrease in the indicator “average energy use for space heating per dwelling” and the number of dwellings.

ODYSSEE results and total energy savings

ODEX is meant to represent total energy savings. However, the changes in the underlying indicator values can be the result of other factors than energy efficiency. E.g. the indicator “average energy consumption per dwelling” is influenced by larger

dwellings, more detached houses instead of multifamily apartment buildings, central heating instead of one room heating, fuel substitution and lower occupation rates. The ODYSSEE indicators are corrected for most of these factors, but for some factors no correction is possible due to insufficient data (e.g. occupation rate). Factors not corrected for cause the so-called “hidden structure effect” which can both lead to over- or underestimating the (true) total energy savings (see **Figure 1-2**).

Figure 1-2: From ODYSSEE energy savings to total savings and policy savings



Source: EMEEES project

ODYSSEE results and policy related savings

The results regard total efficiency improvement and total energy savings which can be due to higher energy prices (excluding taxes) or autonomous technological progress. Therefore, total energy savings are only partly defined by the effect of policy measures. A good example of autonomous efficiency improvement is the flat screen TV that uses by nature less electricity than a conventional TV. The price effect and autonomous savings should be subtracted from the total savings provided by ODYSSEE to find policy related energy savings³ (see **Figure 1-2**).

³ See analysis done in the EC financed EMEEES project to calculate energy savings

2. Energy efficiency and policy measures for Households

2.1. Key strategic issues

Key issues for the coming decade are:

- How to increase the rate of yearly energy efficiency improvement, which will determine whether total energy consumption of households will stabilise or even decrease
- A larger contribution of policy measures, both at EU level and in the member states, to the (higher) rate of energy efficiency improvement
- The detection of effective and efficient policy measures that can be deployed in all member states (innovative and best practice examples)
- Finding combinations of policy measures that more effective than a set of single measures
- Defining the optimal combination of EU policy and policy measures of member states.

In order to help address these strategic issues an analysis is made of trends for energy consumption, unit consumption and specific uses such as space heating or appliances. Also an analysis is executed on policy measures and their impact. To understand factors behind the trends, explanations for observed trends are sought for using important drivers and observed differences between countries. Finally the relationship between energy efficiency trends and impact of policy measures is looked at and innovative policy measures are described (see chapter 4).

2.2. Trends for total household energy consumption⁴

Growth of energy consumption in EU-27 is small and declining in recent years

Total energy consumption in the EU-27 increased by 3% in the period 1997-2002. But growth was less than 2% in the period 2002-2007 (see ratio for EU-27 in **Figure 2-1**). This was probably due to the slowdown in economic growth after the internet bubble in stock markets.

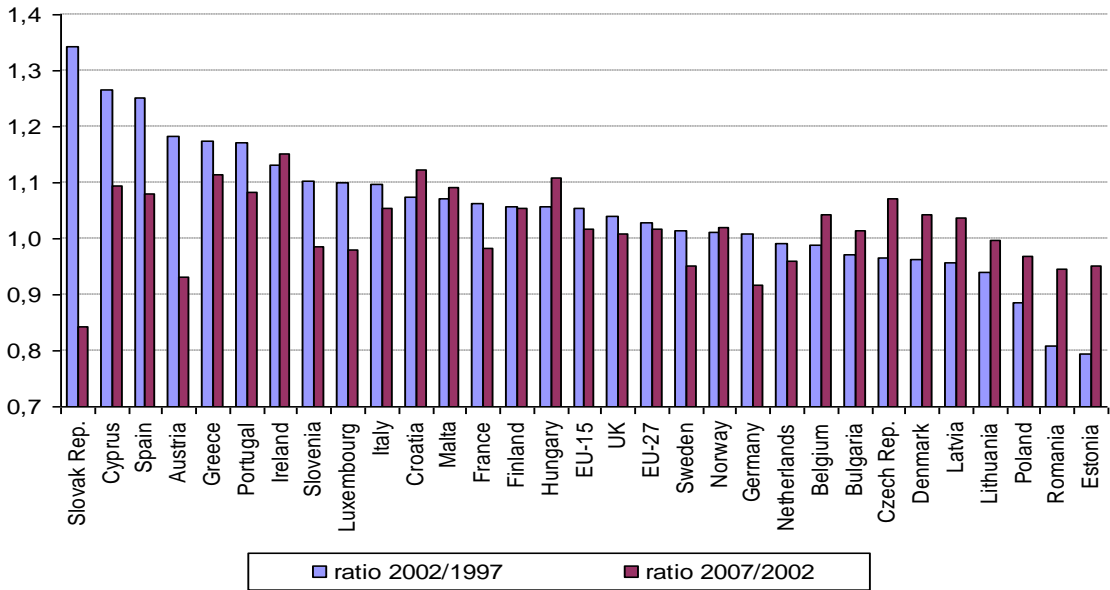
Energy consumption trend for new member states differs from that for EU-15

The EU-15 countries Greece, Portugal, Spain and Ireland show the fastest growth in energy consumption (27-38%) while new member states Estonia and Romania show a considerable decline in energy consumption (-25%). After 2002 the growth rate for EU-15 countries is considerably lower than before. However, this is not the case for

⁴ Unless specified otherwise the following results regard temperature corrected figures (see chapter 5).

most of new member states where the increase is larger or the decline smaller after 2001 (see **Figure 2-1**).

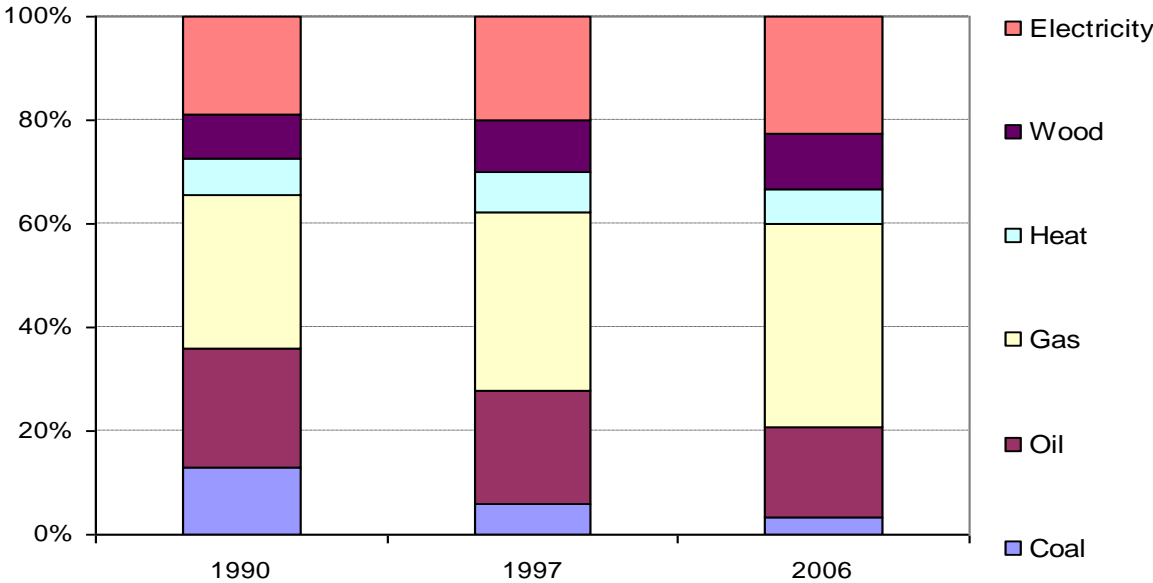
Figure 2-1: Increase in household energy consumption before/after 2002



Shift from coal and oil to gas and electricity has taken place

Natural gas has become the dominant source of energy for households in the EU-27 with 40 % of the market, from 30 % in 1990 (see **Figure 2-2**). Electricity ranks second and is increasing (23 % in 2006 compared to 19 % in 1990). The contributions of coal and oil have fallen significantly, from 13% to 3% for coal and from 23% to 17 % for oil.

Figure 2-2: Energy consumption by energy carrier for households (EU-27)



Heat from district heating represents only 7 % of the total, although it plays an important role in many new member states (see **Box 2-1**). Biomass has a stable market share (9-11 %); it is quite significant in some new member states.

Box 2-1: Countries with an extreme fuel mix and large changes for households

Solid fuels

Ireland has been extremely dependent on peat (60% in 1990) but also has shown a very fast transition in recent years (to 17% in 2006). The same holds for coal use in the Czech Republic (down from 59% in 1990 to 13% in 2006). Poland still holds the largest share for solid fuels (31% in 2006).

Liquid fuels

Island countries, e.g. Cyprus, Greece and Ireland, typically show the highest fractions for oil use, possibly due to the absent, or limited, gas grid. For the relative high fractions of Luxembourg and Belgium there is no obvious reason.

Natural gas

The countries with own gas reserves show the largest use of gas: the Netherlands (70-80%) and the UK (60-70%). The largest increase in gas share regards new member states, e.g. the Czech Republic and Hungary.

Heat from district heating

Large fractions are typically found in Eastern European countries, especially the Baltic countries (about 50%). Only in Romania the share is decreasing substantially.

Wood/biomass

The largest shares are found in countries with a lower GDP (Latvia or Portugal) and/or much wood resources (Austria and Finland). Eastern Europe shows the fastest decline in wood use.

Electricity

High fractions regard small islands (Cyprus and Malta) or countries with nuclear electricity production but limited gas grids (Sweden and Finland).

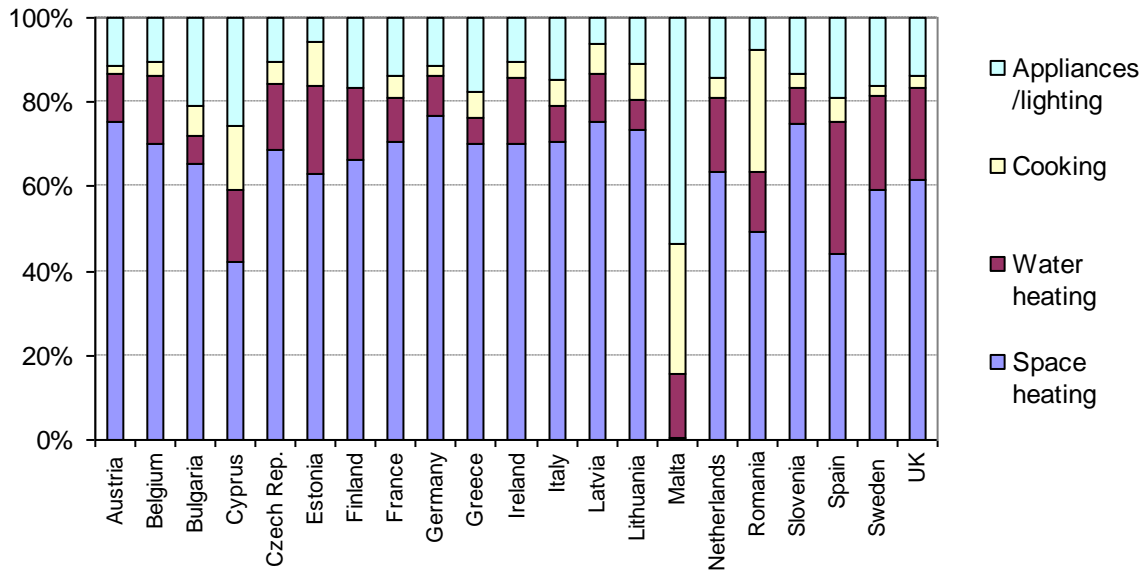
Energy uses differ much between countries

Energy for EU-27 households is mainly used for space heating (70%); other important uses are appliances/lighting (13%) and hot water (14%), while cooking is relatively insignificant (4%). The break down differs substantially between member states (see **Figure 2-3**). For space heating a correlation with cold winters can be expected. Indeed, Cyprus shows a small fraction for space heating. But Sweden does not show the highest fraction, probably due to substantial energy use for other purposes (see average use). Some countries with a moderate winter climate, and even countries with mild winters such as Spain, France and Italy, show rather high fractions for space heating.

There are few changes over time in the break down by type of energy use

In the period 1997-2006 the fraction for appliances/lighting (including air-conditioning) increases with 1-2%-points at EU-27 level, the fraction for space heating is decreasing and the fractions for hot water and cooking are stable. However, for new member states and Spain fractions sometimes change substantially.

Figure 2-3: Break down of household energy use for EU-countries (2005)

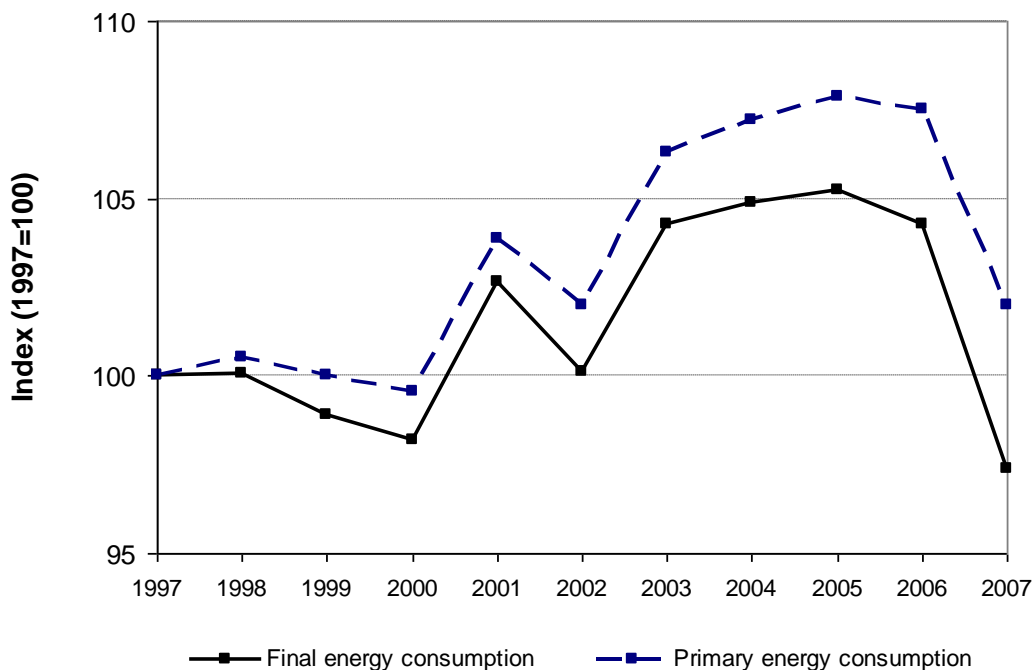


Energy use in primary units increases much faster due to electricity growth

Electricity consumption poses a larger burden on energy supply than fuel consumption due to the conversion losses in power stations and distribution losses (see chapter 5).

Figure 2-4 shows that household energy consumption in primary units for the EU-27 grows by 2% in the period 1997-2007 while final energy consumption decreases with about the same percentage. This is due to electricity consumption, and the input for its generation, growing much faster than fuel use.

Figure 2-4: Final and primary energy consumption trends for households (EU-27)



Household fraction in total primary energy consumption is about stable

For the EU-27 as a whole the share of households in total final energy consumption is 17% and slightly decreasing. But the share in total primary energy consumption is about 22%, and almost stable over the period.

For EU-15 countries the 2007 share in total primary energy consumption lies between 17% (Netherlands) and 28% (Denmark); these extreme cases correspond to the presence respectively absence of a large industrial sector. For new member states the range is much larger, between 16% (Bulgaria) and 36% (Latvia). Differences for the space heating fraction will be due to mild or cold winters (see section 2.4).

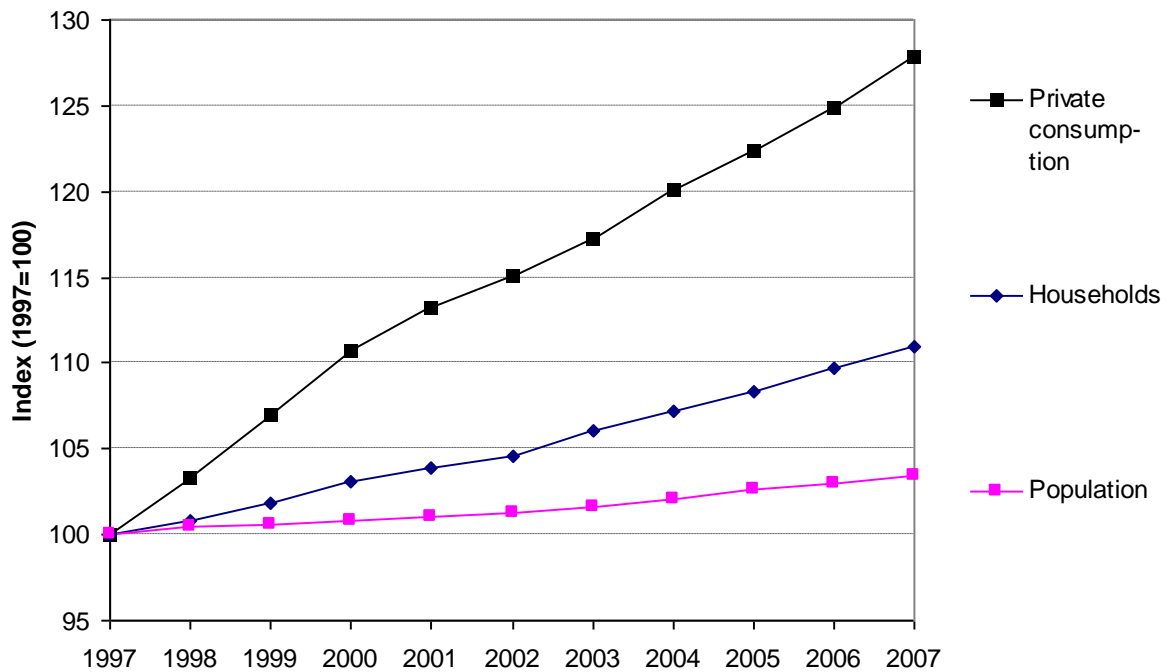
2.3. Unit energy consumption

Number of households increases much faster than population

The number of households depends on demographic trends, such as population growth and persons per household. The number of households increased 3 times faster than the population, 1.0%/year versus 0.3 %/year (

Figure 2-5). The growth in number of households defines the number of dwellings and therefore the demand for space heating and lighting. Thus the steady reduction in the number of persons per households (from 2.8 to 2.5 between 1990 and 2006) due to ageing of the society and the decohabitation is a major cause of extra energy use.

Figure 2-5: Trend for population, households and income (EU-27)



Income increases much faster than number of households.

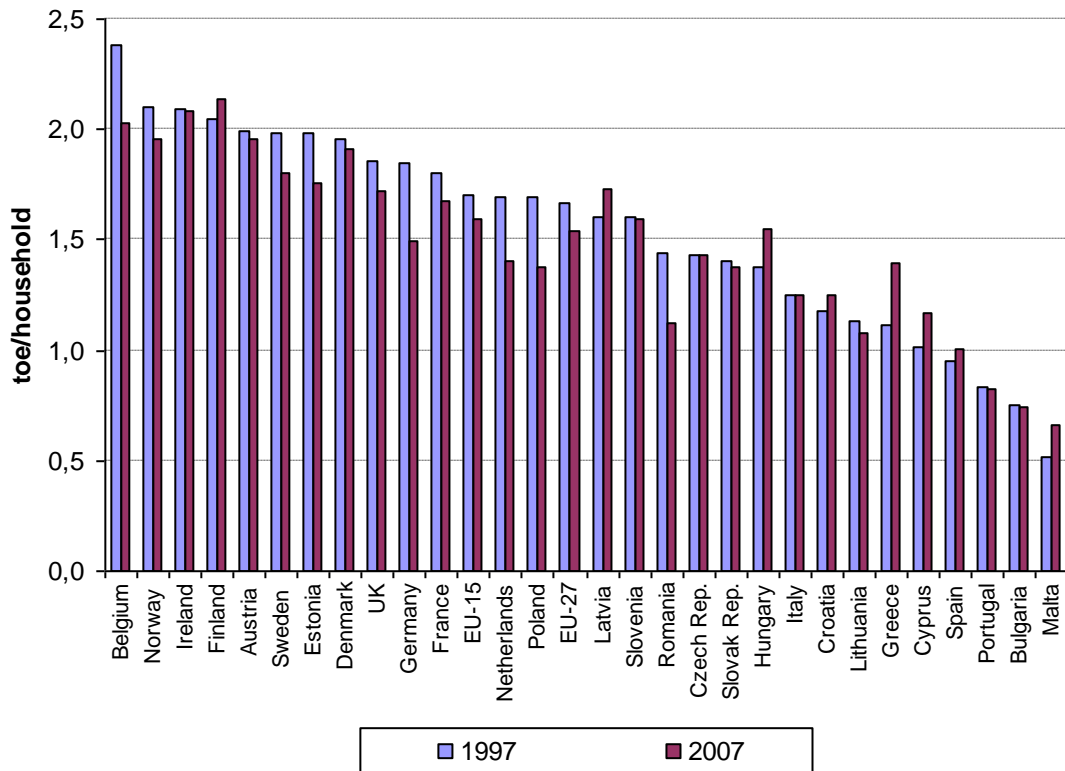
Another driver of increased energy consumption is a higher income⁵ per household, which could lead to larger dwellings, more appliances, etc. The difference in income growth (28%) and number of households (11%) leads to an increase in average household income of 12% over the period (see **Figure 2-5**).

In new member states largest decrease in energy consumption per household

Figure 2-6 shows that the average energy consumption per households in 2007 was at or below the 1997 level in most countries, with Greece, Hungary, Latvia, Finland and Spain as important exceptions. The unit consumption is mostly in the range of 1-2 toe/dwelling, with Belgium and Malta as outliers. Overall, new member states show a much larger decrease than EU-15 countries (10% against 5%) from 1997 tot 2007, especially Poland and Romania (about -20%).

Figure 2-6: Average energy consumption per household (climate corrected)

⁵ Private consumption (household expenditure on goods and services) is used as a proxy for income



Large electricity consumption for some countries is due to use for space heating

Average electricity use per household in EU-27 is about 4000 kWh per year (see

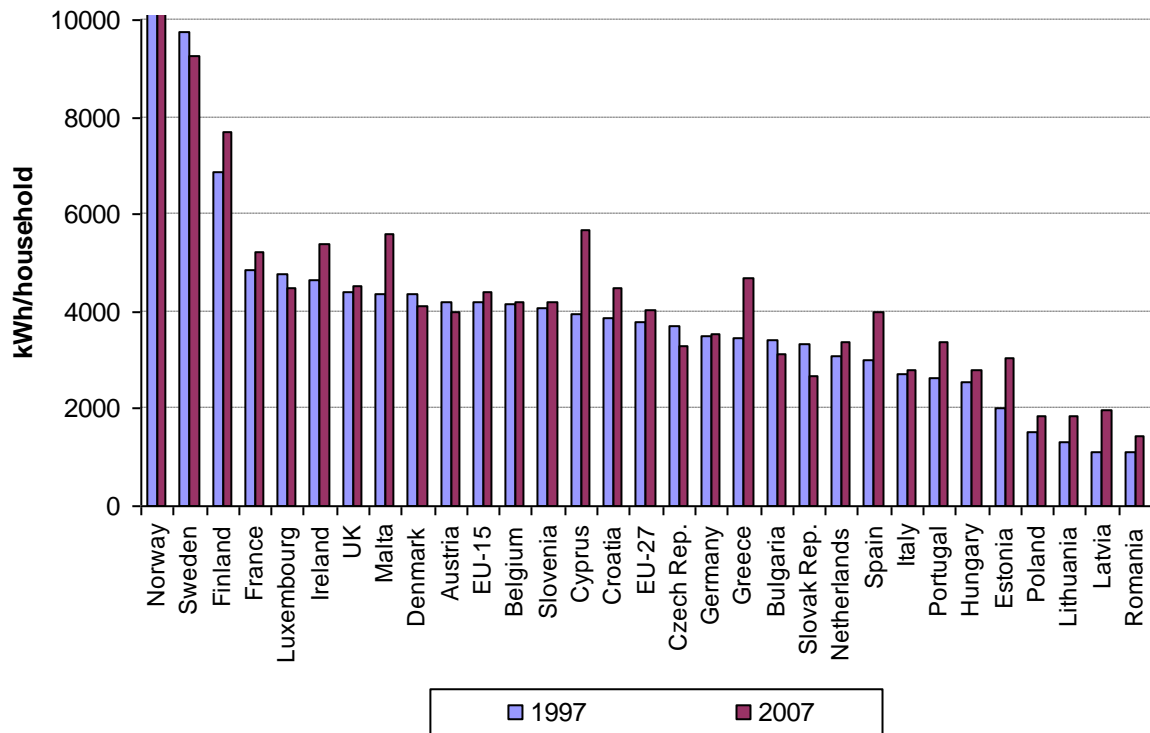
Figure 2-7). However, electricity use is much higher in Norway⁶, Sweden and Finland due to their high use of electricity for space heating.

Growth of electricity use per household is mitigated by smaller households

Between 1997 and 2007 the average EU household uses about 7% more electricity. However, in that period average electricity use per household person increased with 14%. The difference is due to the lower number of persons per household which influences the part of household electricity use that is dependent on the number of persons (appliances and number of lighted rooms used at the same time). With a constant size of households the growth in electricity use per household could have been between 7 and 14%.

Figure 2-7: Average electricity consumption per household

⁶ Norway 17930 kWh in 1997 and 16280 kWh in 2006 (not visible in Figure 2-7)



Electricity use increases most for southern and new “taking up” member states

Electricity consumption per household increased between 1997 and 2007 in most countries. The EU-15 exceptions are Denmark, Austria and Sweden and, for the new member states, Slovakia, Bulgaria and Czech Republic. For Sweden the decrease could be caused by less electricity for space heating. Very high growth rates are shown for EU-15 countries Greece and Spain (+35%) and even higher numbers for the new member states Cyprus, Estonia and Latvia. But in most new member states electricity use remains at a relatively low level (less than 60% of EU average) and does not really catch up with EU-15 countries.

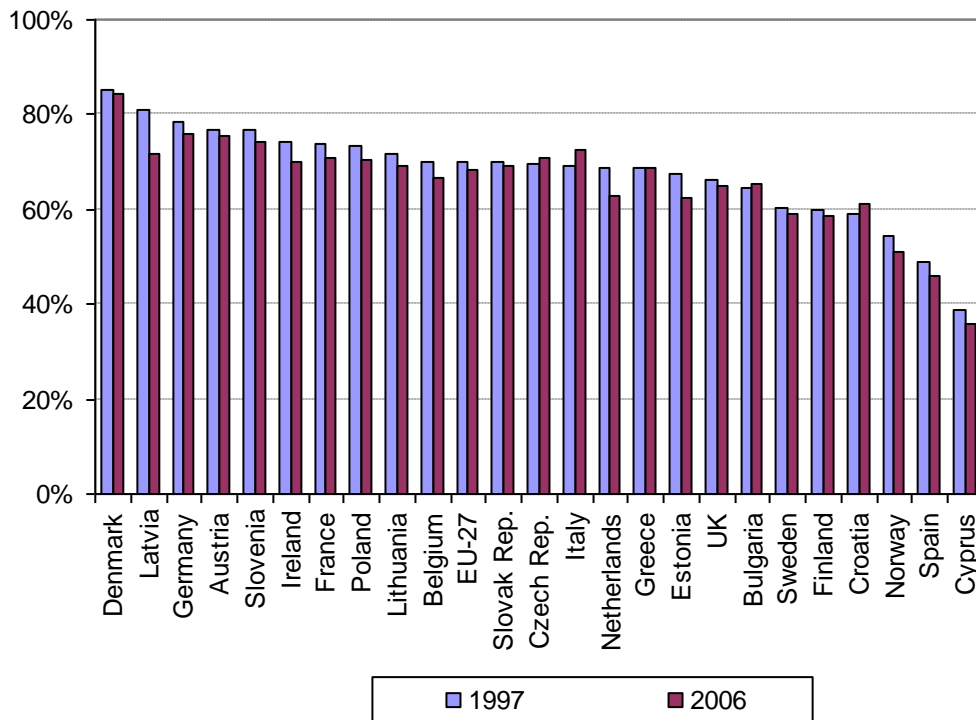
2.4. Energy for space heating

Large part of total energy use for space heating

Energy use for space heating, normally 60-80% of total energy consumption, is the most important part of household energy use (see

Figure 2-8). Lower fractions are generally found for Mediterranean countries with mild winters, like Cyprus and Spain.

Figure 2-8: Space heating fraction in household energy consumption⁷



Space heating less important in total energy consumption

In general the space heating fraction decreases between 1997 and 2006, partly due to the relative strong growth of electricity consumption (the second largest part of household energy use). Exceptions are Italy, Czech Republic, Croatia and Bulgaria where the fraction increases a few %-points (see explanation below).

Highest use for space heating in countries with moderate climate

The highest values for the share of space heating energy use are **not** found in countries with cold winters, like Finland and Sweden, but in countries with moderate winters, such Ireland, Belgium, Denmark and Germany (see

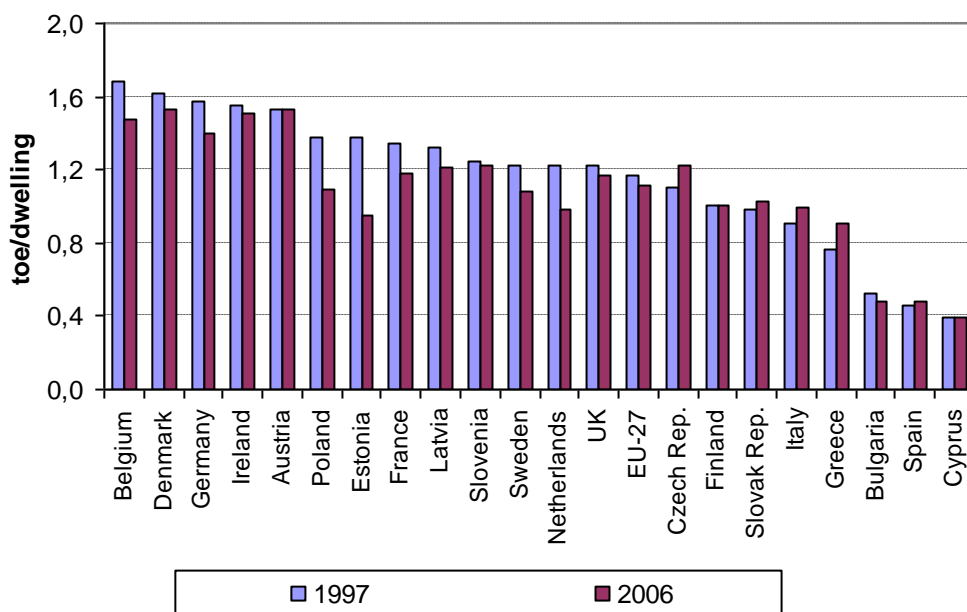
Figure 2-9).

Heated dwellings use less energy, dwellings in mild climate are heated more often

In most countries, energy use per dwelling decreases between 1997 and 2006, except for Greece, Italy and a few new member states. The increase in southern countries is probably caused by more and more dwellings being heated in winter due to increasing comfort demands.

⁷ Climate corrected figures, selected countries

Figure 2-9: Energy use for space heating per dwelling⁸



After adjustments⁹ for climate Estonia, Latvia, Poland and Germany show highest use for space heating

Average energy consumption per dwelling will be dependent on the average size of dwellings and warmer or colder winters. Therefore it is more relevant to compare energy use per m² instead of use per dwelling. Moreover an adjustment should be made for differences in average winter temperature. **Figure 2-10** shows energy consumption per m² floor area taking the EU-27 average winter temperature instead of the country average. The EU average energy use is about 13 koe (150 kWh).

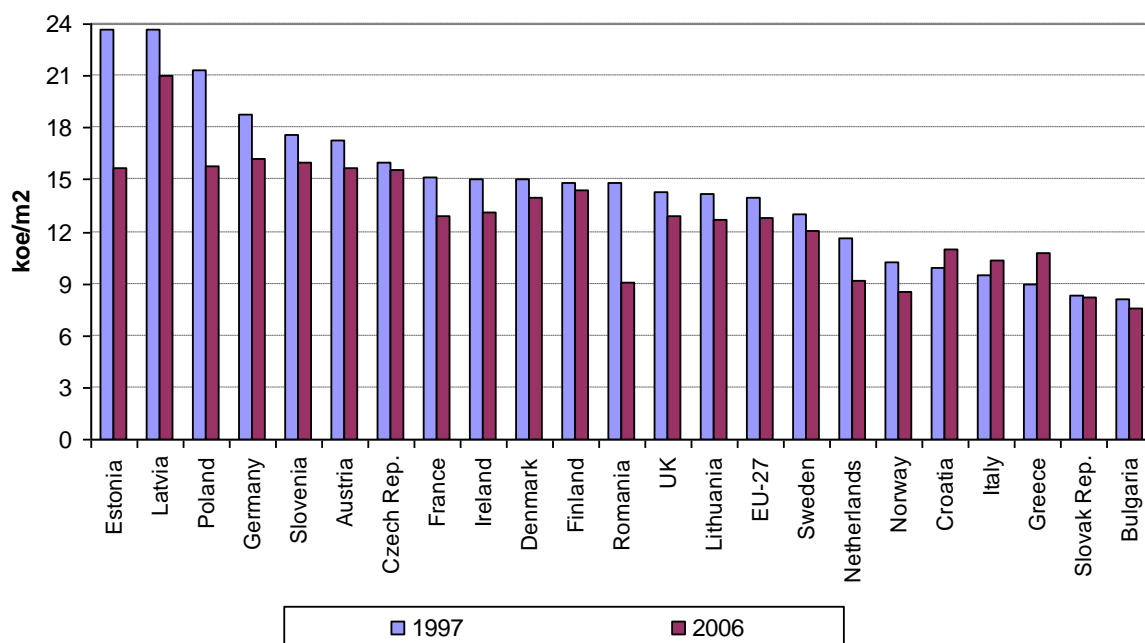
Earlier the highest energy use per dwelling was found for Ireland, Belgium, Denmark and Germany (see **Figure 2-9**). After adjustments Estonia, Latvia and Poland take over the lead while Germany maintains its high ranking.

Figure 2-10: Energy use for space heating per m² floor area adjusted to the EU climate¹⁰

⁸ Climate corrected country figures, selected countries

⁹ Adjustments for differences in floor area and average temperature between countries. Countries with cold winters will often show higher energy use than countries with mild winters. Therefore the (yearly climate corrected) energy use for a country is corrected for the difference between national and EU-27 average climate (see also chapter 5).

¹⁰Total energy use excluding electricity, adjusted to EU mean climate (see footnote 11)



Large improvement for the Netherlands despite already low use for space heating

As to the changes in the period the following can be observed:

- The Netherlands has one of the lowest levels of energy consumption per m^2 . The Netherlands reached a relatively large improvement despite the already low energy use per m^2 in 1997. This could be due to extensive insulation measures in the large social housing sector, the early introduction of high efficiency boilers and the types of dwellings (relatively few detached dwellings).
- Slovakia and Bulgaria show a low level of specific energy consumption for the whole period. This may be the result of high prices that restrict comfort demands (see analysis section).
- Poland realised the strongest decrease in specific energy use in absolute terms; Romania realised the highest relative improvement.

Causes for changes in time and differences between countries

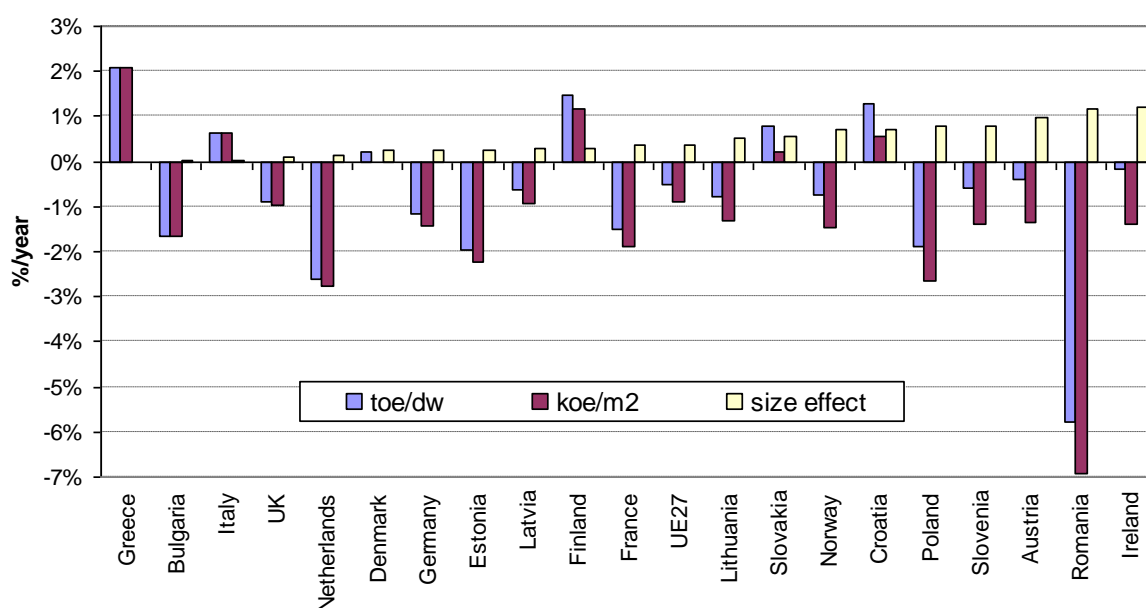
Unit consumption for space heating, corrected for climate, is dependent on the **type** and **size** of existing dwellings, the amount of efficient **new dwellings**, the heated space (**central or local heating**), **fuel substitution**, saving measures (**insulation** and **efficient boilers**) and **behaviour**. The effects of size and new dwellings are shown below. Central versus local heating and fuel substitution are presented in section 2.11. The type of dwelling, i.e. detached house or apartment building, and saving measures have not been analysed due to lacking data.

Up to 40% of efficiency gains in space heating is offset by larger dwellings

In

Figure 2-11 the change in energy use per dwelling for space heating (1997-2007) has been decomposed into a change in floor area and a change in specific energy use per m^2 . The average dwelling size increased, especially in Eastern European countries (about 10%). As a result, energy consumption per dwelling decreased less (0.5%/year) than consumption per m^2 (0.9%/year) in the EU-27. This means that 40% of the energy efficiency progress for thermal uses has been offset, all things being equal, by the fact that dwellings are becoming larger. For new member states the size effect in %/year is much larger, but compared with the large decrease in energy use per m^2 the offsetting is relatively smaller.

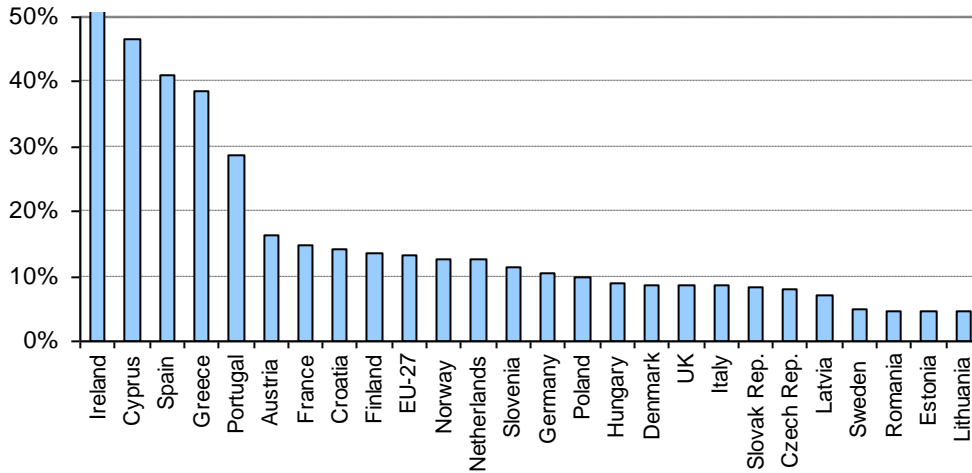
Figure 2-11: Heating energy use: per dwelling, per m^2 and size effect (1997-2007)



Limited number of new dwellings restricts energy savings for space heating

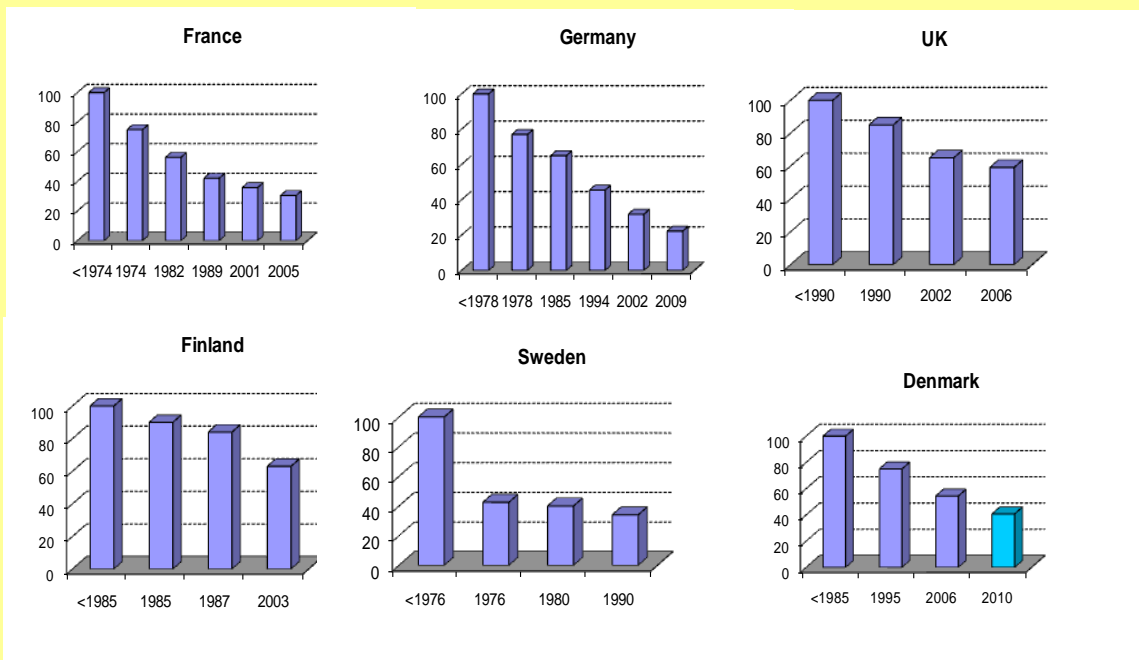
Due to more strict standards new dwellings have much lower energy consumption for space heating than the average existing dwelling (see **Box 2-2**). However, the effect of standards on total savings for space heating is restricted by the often limited amount of new dwellings built. Erreur ! Source du renvoi introuvable. shows the amount of new dwellings as percentage of the total stock. At a yearly basis most EU countries extend their dwelling stock with less than 1%. The main exceptions are Ireland, Greece, Spain and Portugal. Eastern European countries have built very few new dwellings.

Figure 2-12: Growth of dwelling stock between 1997 and 2007



Box 2-2: Strengthening of standards for new dwellings

In past years the standards have been strengthened step by step resulting in a continuous decrease in energy use (see examples below, energy consumption without standard = 100). The first standards regarded the insulation of walls, roof and ground floor, double glazing and boilers separately. Presently energy performance standards are applied that prescribe maximum total energy use. The saving measures to be applied are left to the builder of the dwelling. The Energy Performance of Buildings directive (EPBD) will stimulate further strengthening of standards (see also Box 2.5)

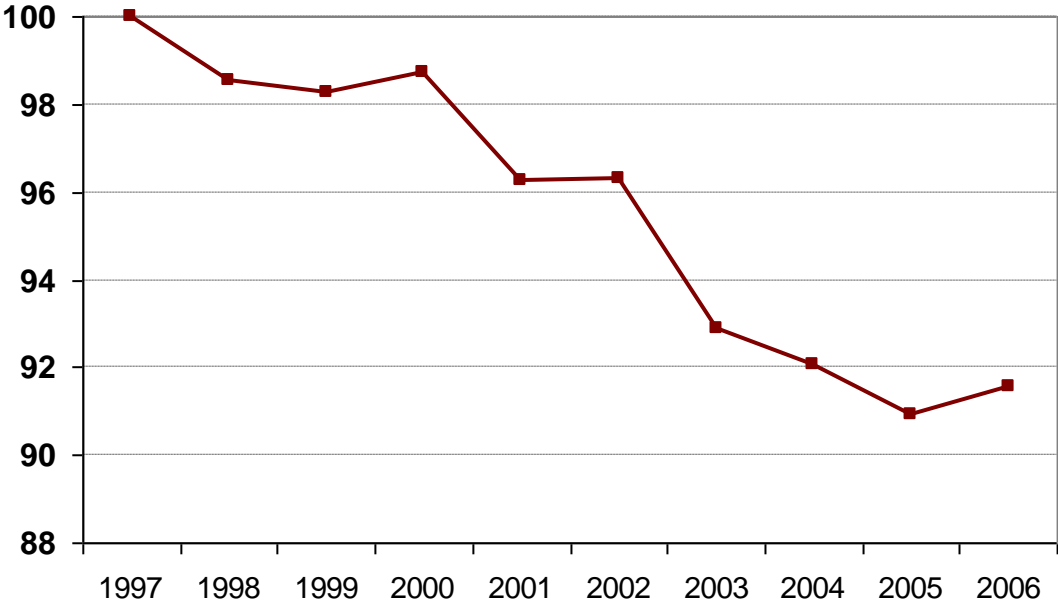


Efficiency trend for space heating stagnates at European level

The efficiency trend for space heating is calculated on basis of the decrease in (climate corrected) energy use per m² floor space¹¹. In the period 1997-2006 the decrease for EU-27 was almost 9% (see

Figure 2-13) but limited improvement is visible in recent years.

Figure 2-13: Energy efficiency trend for space heating in dwellings (EU-27)

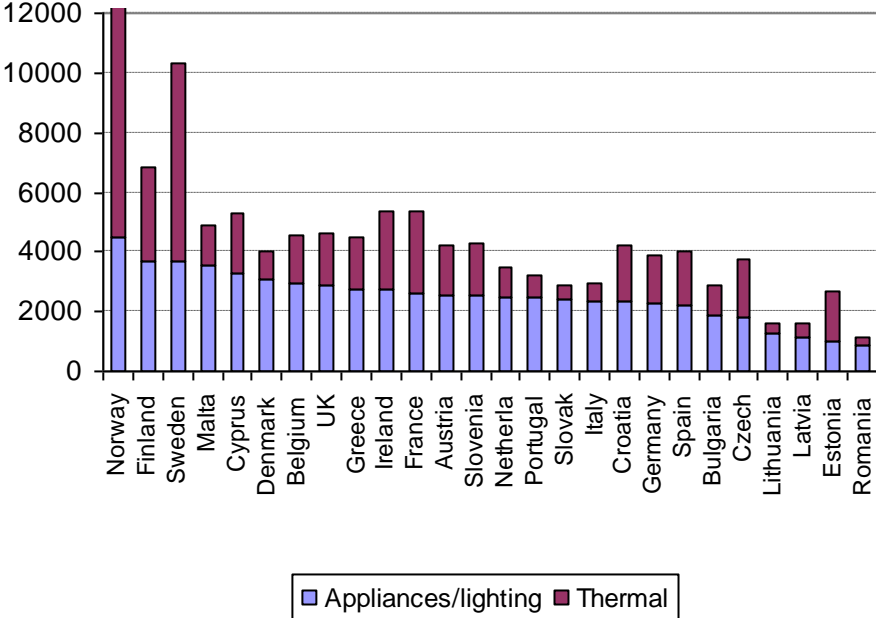


2.5. Electricity for appliances

¹¹ Corrected for more central heating, the energy efficiency improvement due to substitution between energy carriers is included

For most EU countries the largest part of electricity consumption per households is for appliances and lighting. But thermal uses are very large for Norway¹² and Sweden, and substantial for Finland, France and Ireland (see **Figure 2-14**).

Figure 2-14: Electricity use per household with/without thermal uses (2004)

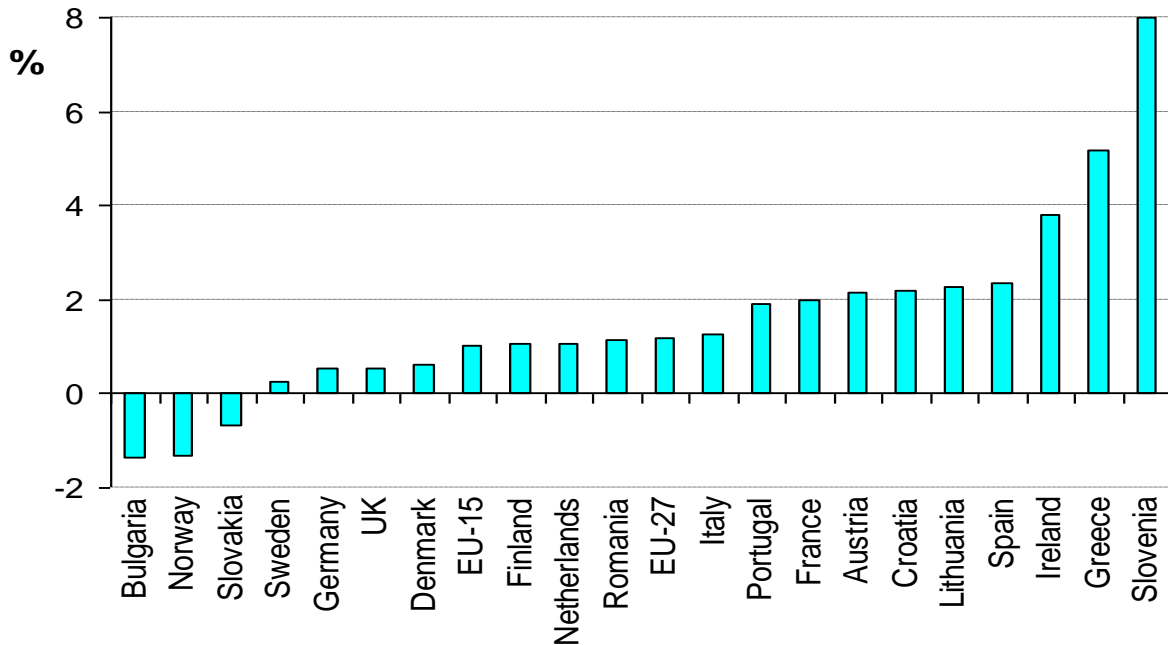


Appliance electricity use increases, but high growth only due to specific factors

Figure 2-15 shows that during the period 1997-2006 electricity consumption for appliances & lighting increased in all countries, except for Bulgaria and Slovakia (relative low consumption level of about 2500 kWh) as well as Norway (higher consumption level of about 4500 kWh). The progression has been rather moderate in Sweden, Germany, UK and Denmark which are countries with an already high electricity use. It is substantial for Ireland, with the highest economic growth, and in all southern countries where the use of air-conditioning systems has grown.

¹² Total for Norway is 16000 kWh (not shown)

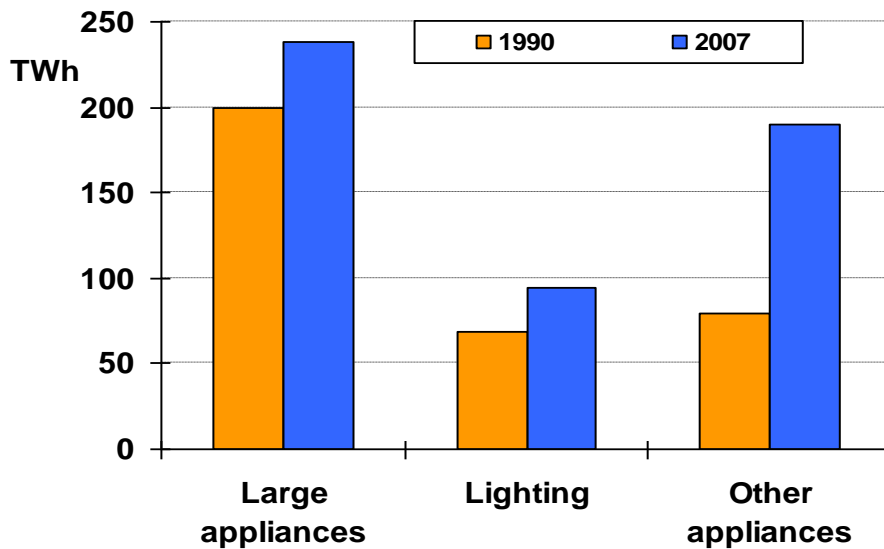
Figure 2-15: Yearly growth in electricity use per household for appliances & lighting (1997-2006)



Growth of electricity consumption concentrated at small appliances

The breakdown of appliances consumption (see **Figure 2-16**) shows that the strongest growth is recorded for the category small appliances. These appliances registered an increase of its market share from 23% in 1990 to 36% in 2007. The consumption by large appliances records a growth at moderate rate and its market share declines from 58% to 46%. With a market share of approximately of 20%, the category lighting is stable.

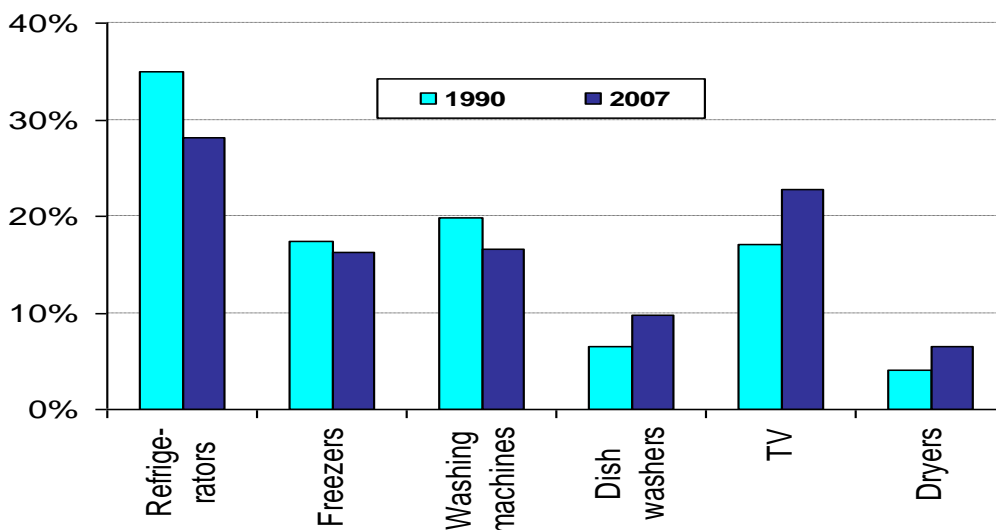
Figure 2-16: Change in total electricity use for large/small appliances and lighting



Clothes dryers and dishwashers drive electricity consumption upwards

Figure 2-17 shows the development of electricity consumption by appliances being heavy users in terms of their fraction in the total for all appliances. Televisions, dryers and dish washers increased their share during the years 1990-2007. For dryers and dishwashers this was due to higher penetration rates. Refrigerators and washing machines registered a decline, mainly due to substantial electricity savings.

Figure 2-17: Shares of large appliances in total appliance electricity use

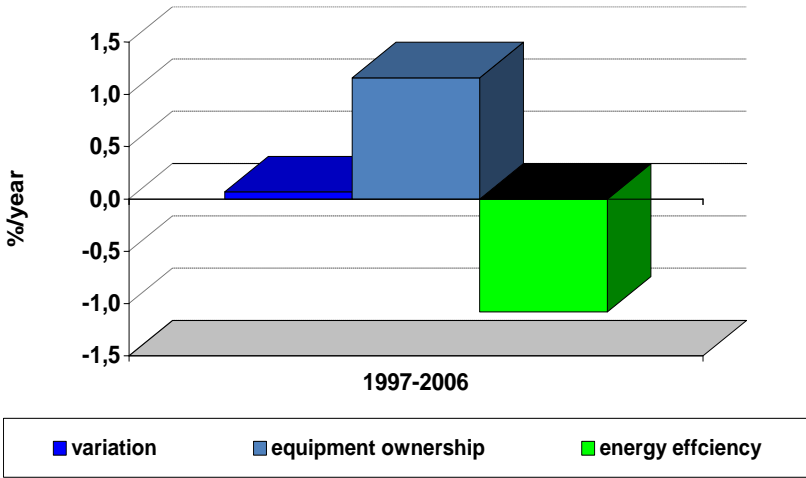


Efficiency increase appliances has been offset by increased ownership

The decomposition of the observed change in electricity use by large appliances in **Figure 2-18** shows that almost all energy efficiency gains over the last years have been

offset by an increase in equipment ownership. As a result, electricity consumption per household for large appliances is only slightly lower in 2006 than in 1997.

Figure 2-18: Decomposition of change in electricity use of large appliances



2.6. Savings by renewable energy technologies

Energy consumption can be lowered by saving measures that reduce energy demand (e.g. double glazing), convert fuels more efficiently (e.g. high efficiency boilers) or use electricity more efficient (e.g. label A washing machines).

The deployment of renewable energy sources in dwellings can also lower (fossil) energy consumption. Therefore the output of these “renewables-behind-the-meter” technologies is counted as energy savings. Examples are photovoltaic cells (PV) that produce electricity, solar collectors that produce heat and heat pumps that transform ambient heat into useful heat with help of electricity.

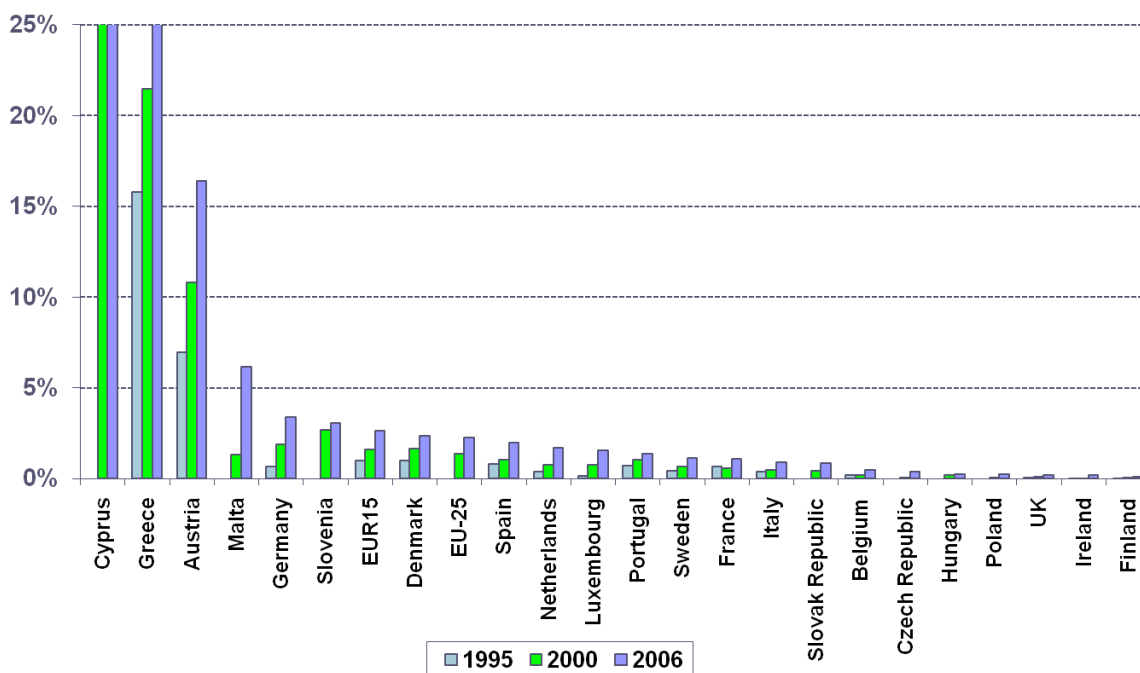
Penetration of solar water heaters more dependent on policy than on sunshine

Solar water heaters are mainly used for the supply of hot water, in combination with a system using fossil fuels or electricity.

The amount of dwellings with solar water heaters in European countries generally is only a few percent (see **Figure 2-19**). Some countries with a sunny climate, such as Cyprus and Greece, score much higher. But comparable countries like Italy and Spain show below average figures. On the other hand, Austria performs much above average, probably due to successful stimulation programs.

Between 1995 and 2006 the relative amount of solar water heaters has more than doubled in most countries; at EU level there was an increase of 50% between 2000 and 2006.

Figure 2-19: Development of the fraction of dwellings with a solar water heater



2.7. Overall energy efficiency and CO₂ emission reduction

The overall efficiency improvement is given by the so-called ODEX¹³ which is calculated from the efficiency increase for the set of indicators for households.

Household energy efficiency for EU-27 has improved by 8-10% since 1997

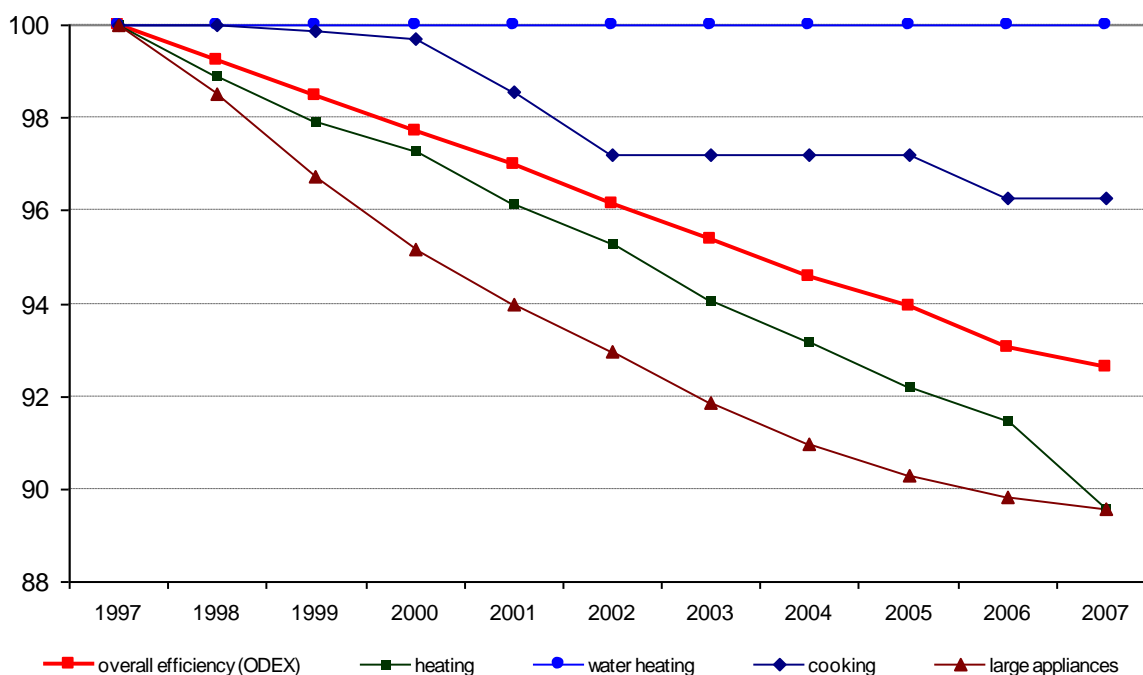
The ODEX overall efficiency trend¹⁴ for European households shows an improvement of almost 8% for the period 1997-2007 (see **Figure 2-20**), or about 0.8% per year. The efficiency improvement for both heating and large appliances reaches more than 10%. But for cooking the figure is much lower and for hot water no savings have been observed. Therefore overall efficiency lags behind that for heating/appliances.

The energy savings are largely due to the deployment of technologies that reduce energy demand (e.g. double glazing), convert fuels more efficiently (e.g. high efficiency boilers) or use less electricity more efficiently (e.g. label A washing machines). There are other technologies available that are important for future energy savings but have not contributed up to now substantially to total savings (see **Box 2-3**).

Figure 2-20: Overall efficiency index ODEX of households for EU-27

¹³ The set of indicators for the end-use sectors has been converted into one aggregated index called ODEX that represents total efficiency improvement (see also chapter 5).

¹⁴ The yearly figures for ODEX have been converted into three-year moving average values (see chapter 5).



Box 2-3: Overview of household saving technologies

The most common saving measures area;

- Insulation of walls, roof and attic floor
- Double glazing
- High efficiency boilers
- Efficient appliances (refrigerators, washing machines, dish washers)
- Efficient lighting (CFLs)

Advanced saving measures :

- Forced ventilation with heat recuperation
- Heat pumps, using ground(water) heat
- Hotfill washing machines
- Micro cogeneration

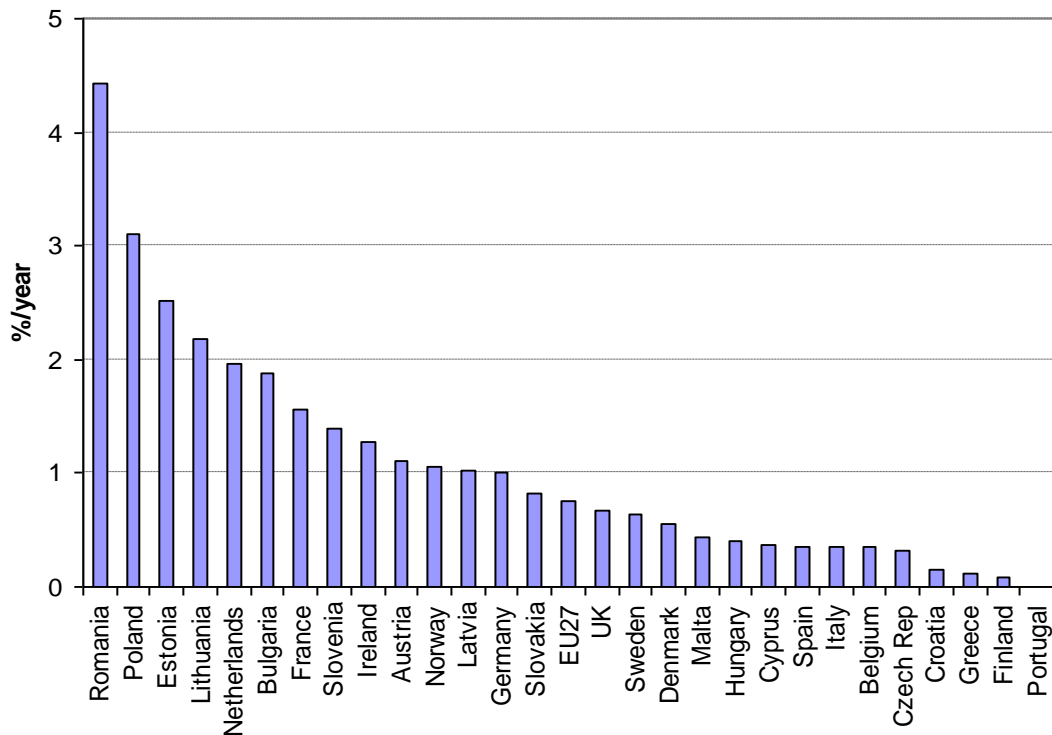
Renewable options:

- Solar water heater
- Solar PV cells

New member states show very high overall efficiency improvement

The four EU countries with by far the highest efficiency improvement are the new Member States Romania, Poland, Estonia and Lithuania (see **Figure 2-21**). Most other new Member States also do better than the EU-27 average improvement of 0.8%/year.

Figure 2-21: Yearly energy efficiency improvement by country (1997-2007)



Most EU-15 countries realise less savings than according to EU targets¹⁵

The historical improvement of energy efficiency for EU-27 is lower than the 1%/year, requested in the Energy Service directive by the European Commission (see section on EU policy). Especially some EU-15 countries show a much lower efficiency improvement than they should attain in the period 2008-2016.

Energy savings and fuel switching reduced direct CO₂ emissions in the EU-27

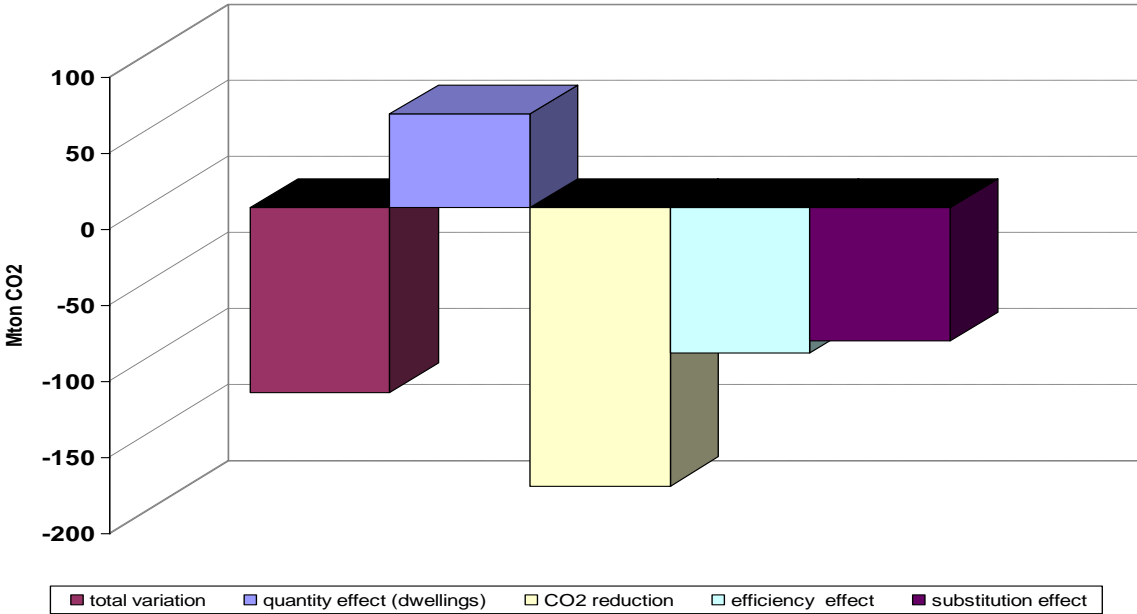
Direct CO₂ emissions regard the emissions at the dwellings, thus without the emissions elsewhere for district heat or electricity. In the period 1996-2007 emissions of EU-27 households decreased from 534 to 413 Mton, or 8% (see “variation” of 121 Mton¹⁶ in **Figure 2-22**). This result was achieved despite an increase in the stock of dwellings and the increased number of appliances owned. These two developments would have implied, all other things being equal, an emission increase of about 60 Mton. The lower level of emissions was made possible by efficiency improvements and substitution between energy carriers, which each provided half of the CO₂ reduction of about 180 Mton. This large contribution of substitution is due to switches to fuels with

¹⁵ For some countries no index could be calculated; the average savings have been set at 0%. The low values for efficiency improvement can be due to data limitations as it is often not possible to fully correct for the effect of a change in comfort level with regard to space heating or use of appliances. For instance, in the UK it has been observed that low income households raise their thermostat setting after saving measures have been taken and the energy bill has decreased. This may lead to an underestimation of the actual energy efficiency progress

¹⁶ All the figures given here are not corrected for climate variations.

a lower CO₂ content (e.g. gas, heat and biomass) or to electricity, the emissions of which are not included in the household sector.

Figure 2-22: Decomposition of 1996-2007 variation in CO₂ emissions for EU 27

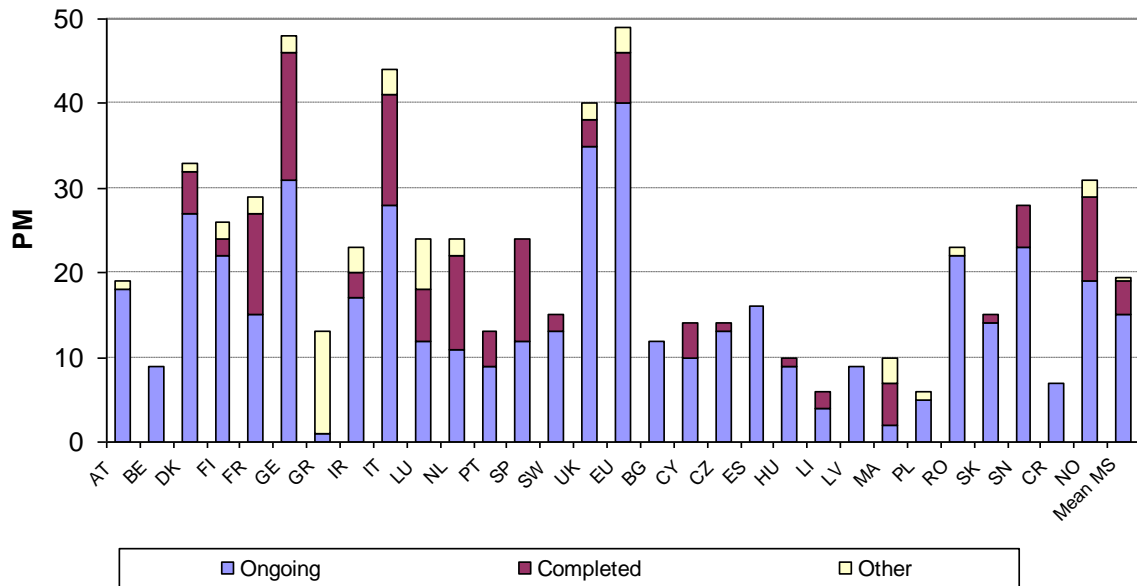


2.8. Policy measure developments

Germany and UK have largest number of policy measures

Figure 2-23 shows that Germany, Italy and the UK have the largest total number of policy measures in the household sector; the high number for the EU is partly due to counting all labels for appliances as separate policy measures. For some countries a considerable fraction of policy measures is completed, e.g. the Netherlands, France and Spain. However, these measures should not be disregarded as they still can have influence on present energy savings. Half of countries have other measures, mainly planned measures.

Figure 2-23: Number of policy measures and status for households (2006)



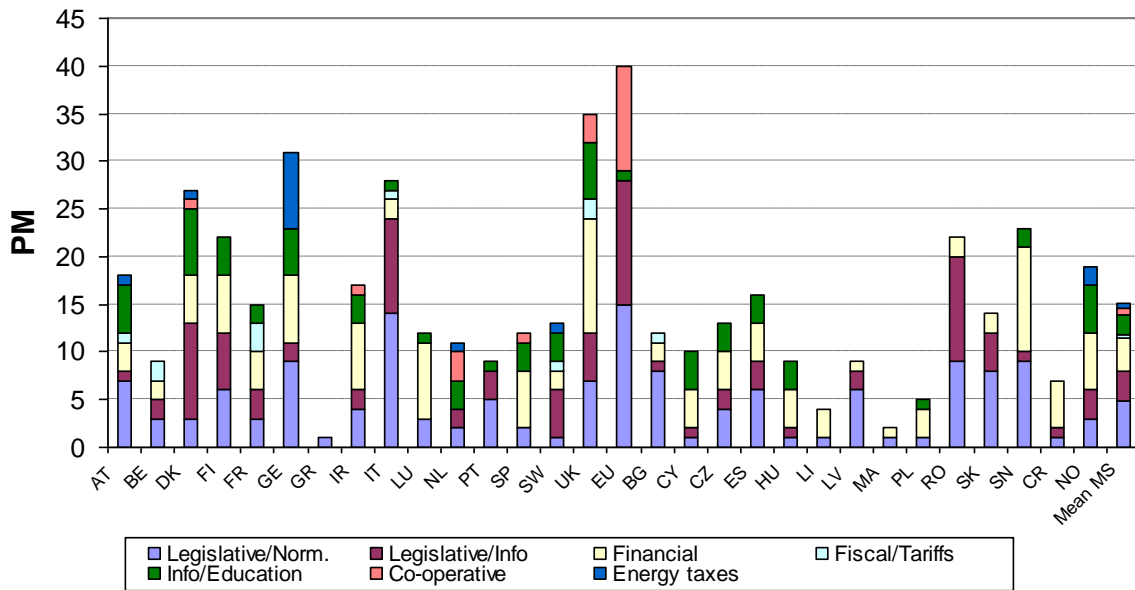
In the MURE database policy measure are classified into the following types:

- legislative/normative (e.g. standards)
- legislative/informative (e.g. mandatory labels)
- financial (e.g. subsidies)
- fiscal (tax deductions)
- information/education
- co-operative (e.g. voluntary agreements)
- taxes (on energy or CO₂ emissions).

Most countries deploy standards and subsidies, but few deploy taxes

The overview of policy measure types in **Figure 2-24** shows very diverse combinations per country and the EU itself (see **Box 2-4** on extreme policy measure choices). However, some general observations can be made. Legislative and financial measures are very common, while co-operative and tax measures are sparsely applied.

Figure 2-24: Policy measures per type for households (ongoing, 2006)



Box 2-4: Extreme policy measure choices per country for households

Greece has almost no policy measures and only on standards

Italy is almost entirely focusing on legislative policy measures (white certificates,,)

Lithuania has only standards on buildings and financial support

Portugal does not provide any financial support, no subsidies nor fiscal rebates

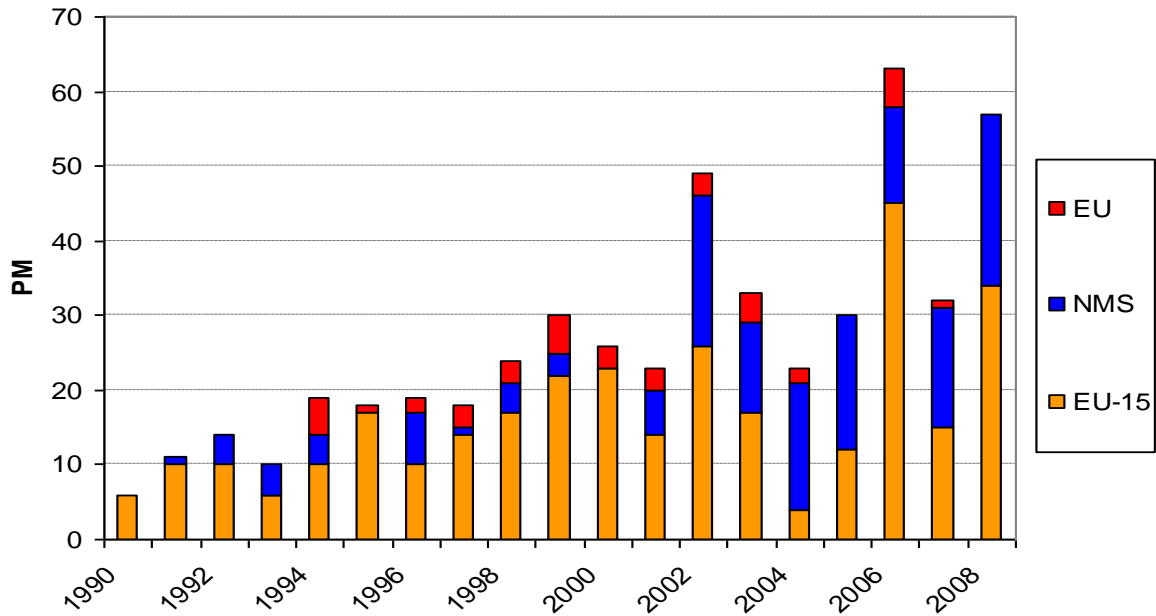
Germany, Spain and Cyprus have relatively few measures on space heating (< 30%)

Belgium, Greece, Bulgaria, Latvia, Romania and Slovakia do not deploy any policy measure on information specifically focused on households

Continuous introduction of new measures, except for 2004

In past years policy measures have been introduced at a varying rate in the EU-27 (see **Figure 2-25**). The EU itself has started with policy measures from 1995 on. For new member states the introduction has increased as they became part of the EU. The “dip” around 2004 is mainly caused by the low introduction levels in EU-15 countries in 2004 and 2005. The large number of new policy measures in 2006 is due to the transposition of EPBD (see Box 2-5).

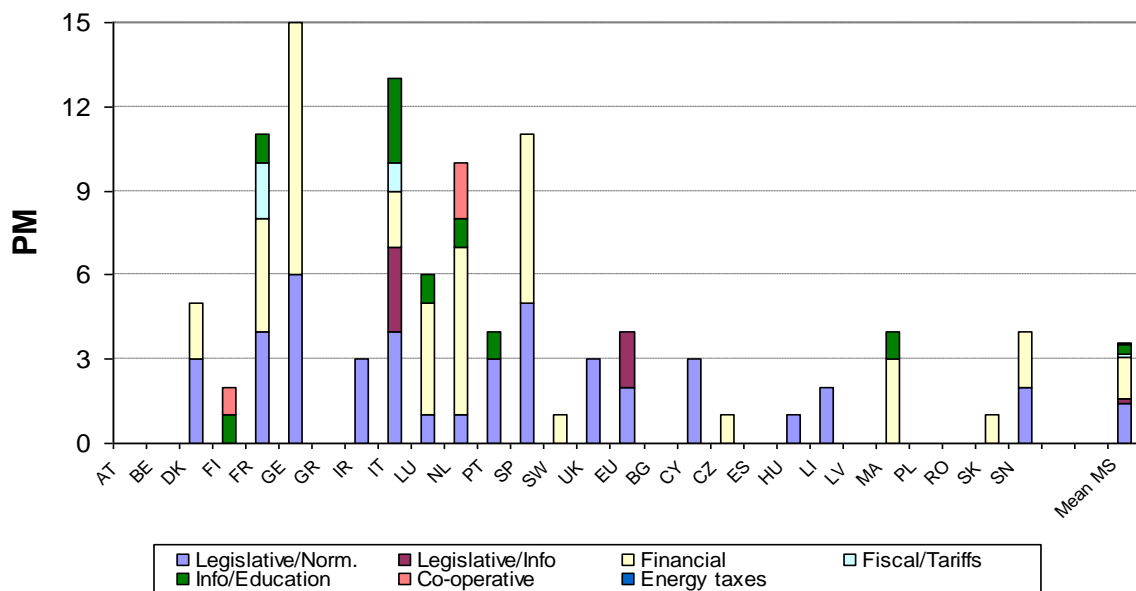
Figure 2-25: Yearly introduced new policy measures for households



Financial measures often have a short life time

From all policy measures ever introduced presently about 20% have been scrapped. Especially financial measures, such as subsidies, do not have a long lifetime (see **Figure 2-26**). The opposite is true for standards (legislative/normative) as completed measures are replaced by stricter standards.

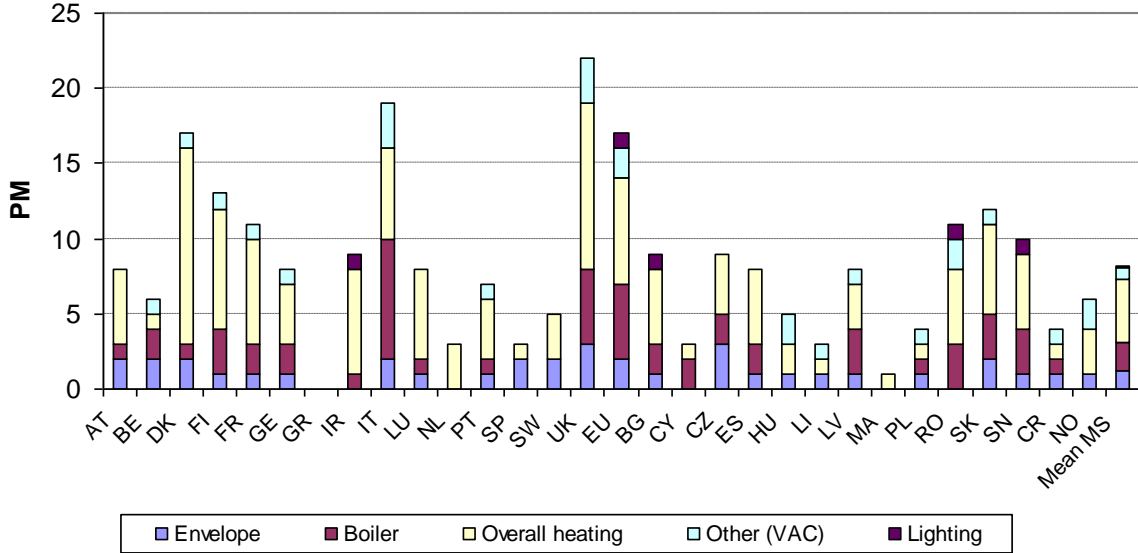
Figure 2-26: Completed policy measures per type for households (1990-2006)



Performance standards on dwelling as a whole are applied the most

Household policy measures targeted at dwelling related uses can regard the envelope, boilers, overall heating, ventilation/air-conditioning and lighting (see **Figure 2-27**). In the past policy measures on heating were targeted at the envelope (prescribed thickness of insulation) or boiler efficiency separately. Presently these are both the target of performance standards (see overall heating in the **Figure 2-27**). Very few policy measures were focused on lighting in households, only recently a ban on incandescent lamps was introduced. There is also a lack of policy on fuels for cooking.

Figure 2-27: Policy measures targeted at dwelling related uses (2006)



Some countries still lack policy measures that are demanded by the EU

All countries have ongoing policy measures focused at new dwellings, as demanded by the Energy Performance on Buildings directive of the EU. Portugal and Malta do not have policy measures focused at existing dwellings. However, they have policy measures focused at both new and existing dwellings. Greece only very recently implemented policy measures on appliances. Lithuania and Poland do not have policy measures yet on appliances in their National Energy Efficiency Action Plans (NEEAP)¹⁷, although the EU directive on labels should be transposed into national policy measures.

Few or no policy measures to influence daily energy use

Most policy measures focus on buying more efficient appliances or investing in energy savings. However, there is also a need to influence daily energy use, e.g. by monthly information on energy consumption or by energy taxes. Yet, some countries do not have any such policy measures (Belgium, Lithuania, Malta, Poland and Croatia). Recently the obligation in the Energy Service directive to inform customers about their

¹⁷ As of 2007 NEEAPs have been requested by the EC as part of the Energy Service directive.

electricity or gas consumption has led to some national policy measures on the introduction of smart meters.

2.9. EU based policy measures

For the households sector the most important EU policy constitutes:

- Directive on mandatory labels for appliances
- Energy Performance of Buildings directive (EPBD)
- Energy Services directive (ESD)
- Ecodesign directive.

The introduction of obligatory labels on appliances has stimulated the market for more efficient appliances and thus decreased electricity use for refrigerators, washing machines, cloth dryers, etc.

The EPBD demands certificates for dwellings to be sold or rented which should lead to retrofit measures (see **Box 2-5**). The ESD expects that countries will realise 9% energy savings in the period 2008-2016 and facilitates this in different ways. Although the ESD does not introduce specific policy measures it will probably have much influence on the introduction of (new) policy measures by countries.

Box 2-5: Energy Performance of Buildings directive (EPBD)

This directive from 2002 formulates three main obligations for countries.

Timely renewed standards for new dwellings

Countries should renew their standards every few year in line with possibilities for cost-effective measures. However, the EU has not defined a common maximum energy use because of differences for climate and building practices. Therefore, the effort put into energy saving new dwellings can differ.

Certificates on existing dwellings

When houses are sold or rented they should have a certificate that describes the energetic quality of the dwelling. It is expected that new owners or renters will take measures to make the dwelling more energy efficient. However, the certification does not always provide possible measures and few countries make them mandatory.

Maintenance of boilers

Boilers should be regularly inspected and maintained in order to prevent a deterioration of the conversion efficiency.

Presently the discussion about the recast of the directive focuses on the use of standards when renovating small buildings or dwelling complexes.

The Ecodesign directive takes a further step by introducing minimum efficiency standards for a larger array of energy using appliances and systems compared to the labelling directive (see **Box 2-6**).

Box 2-6: Ecodesign directive on energy using products

The Ecodesign directive does not introduce directly binding requirements for specific products, but establishes a framework of condition and criteria that need to be respected when introducing implementing measures. The binding requirements for each product group regard also maximum energy use.

Since 2007 the Commission has established a working plan in order to set out priorities with respect to implementation measures for product groups.

Implementing measures are finalized for lighting (incandescent bulb), televisions and standby losses. In progress are implementing measures for boilers, water heaters, washing machines, dishwashers, refrigerators and freezers, commercial refrigerators, electric motors, computers, imaging equipment, electric pumps, fans for ventilation, room airconditioners, complex set-top boxes, laundry driers and vacuum cleaners.

An indicative list of new product groups regards:

- Air-conditioning and ventilation systems;
- Electric and fossil fuelled heating equipment;
- Food preparing equipment;
- Industrial and laboratory furnaces and ovens;
- Machine tools;
- Network, data processing and data storing equipment;
- Refrigerating and freezing equipment;
- Sound and imaging equipment;
- Transformers;
- Water using equipment

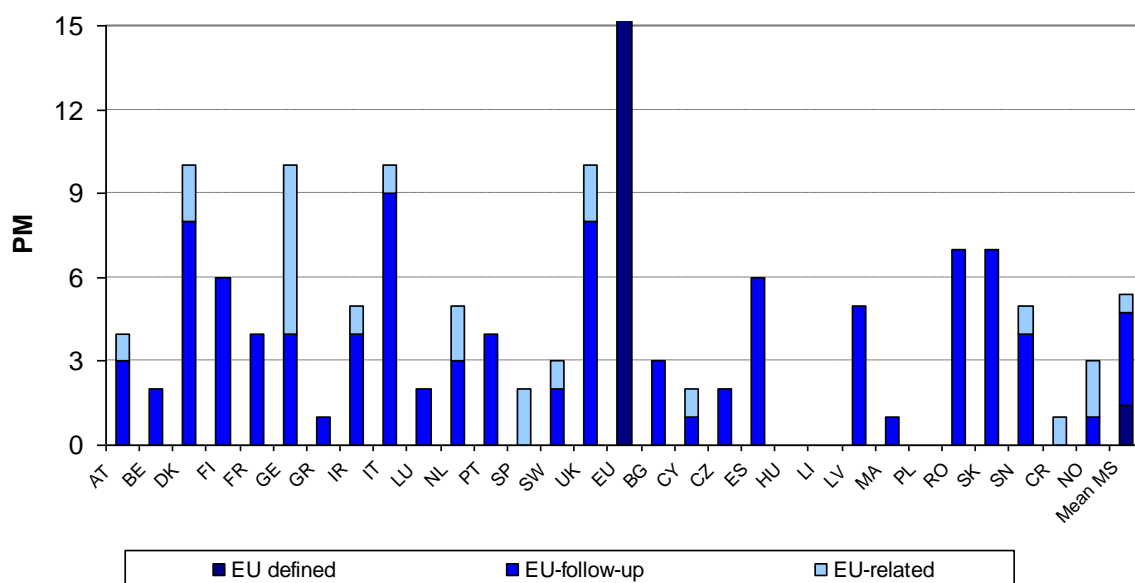
Substantial part of national policy measures due to EU policy

EU policy has influence on national energy efficiency in three ways:

- directly by EU policy measures, e.g. covenants with European appliance manufacturers (EU-defined),
- transposition of EU directives into national policy, e.g. labels for appliances (EU-follow-up)
- national measures stimulated by EU policy, e.g. municipal action plans or regional information centres (EU-related).

From **Figure 2-28** it appears that on average 5 policy measures per country are the result of EU policy. The large number (40) of EU-defined policy measures is partly due to the separate label measures for each appliance.

Figure 2-28: EU policy influencing national policy measures for households



EU policy on appliance labeling fully transposed in national legislation

Directive 92/75/EEC on household appliances aimed to harmonise national measures on labeling and providing information regarding energy consumption, in order to allow consumers to choose the most energy efficient appliances. Implementing Directives regulate the labeling specifications for each product type. From 1992 on it regards the following appliances:

- refrigerators, freezers and their combinations
- washing machines, dryers and their combinations
- dishwashers
- ovens
- water heaters and hot water storage appliances
- lighting sources
- air-conditioning appliances.

In addition, there are the two Directives establishing minimum efficiency requirements for ballasts for fluorescent lighting and for household electric refrigerators, freezers and combinations. Through an amendment these Directives have become the first implementing measures of the recently adopted Ecodesign directive.

As shown in **Table 2-1** all 27 member states have transposed either partially or completely the EU directives related to labelling and minimum energy efficiency requirements into their national legislations. The table does not show the transposition of the amendments to directives afterwards.

The first set of adopted implementing measures regarded large appliances (i.e. refrigerators, freezers and their combination, washing machines, electric tumble

driers), during the timeframe 1995-1997 and transposed in EU-15 member states in the years 1996-1997. During the 2001-2004 timeframe most of the new members states have transposed the ‘package of European Labels Directives’ which by then included as well the Directives regarding dishwashers, air-conditioners and electric ovens, adopted at European level between 1999 and 2002. These last directives have been implemented by the EU-15 member states during the same time spam (2001-2004).

Table 2-1: Implemented EU Directives by countries, per appliance and period

	1994- 1996		1997- 2000		2001-2004		2005-2008	
	Number of countries	Countries	Number of countries	Countries	Number of countries	Countries	Number of countries	Countries
Refrigerators, Freezers and their Combinations (94/2/EC)	11	AT, DK,FR,NL,RO,SP, SE, BE, EL,PT, UK	2	IT, DE	8	CY, CZ,EE, HU,LV,MT,SK,SI	2	BG, PL
Washing Machines (95/12/EC)	1	FR	11	AU, BE, DK, DE, EL,IT, NL, PT, SP, UK, CZ	8	CY,EE, HU, MT, RO, SK, SI, LV	2	BG, PO
Electric Tumble Driers (95/13/EC)	9	AU, DK,FR, DE, EL, NL, PT, SP, SE	2	BE, IT	10	CY,CZ,EE,HU,LV, MA,PL,RO,SK,SI,	1	BG
Washer Driers (96/60/EC)	3	AU,FR, NL	9	BE,DK,DE,EL,IT, PT,SP,SE,UK	11	CY, CZ, EE, HU, LV, LT, MT, PO, RO, SK, SI	1	BG
Dishwashers (97/17/EC)	1	FR	8	AU, BE, FI, DE, IT, NL, PT, SP	10	CY, CZ, EE, HU, LV, MT, PL, RO, SK, SI	1	BG
Air-conditioners (2002/31/EC)					22	AU, BE, CY, CZ; DK, EE, FI, DE, EL; HU, IT, LV, LU, MT, NL, PT, RO, SK, SI, SP, SE, UK	2	BG, PL
Energy Labelling of Household Electric Ovens (2002/40/EC)					22	AU, BE, CY, CZ; DK, EE, DE, EL; HU, IT, LV, LU, MT, NL,PL, PT, RO, SK, SI, SP, SE, UK	1	BG
Minimum standards for Refrigerators, Freezers (Directive 96/57)			15	AU, BG, CZ, DK, FI, FR, AL, IE, LT, NL, PT, RO, SP, SE, UK,	7	CY, EE, HU, MA, PT, SK, SL		
Energy Labelling of Household Lamps (98/11/EC)			6	AU, BE, FR, DE, SP, UK	11	CY, CZ; EE, HU, LV, NL, PL, PT, RO, SK, SL	1	BG
Energy efficiency requirements for ballasts for fluorescent lighting (00/55/EC)					20	AU, BE, CY, CZ, EE, FR, DE, EL, HU, IE, IT, LT, MT, NL, PT, RO, SK, SL, SP, SE	2	BG, PL
	Number of countries	Countries	Number of countries	Countries	Number of countries	Countries	Number of countries	Countries
	1994- 1996		1997- 2000		2001-2004		2005-2008	

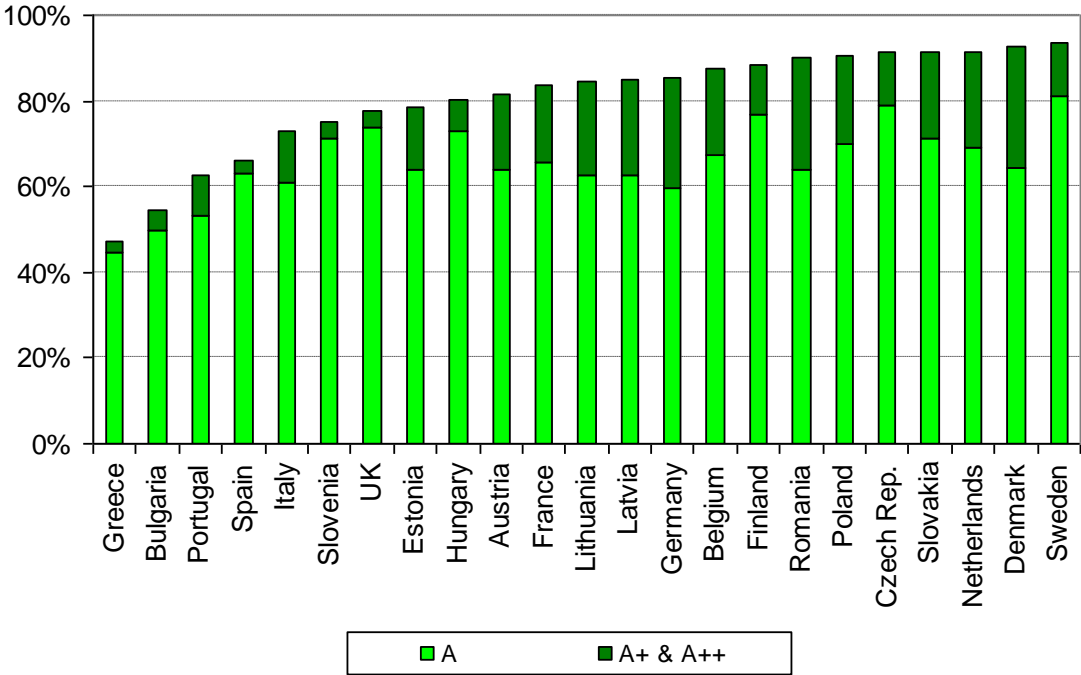
Overall it can be concluded that the deadlines for transposition of the Labels Directive have been respected by most of the EU member states and that full implementation of

the Directives in the 27 member states took place mainly during in the period of 2001-2004.

Southern countries slowest on buying efficient appliances

For refrigerators **Figure 2-29** shows the penetration of the labels categories A and A+ plus A++ in 2006. The average penetration rate for all labeling categories together is 81% and the share for the most efficient A+ and A++ appliances is 15%. Remarkably the shares for new member states are slightly higher than for EU-27. Especially for southern countries there is still potential for more sales of efficient appliances.

Figure 2-29: Penetration of labels A and A+/A++ for refrigerators (2006)

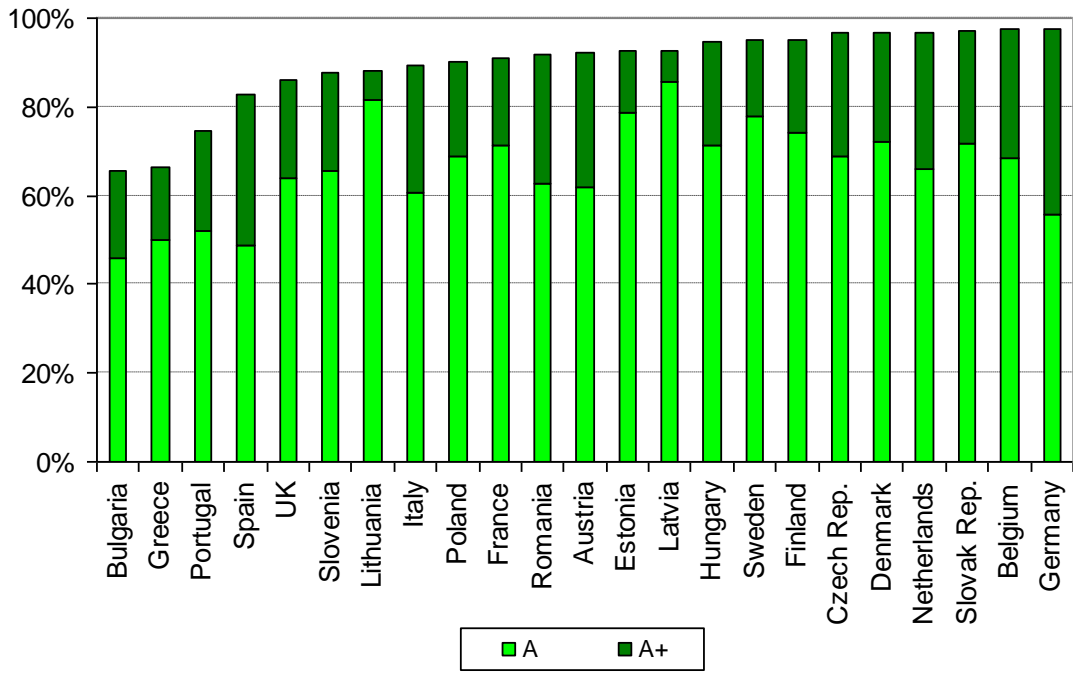


For washing machines only room for the most efficient versions

For washing machines the penetration of all A-label categories together is about 90% on average, with a share of 28% for the most efficient A+ appliances (see **Figure 2-30**). Northern and western countries score highest, also on A+ shares. Four southern countries score lowest (Bulgaria, Greece, Portugal and Spain), as was also the case for refrigerators. Because three-quarters already has penetration levels above 90% there is not much room any more for sales of A and A+ washing machines.

It is worth noting that the manufacturers of washing machines are nowadays only producing practically A and A+ models. Therefore it can be expected that in a few years these models will constitute 100% of the market. However, and increased penetration of A+ and A++ still offer a large savings potential.

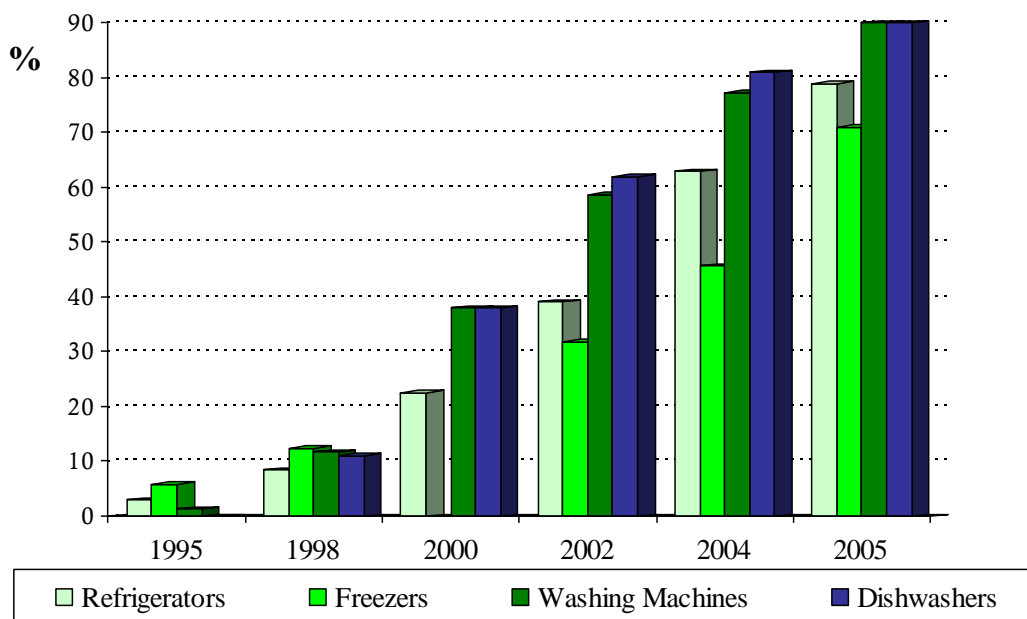
Figure 2-30: Penetration of labels A and A+ for washing machines (2006)



Substantial impact of labels on the market for efficient appliances

During the past decade the EU Directives have deeply transformed the market for (more efficient) large appliances, in combination with national measures to increase the purchasing awareness and habits of the consumers. **Figure 2-31** shows the steady increase of energy efficient appliances. This has led, as highlighted earlier, to an overall energy efficiency improvement of 11% in the period 1997-2006.

Figure 2-31: Market share of A/A+ labels for cold and washing appliances (EU)



Combination of EU labels with national supporting measures decisive for success

Along with the transposition of the Labelling Directives, a dozen of countries have decided to reinforce the market transformation effect of these directives by establishing ‘accompanying or supporting measures’. Most of these measures consist in subsidies or rebates granted to citizens to support the purchase of highly efficient appliances labelled A/A+ or compact fluorescent lamps (see **Table 2-2**).

Table 2-2: National supporting measures to the EU label system

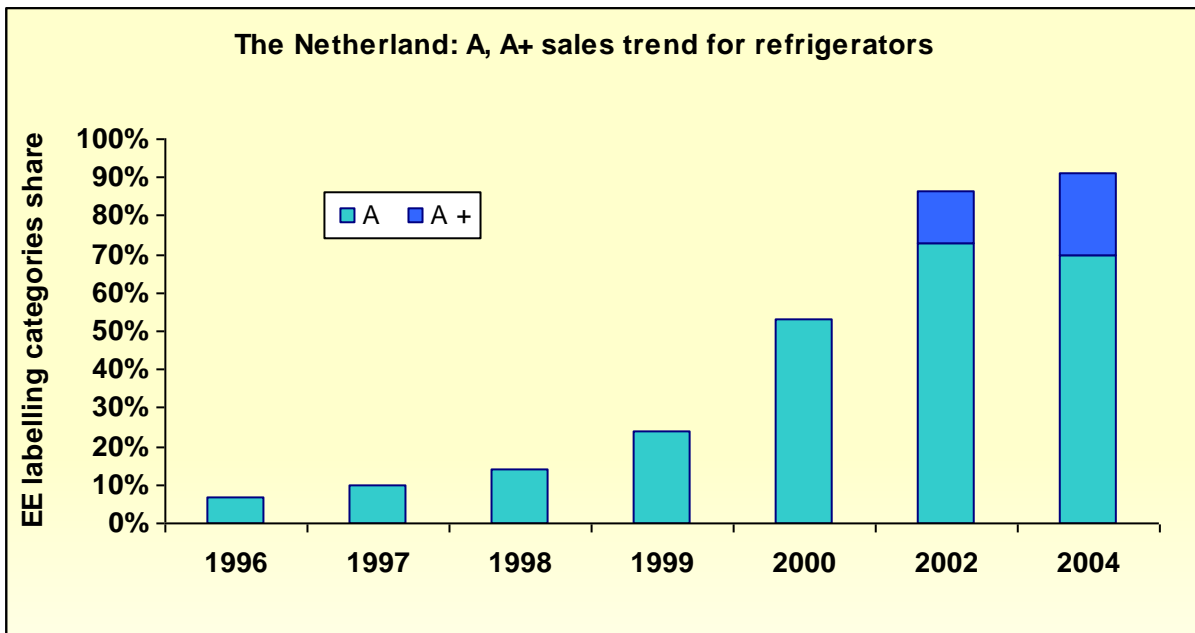
	Facilitating Measures: Main Instruments
Cyprus	Scheme for subsidising CFL lamps (2007): free distribution of CFLs lamps to the households (up to 6 lamps/household)
Denmark	Electricity Saving Trust (1997 - 2008): Information, Issuing of consumers guidelines
Germany	Program for introducing new, highly efficient household appliances to the market: Subsidies to very efficient household on the basis of the "Top Runner Strategy" (Measure proposed)
Italy	Financing Laws 2007 & 2008: Tax Subsidies for the purchase of A+ (or better) models.
Malta	Rebates on investments in energy efficiency by domestic consumers (2007): subsidies for the purchase of A (or better) models (rebate on the purchase price)
The Netherlands	The energy premiums scheme (1999 - 2003): subsidies for the purchase of A (or better) models
Romania	The promotion of the use of energy-efficient household electrical appliances (proposed): subsidies for the purchase of an appliance with an A/A+ label.
Spain	Action Plan 2005 - 2007 and 2008 - 2012: subsidies to the households to replace the "D" appliances with the A (or better) ones.
Slovenia	Stimulation of the investments in energy efficiency measures in households: subsidies for the purchase of CFLs (1996) and efficient appliances (2008)
UK	Energy Efficiency Commitment: mainly addressed to energy suppliers that are required to achieve targets for the promotion of energy efficiency improvements in the household sector. Tax rebates are also foreseen for low income households

Netherlands successful in market transformation using subsidies

For the years 1999-2000, the Netherlands set in place ‘The Energy Premiums Scheme’ that granted subsidies for the purchase of high efficient appliances labelled A/A+. **Figure 2-32** shows that it brought the sales for A/A+ refrigerators to increase from 25% in 1999, before the measure was implemented, to 92% in 2004 (+ 74% of A/A+ sales).

By acting as “launching customer” a market has been created for efficient appliances, which made it advantageous to offer these appliances also in other countries. With some delay efficient appliances also penetrate the market in other countries without a dedicated stimulation policy.

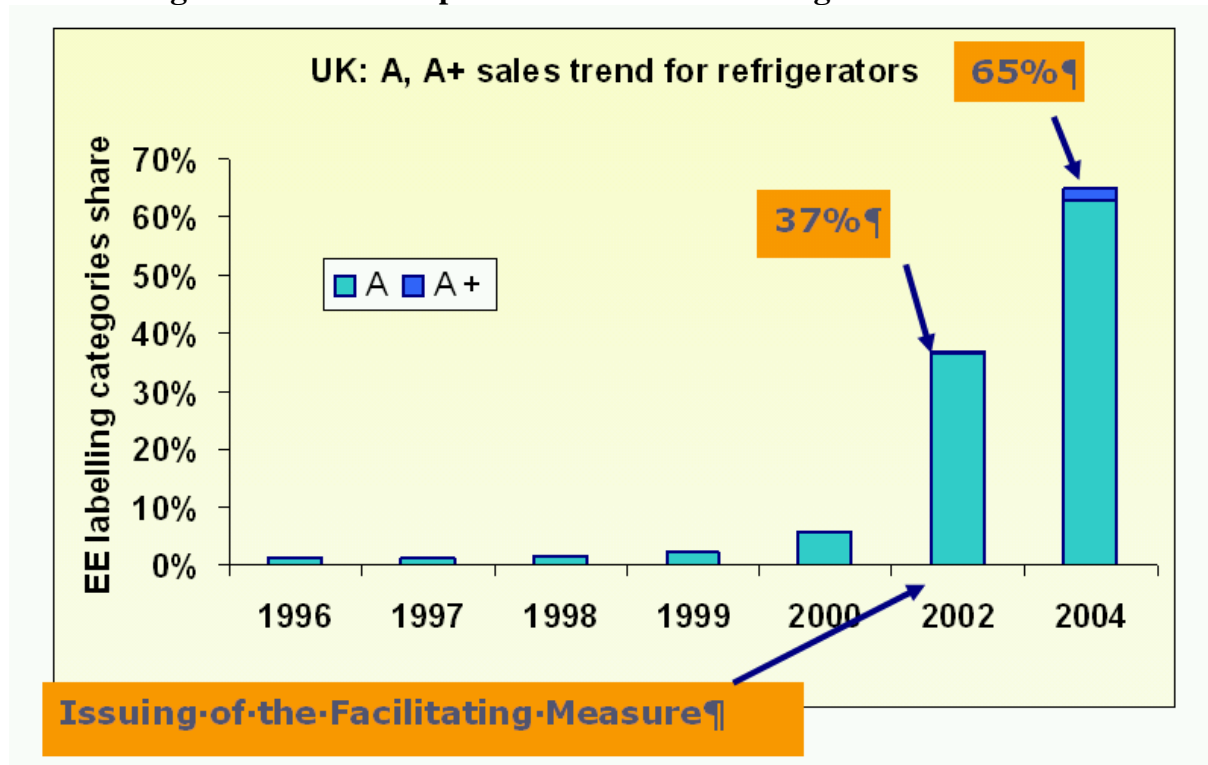
Figure 2-32: Market penetration trend for refrigerators in the Netherlands



UK successful in market transformation using tax rebates

The UK has implemented in 2002 measures to address both equipment producers and consumers (see **Figure 2-33**). Consumer got tax rebates for the purchase of highly efficient appliances that has been an important factor to bring the market share of cold appliances labelled A/A+ from 37% in 2002 to 65% in 2004 (+ 75% of A/A+ sales).

Figure 2-33: Market penetration trend for refrigerators in the UK

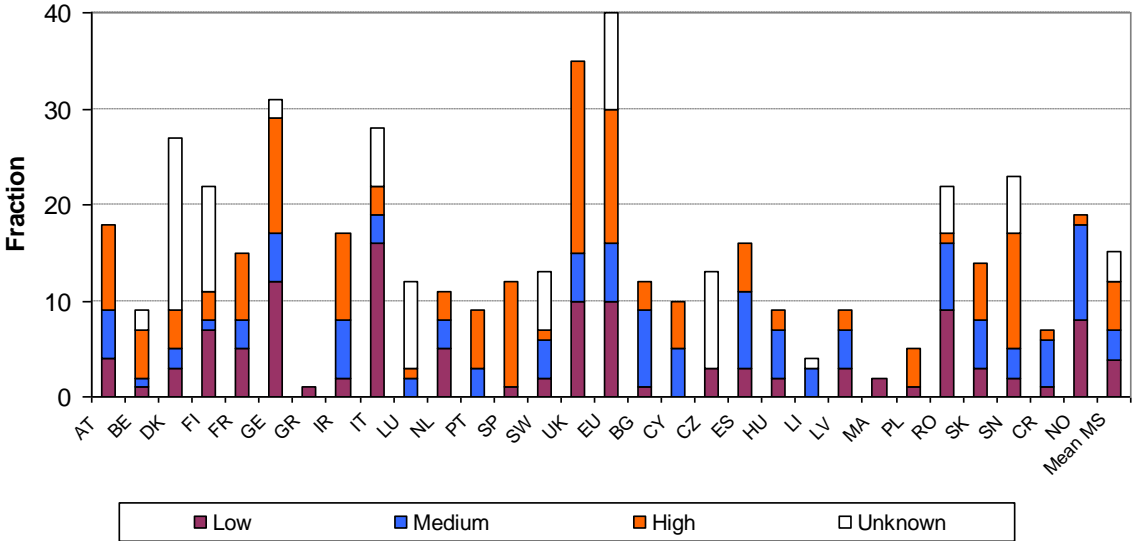


2.10. Policy impact and realised energy savings

One third of policy measures rated as having high impact

The saving effect of each policy measure in the EU countries has been estimated and given a qualitative value “High”, “Medium” or “Low”. For all EU countries together about one-third is rated High and a quarter is rated Low; one-fifth has not been rated (see “Mean MS” in **Figure 2-34**). From the impact values the overall impact of all policy measures has been calculated (see **Box 2-7**).

Figure 2-34: Policy measures per impact level for households (ongoing)



Box 2-7: Determination of the impact of policy measures

The impact, or saving effect, of a policy measure is estimated on basis of available quantitative evaluations or the judgement of the expert for each country. The estimated impact is related to total sectoral energy consumption: Low means energy savings smaller than 0.1% of sector use, Medium 0.1% to 0.5% and High greater than 0.5%.

When adding up the impact of policy measures a weighting factor is applied: for Low 1 point, for Medium 3 points and for High 5 points. The weighting factors correspond to the amount of savings as fraction of total energy use.

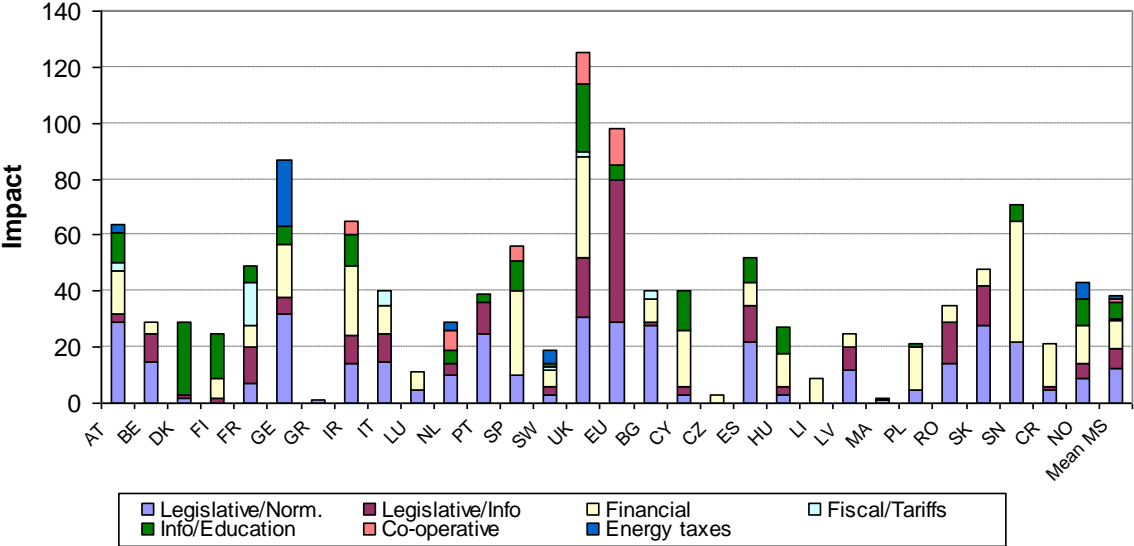
The impact is calculated for all policy measures up to 2006. The impact will gradually increase with time (except for taxes). Therefore the impact has to be adjusted for the time the policy measure is already ongoing.

The application of this semi-quantitative evaluation is restricted to screening of policy measures and providing a first order estimate of the impact of policy measures.

Highest policy impact for UK and Germany that deploy most policy measures

The total impact per country is highest for the countries with the highest number of policy measures, the UK and Germany (see **Figure 2-35**).

Figure 2-35: Total impact of household policy measures, split per type (2006)



Standards and subsidies provide most of the policy measure impact

The contribution of policy measure types to total impact differs substantially. Overall one-third of the total impact is due to standards (legislative/normative) and a quarter to financial measures (see “Mean MS” in

Figure 2-35). Fiscal measures, voluntary agreements (co-operative) and taxes only provide a small fraction of the total impact. For fiscal measures and taxes this is mainly due to the sparse deployment of these policy measure types.

Standards often have a high impact and voluntary agreements have a low impact

The total impact per type of policy measure has been related to the adjacent number of policy measures (i.e. with a specified impact). Standards have on average the highest impact rating, but the difference with most other policy measure types is not large. However, the average impact of voluntary agreements (co-operative) is clearly rated the lowest There are successful voluntary agreements (e.g. in Finland and the Netherlands) but the success is due to the combination with subsidies. Agreements on their own are rated as much less effective. .

Most powerful policy set applied by Spain, Portugal, Poland and Slovenia.

The total impact per country can be related to number of all policy measures as well. Then it appears that relative powerful sets of policy measures are applied by Spain, Portugal, Poland and Slovenia. The lowest average impact is found for Greece, Czech Republic and Malta, the countries that only apply policy measures with a low impact. The average impact for the UK and Germany (with highest total impact) lies between that of the countries mentioned.

High impact measures often of legislative-normative/informative type

Table 2-3 shows a list of high impact policy measures. The classification of measure types in the last column shows that these are often legislative-normative measures (building regulations, mandatory individual heat billing). For EU-15 countries and Norway 10 out of 16 consider building regulation as a high-impact measure.

Table 2-3: Examples of high impact measures in the household sector

Country	Measure title	Measure type
Various	Minimum thermal standards for buildings	Legislative-Normative
Portugal	Regulation on HVAC systems in buildings	Legislative-Normative
Bulgaria	Residential energy efficiency credit facility REECL	Financial
Germany	Ecological tax reform	Taxes
France	VAT reduction on energy efficiency investments	Fiscal
EU	Minimum efficiency requirements for new hot water boilers	Legislative-Normative
Various	Labels on electrical household appliances	Legislative-Informative
Netherlands	More with Less action plan for non-emission trading sectors	Voluntary agreements
Finland	Window energy rating system	Informative

No clear relationship between policy impact and efficiency increase

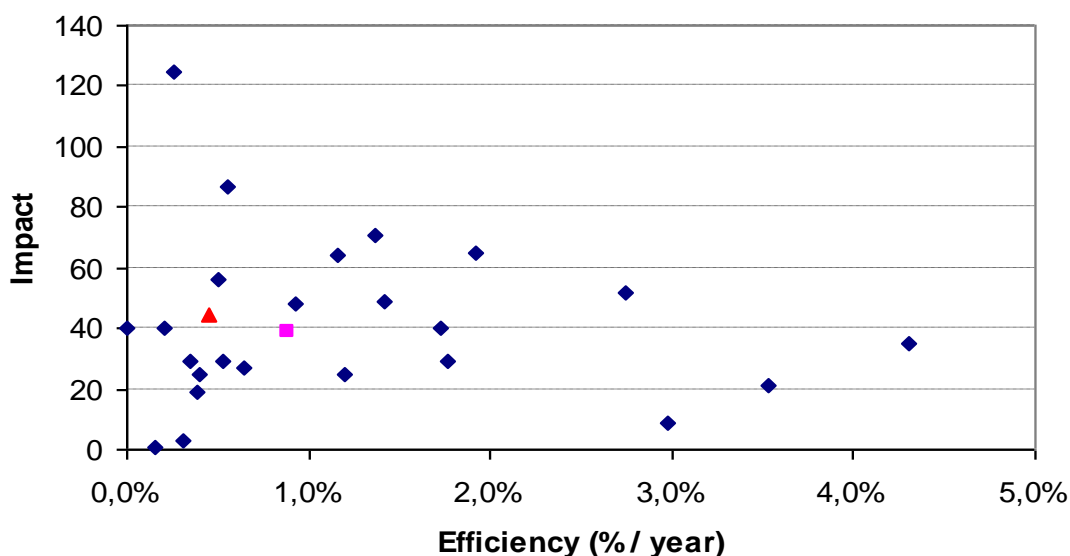
The overall increase in household energy efficiency, as shown by ODEX, has been dealt with in section 2.7. In **Figure 2.23** the efficiency increase per country was been presented. These results are compared to the total impact of policy measures (as shown in **Figure 2-35**).

The relation between total policy impact in 2006 and the efficiency increase for 1997-2006 is shown in **Figure 2-36**. It must be concluded that no clear relationship seems to appear between policy impact and realised energy savings.

A number of reasons can be mentioned to explain this lack of coherence:

- only part of all efficiency increase is due to policy measures; there are also so-called autonomous energy savings due to technological progress and (high) energy prices
- the efficiency increase, insofar policy related, is probably the result of policy measures from 1990 on. The influence of these policy measures is only partly represented by the calculated policy impact in 2006.

Figure 2-36: Policy impact and overall energy efficiency increase for households



The same analysis for space heating leads to more or less the same results, as space heating dominates the overall results for households. For appliances the impact data were not complete, so no separate conclusions could be drawn.

2.11. Analysis of drivers and factors behind trends and differences

Many drivers and explaining variables define energy consumption trends

Drivers are explanatory factors that have a direct physical relationship with energy use, such as population, number of households, number and size of dwellings, central/local heating and ownership of appliances. The influence of drivers can be shown in so-called decomposition analyses, where the change for energy quantities is attributed to changes for the drivers.

Explaining variables are the factors that influence energy consumption indirectly, e.g. by changing energy using behaviour. Examples are income, energy prices and savings

policy, but also saturation could play a role in explaining energy trends. The influence of explaining variables can only be analysed by comparing visually the relationship between values or changes for energy quantities and explaining variables.

Energy trends can be understood by either time series or country comparison

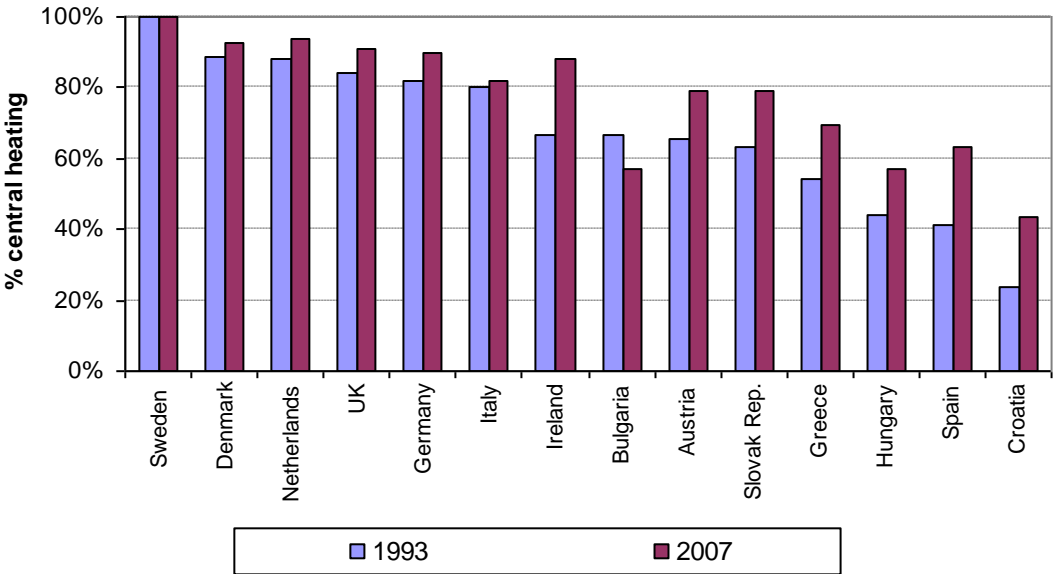
Trends show changes over a period for (groups of) countries, which can be related to changes in drivers or explaining variables. Differences between countries can also be related to differences in drivers or explaining variables. Both time series and cross section analysis are used for understanding developments in energy use and savings.

General trend for more central heating drives energy use up

For space heating the most important drivers for energy use are the number of dwellings, average floor space, penetration of central heating and fuel substitution. Dwellings and average floor space have already been presented in the section on energy use for space heating.

In past decades local heating with one or more stoves per room has gradually been replaced by individual central heating using a boiler or, in some countries, by district heating (see **Figure 2-37**). In EU-15 countries the relatively high penetration has increased further, except in Sweden where it was already 100%. In most new member states the penetration has increased from a much lower level. The decrease in Bulgaria for both individual central heating (-6%-points) and district heat (-4%-points) is probably due to high prices and low incomes (see following analysis).

Figure 2-37: Penetration of central heating in dwellings (selected countries)



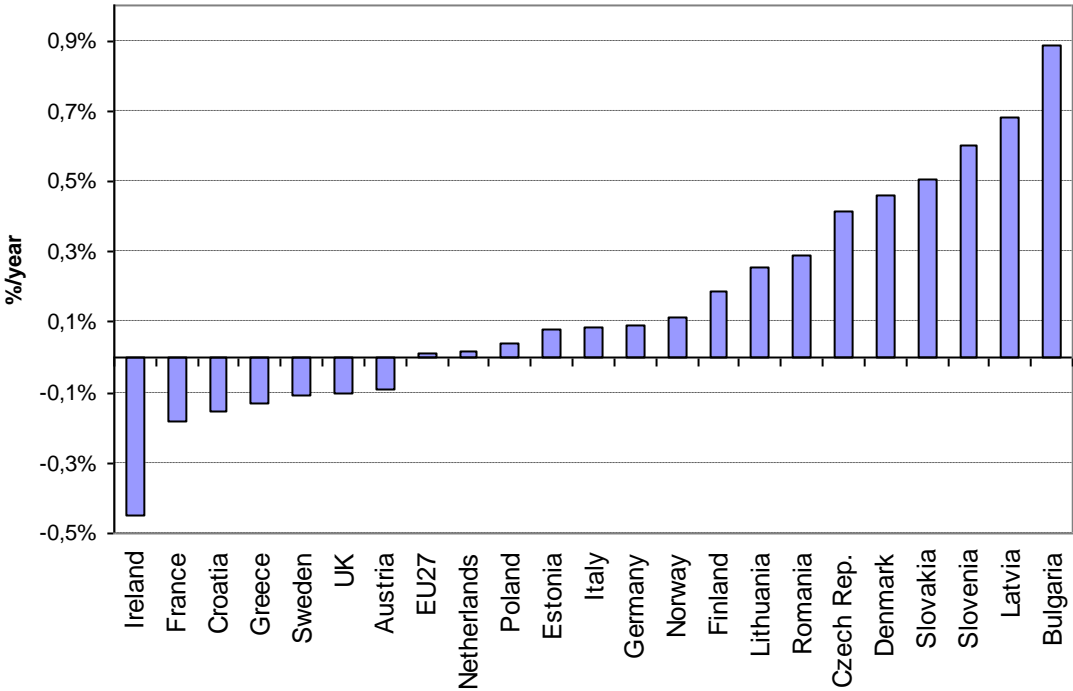
The increasing energy use for space heating due to the penetration of central heating is not always visible in the change in unit consumption as shown earlier in

Figure 2-9. This is because at the same time energy is saved in space heating.

Fuel substitution saves energy but not if district heat is replaced

Fuel substitution is defined here as any change in type of energy carrier. In EU-15 countries “old fashioned” energy carriers, such as peat (in Ireland), wood (Austria) or coal are replaced by gas. By nature gas has a higher conversion than coal or peat; thus fuel substitution leads to more efficiency (see **Figure 2-38**). In some new member states, such as Bulgaria, district heating is replaced by (individual) heating using gas. Because district heat is produced very efficiently in cogeneration plants the conversion losses for households increase when changing to gas. In these cases fuel substitution results in increased (final energy) unit consumption (see Figure). It must be remarked that the effects of both types of substitution can compensate each other, e.g. for Poland where both coal to gas and district heating to gas play a role.

Figure 2-38: Contribution of fuel substitution to unit consumption per m²



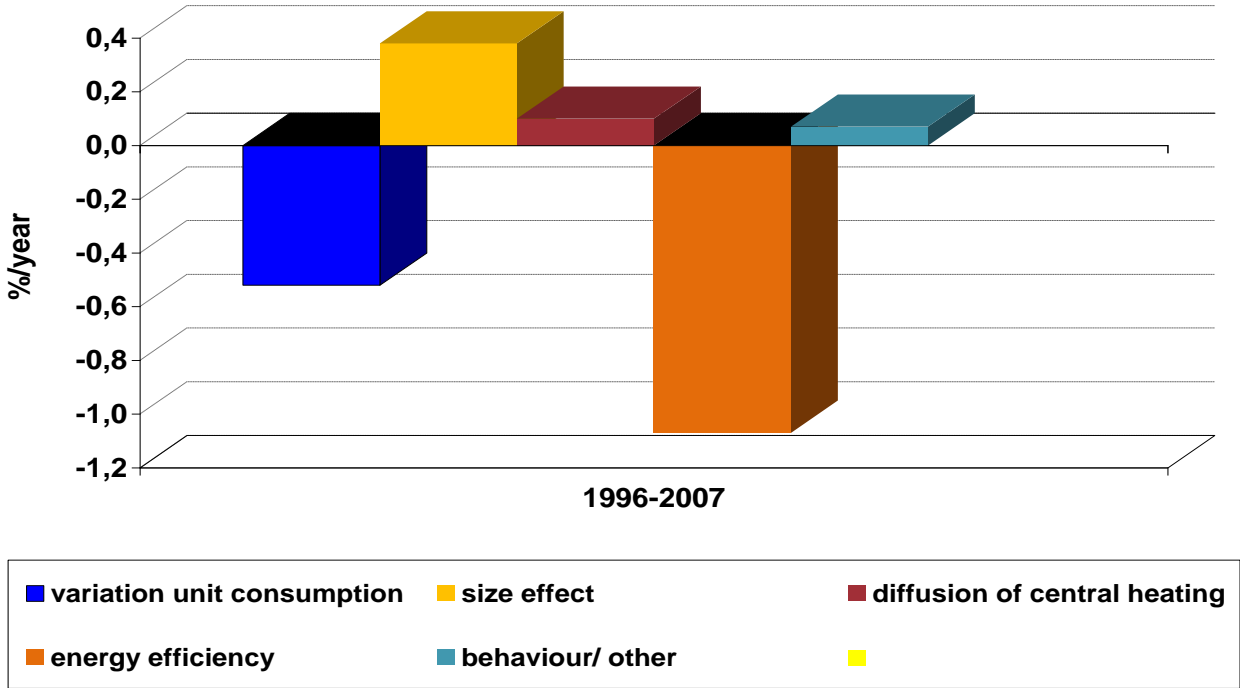
Efficiency increase is the most important factor in observed lower unit consumption

Figure 2-39 shows how the change (variation) in unit consumption per dwelling that can be decomposed into the effects of explanatory factors: size (floor space), central heating, energy efficiency and behaviour/other (e.g. fuel substitution).

For EU-15 countries, the size effect is smaller than for new member states that take up from a low average dwelling floor area. The effect of the penetration of central heating regards both groups of countries. This effect will reach a saturation level, as it already did for some EU-15 countries (see **Figure 2-37**).

The net unit consumption decrease (variation) is about 0.5% per year. This is considerable lower than the efficiency gain of 1.1% per year.

Figure 2-39: Decomposition of change in heating energy use per dwelling (EU-27)



Higher incomes determine increased energy use, but not by definition

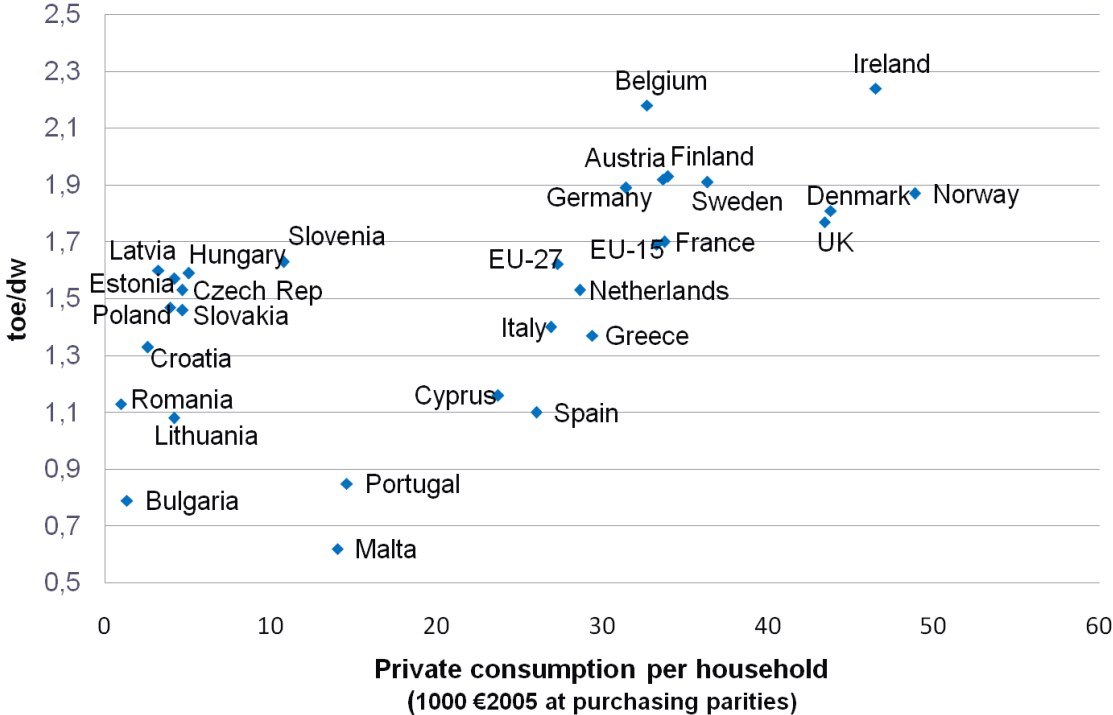
Next to energy prices (see below) and policy (see previous sections) income/private consumption determines energy consumption, either directly (e.g. affordable comfort level for space heating) and indirectly (e.g. size of dwelling and number of appliances) the level of energy consumption. Income has been corrected for differences in purchasing power parity (PPP¹⁸). From

Figure 2-40 it can be concluded that overall there is no robust relationship between both. For instance, Belgium uses substantially more energy than the Netherlands for the same income (and winter climate). On the other hand the comparable energy consumption of the Czech Republic is coupled to a much lower income. These examples show that other factors, such as the quality of the housing stock, could play a

¹⁸ The economic performance of EU-countries, e.g. GDP/capita or income per household, differs substantially between EU-15 and new member states. However, in practical life the large differences are not experienced as such, because prices of goods and services are relatively low in the new member states. Therefore, economic quantities are adjusted for power purchasing parity (PPP).

role. However, for the EU-15 as a separate group there is a global relationship between income and energy consumption. The same seems true for the group of new member states excluding Malta and Cyprus, taking into account the condensed scale for income.

Figure 2-40: Energy consumption versus income, per household (PPP¹⁸, 2006)

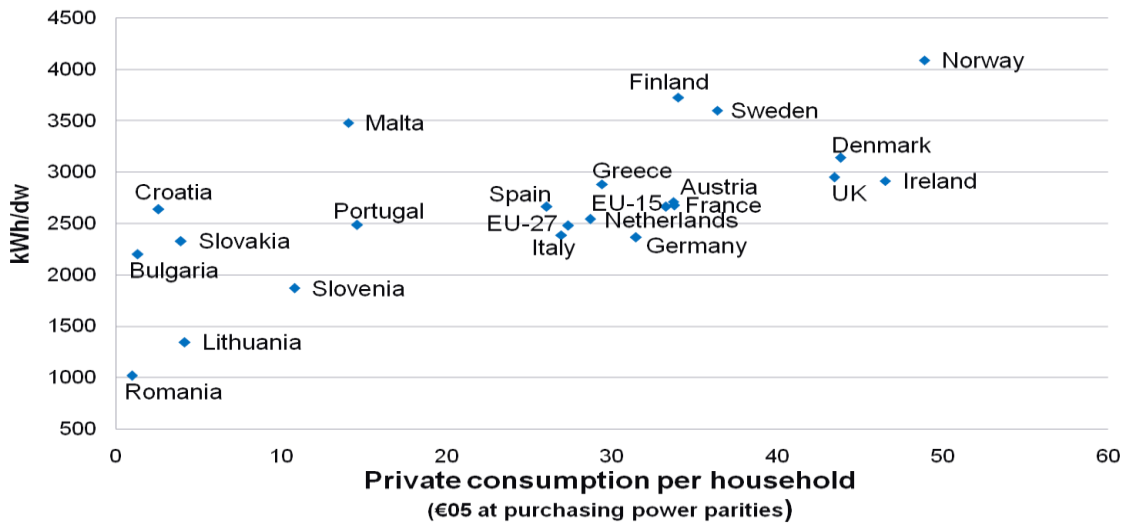


Higher incomes stimulate electricity consumption, up to a saturation level

For electrical appliances plus lighting, electricity use and average income show a more explicit correlation (see **Figure 2-41**). The correlation is well represented by the two countries at the opposite position: Norway (4000 kWh) and Romania (almost 1000 kWh). A cross reading with

Figure 2-15 underlines this relation as the energy consumption in Norway has a declining trend while Romania shows a steady growth.

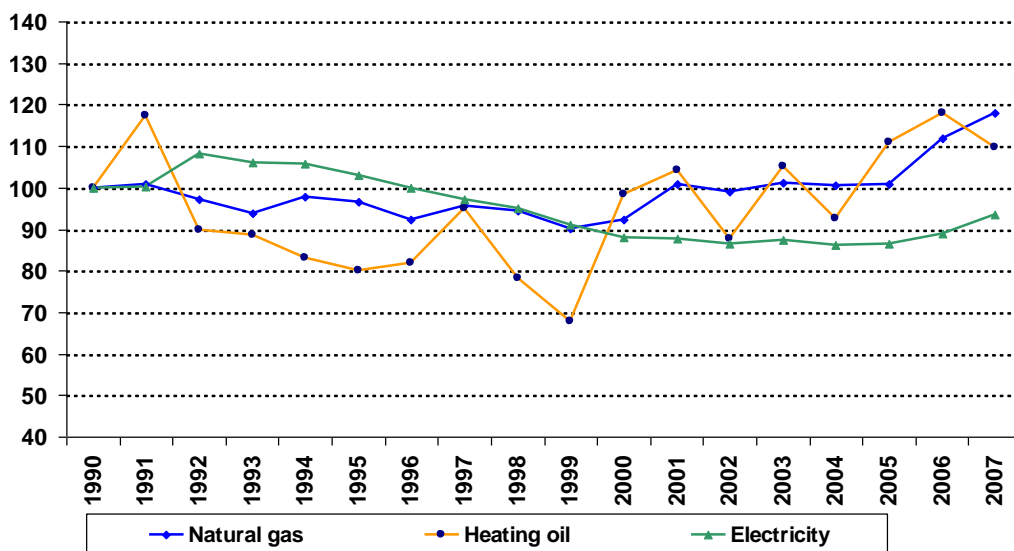
Figure 2-41: Appliance electricity use versus income, per household (PPP¹⁸, 2006)



At EU-level influence of energy prices will be limited due to rather stable prices

In Figure 2-42 the trends for prices of different energy carriers are shown (index, constant 1990 prices). The prices of gas and heating oil decreased from 1990 on until 2000; then the trend reversed and prices ended up 10-20% higher. For electricity the price level came below the 1990 value only by 1996 and started to rise only by 2005.

Figure 2-42: Trend in energy prices for households, weighted EU-27 average



In the period 1997-2001, with decreasing energy prices, the average energy consumption per household¹⁹ for EU-15 showed a less favourable trend than in the

¹⁹ Climate corrected, see also

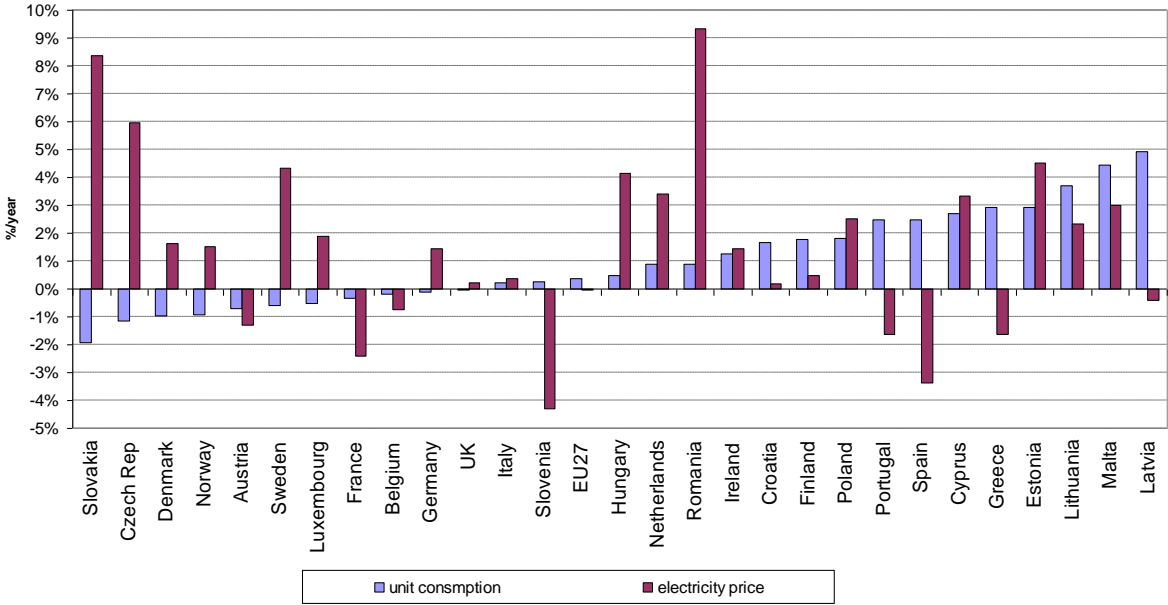
period 2001-2005 with rising prices. This confirms the expectation that rising prices discourage growth of energy use.

Growth rate and price for electricity consumption per country are often related

The rather stable electricity prices at EU-27 level hide substantial changes at the level of individual countries, especially for new Member States (see

Figure 2-43). In most cases with no growth of unit electricity consumption the price level has substantially increased. A high growth rate is more related to stable or decreasing price levels. But there are striking exceptions, such as France (lower prices and less electricity use) and Romania (more electricity use despite much higher prices).

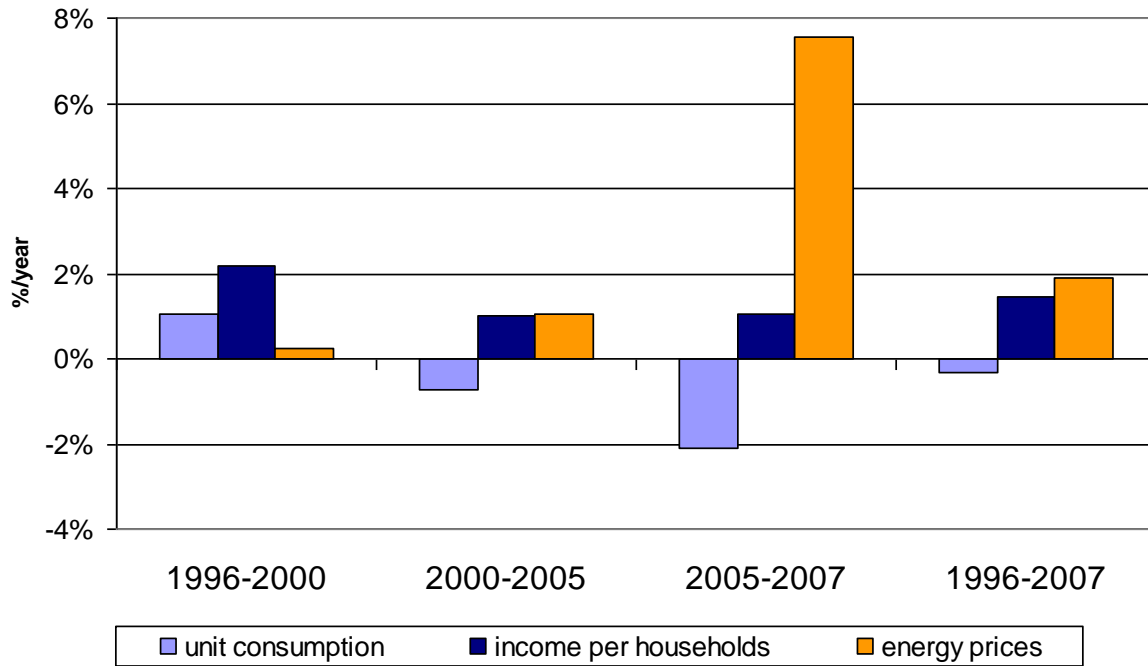
Figure 2-43: Electricity use per household and price variations (1996-2004)



The combined influence of income and price has affected average energy use

The average energy consumption per household in the EU-27 increased by about 1% per year up to 2000 with more than 2% income growth and stable prices (see **Figure 2-44**). After 2000 energy consumption decreased with income growth halved (dot-com economic crisis) and then decreased faster with rising prices. Overall unit consumption more or less stabilized for the period 1996-2007.

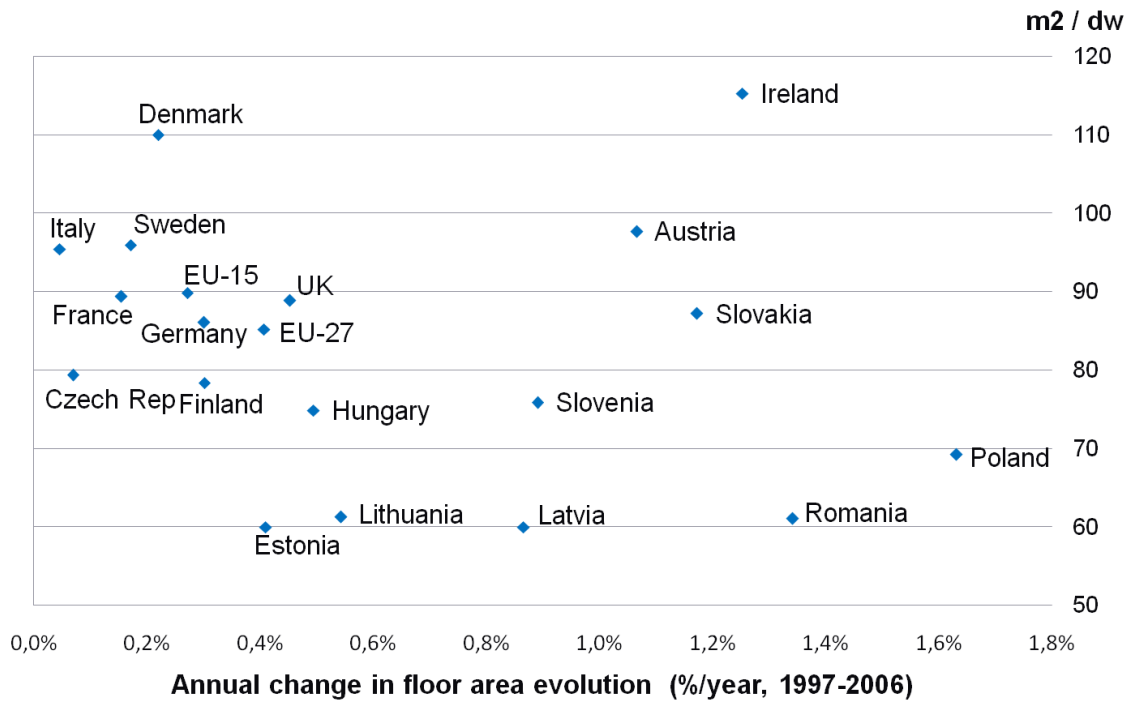
Figure 2-44: Income, energy price and average energy use per household (EU-27)



Saturation effects for floor space are not convincing

Saturation means that trends, mostly increasing energy use, reach a natural ceiling over time. For instance, if Sweden has 100% central heating no further increase due to more central heating is possible. Saturation of average floor space is important as it defines to a large extent the further increase in demand for space heating. In **Figure 2-45** the existing amount of floor space is compared with the historic growth in floor space. Saturation means that a larger floor space for a country will lead to lower growth figures (see arrow). There are too many outliers to conclude that a saturation mechanism is present in EU countries.

Figure 2-45: Average floor area of dwellings versus growth rate (1997-2006)



2.12. Observations and lessons learned

The following observations and conclusions are valid:

- Growth of household energy consumption in the EU-27 is declining in recent years, 3% in the period 1997-2002 and less than 2% in the period 2002-2007. The energy consumption trend for new member states is very different from that for EU-15. Some new member states show a considerable decline, but after 2001 their growth rate accelerates.
- A significant shift away from coal (from 13% to 3%) and oil (from 23% to 17%) is compensated by more use of gas (up to 40%) and electricity. (up to 23%). Heat from district heating and use of biomass play an important role in many new member states.
- At EU-27 level energy is mainly used for space heating (71% in 2000); other important uses are appliances/lighting and hot water, while cooking is relatively insignificant (4%). These fractions are rather stable in time. The composition per member state differs, e.g. due to cold winters. But even countries with mild winters show rather high fractions for space heating.
- Energy consumption of households in primary terms for the EU-27 grows almost twice as much as the final energy consumption. This is due to growing electricity use, while fuel use stabilises.
- Average energy consumption per household has become lower in the majority of countries. Overall, EU-15 countries show less decrease than new member states (-5% versus -10%).
- Average electricity use per household in EU-27 is about 4000 kWh per year. It is much higher in Sweden and Finland because electricity is used for space heating as well. It is much lower in most new member states where it does not really catch up with EU-15 countries.
- The fraction of energy devoted to space heating decreases, partly due to the relative strong growth of electricity consumption. The highest fractions are not found in countries with severe winters but in countries with a moderate climate.
- Energy use for space heating in countries with mild winters, e.g. Cyprus and Greece, increases because more households start heating their dwelling.
- After corrections for differences in floor area and climate Latvia, Poland and Germany show the highest energy use for space heating. The Netherlands, Slovak Republic and Bulgaria show the lowest values. These last countries also score lowest on useful heat demand, underlining their special position.
- About 40% of energy efficiency progress has been offset by dwellings becoming larger.
- Due to more strict standards new dwellings have much lower energy consumption for space heating than existing dwellings. However, the effect of standards on total savings for space heating is hampered by the often limited amount of new dwellings built, in most EU countries less than 1% per year.

- Electricity consumption for appliances & lighting increased in all member states except Bulgaria and Slovakia (about 2500 kWh) as well as Norway (5000 kWh). The strongest growth is recorded for small appliances.
- For large appliances all the energy efficiency gains of the last 15 years has been offset by an increase in equipment ownership.
- The majority of new refrigerators has label A or A+ but there are still countries in which the efficiency potential is rather high.
- The amount of EU dwellings with a solar water heater 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.
- Between 1997 and 2007 the energy efficiency progress in households was 0.8 % per year for the EU-27 (almost 8% over the period). The improvement in energy efficiency has slowed down compared to the period 1990-2000 (see earlier ODYSSEE reports)
- Energy savings for space heating and for efficient appliances are higher (1.1% per year) than overall household efficiency improvement.
- European countries deploy on average 15 policy measures to stimulate energy efficiency; moreover about 4 completed policy measures will contribute to present energy savings. Standards on dwellings and financial support (e.g. subsidies) are often used; taxes and voluntary agreements are sparsely used.
- About one-third of the policy measures is related to EU policy, often in the form of transposition of the EU directives: labels for appliances, Energy Performance of Buildings (EPBD), Energy Efficiency and Energy Services (ESD) and Ecodesign (standards for energy using systems).
- The label directive has already contributed to the relatively large energy savings for appliances, but the effect of other EU policy is not visible yet as implementation has only started after 2006.
- New member states differ from EU-15 countries as to the amount of policy measures (lower) and the amount of realised savings (substantially higher). However, higher savings do not lead to lower energy use because fast economic growth stimulates energy demand, e.g. by a shift from local to central heating and extra growth of electricity use. It must be remarked that the same trends are visible for the less rich EU-15 countries, such as Greece and Portugal.
- Fuel substitution can lead to energy savings, e.g. if coal and peat (e.g. Ireland) are replaced by gas. But it can also lead to more energy use if district heating is replaced by individual gas heating (e.g. in new member states).
- The impact of policy measures has been determined in a qualitative way (High, Medium or Low). If the total impact of all policy measures for a country is compared with the total efficiency gains, no clear relationship emerges.
- Trends for CO₂ emissions are more favourable than for energy consumption due to substitution to low-CO₂ fuels and due to a higher fraction of electricity which does not lead to emissions at the place of use.
- The Netherlands can be regarded as a benchmark as to space heating because it shows the lowest energy use for EU-15 countries. Nearby competitors are only new member states where low energy use is due to socio-economic factors.

3. Energy use and policy for Tertiary sectors

3.1. Key strategic issues

Key strategic issues in Tertiary sectors are:

- The relatively fast economic growth that will lead to growing energy consumption, unless it is compensated for by structural changes, such as a decoupling between value added and energy use, and energy savings
- Continuation of current electrification of energy use continue as a result of the penetration of air-conditioning, deployment of ICT and, possibly, energy neutral buildings
- The introduction of more effective policy measures that really influence energy consumption, which is very diverse, small scale and not costly enough to focus the attention of users on efficiency improvements

In order to help address these strategic issues an analysis is made of **trends** for energy consumption and **unit consumption**. Also an analysis is executed on **policy measures** and their **impact**. However, the analysis is hindered by a substantial lack of reliable data on energy use and explaining factors. Due to the lack of data no rate of yearly energy efficiency improvement can be determined, nor the relationship with policy impacts. Also few explanations for observed trends can be found for Tertiary sectors.

Innovative policy measures for Tertiary sectors are described in chapter 4

3.2. Trends for energy consumption²⁰

The tertiary sector comprises energy users outside industry/agriculture/construction, households and transport, e.g. offices, shops and hospitals. A large part of energy consumption in the service sectors comprises energy for public and private buildings.

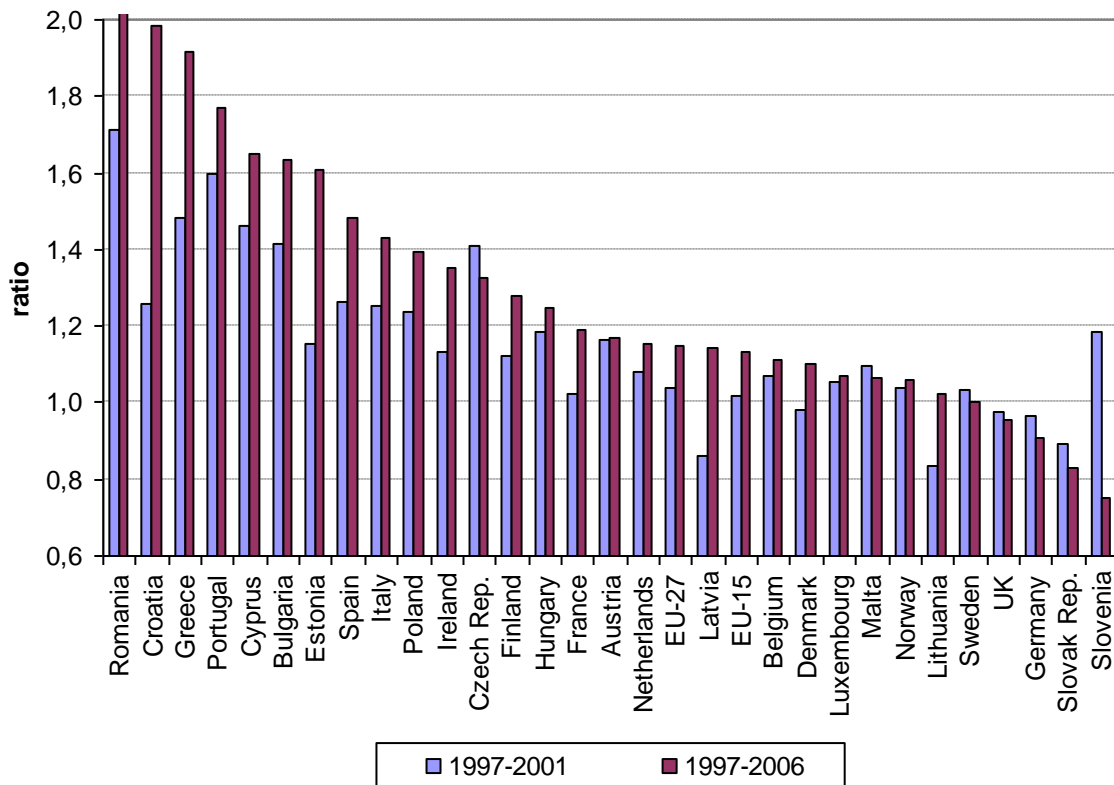
No clear pattern for direction of energy consumption trend in countries

Energy consumption in almost all countries increases in the period 1997-2006, as is shown by the ratio above 1 for most countries in **Figure 3-1**. A decrease can be observed for some EU-15 countries (UK and Germany) but also for some new member states (Slovakia and Slovenia). Other new member states (e.g. Romania²¹, Croatia and Bulgaria) show very high growth rates, but the same is true for some EU-15 countries (e.g. Portugal and Greece). Overall for EU-27, energy consumption increases by 15%.

²⁰ Unless stated otherwise climate corrected energy use figures are used

²¹ Growth ratio 2.9, not fully shown in figure

Figure 3-1: Increase in energy consumption of Tertiary sectors



Growth of energy use is generally accelerating by 2000, especially for some new member states

The Figure also shows energy consumption growth for the first years 1997-2001, when it only 4% for EU-27 (against 15% for the full period). The acceleration of the growth rate by 2000 is moderate for most EU-15 countries (excluding Greece) but some times absent. It is substantial for some new member states but absent as well (e.g. Slovenia). Overall the acceleration does not differ much between EU-15 and new member states.

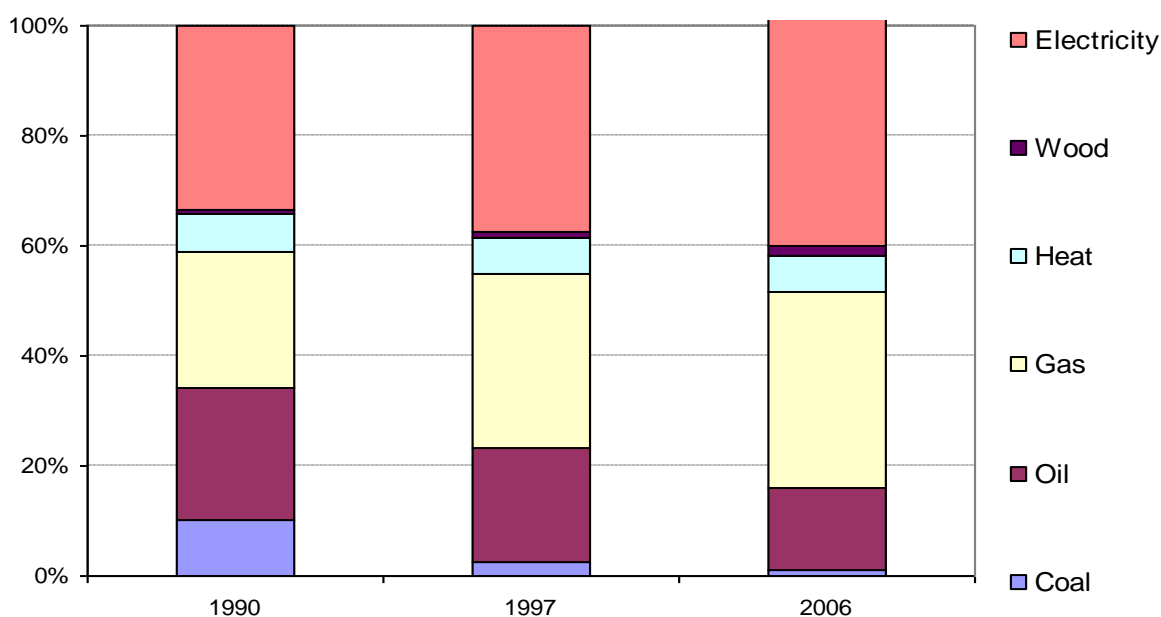
Coal no longer used in new member states and oil fraction much lower

Gas met 36% of the energy consumption in 2006, up from 25% in 1990 (see (Figure 3-2). Coal has virtually disappeared as energy carrier in most countries (see also Box 3-1). The contribution of oil has decreased from 24% to 15%, again with some exceptions.

Electricity is more and more the main energy carrier for Tertiary

The share for electricity has increased a lot due the greater use of electricity, especially for information/communication technologies and air conditioning, from 33 to 46%.

Figure 3-2: Energy consumption²² by energy carrier for Tertiary (EU-27)



Box 3-1: Countries with an extreme fuel mix and large changes for Tertiary

Solid fuels

Most countries hardly use coal but Poland, Lithuania, Slovakia, Latvia and the Czech Republic had a share from 27% to 5% in 1997. The share is dropping fast, the most for Poland and Slovakia.

Liquid fuels

Slovenia, Ireland, Portugal and Malta have the highest share for oil (40-50% in 2000), probably to the absent, or limited, gas grid. The oil share generally drops, the most for Romania (see natural gas) and Ireland (15%-point), but a reversed change has occurred for Greece and Croatia.

Natural gas

The increase in share for Romania stands out to any other country, from 28% to 58%. Poland, Estonia and Hungary follow with about +10%-points. The countries with own gas reserves show a large share in 2006 (Netherlands 59% and the UK 44%), but the largest share is found in Hungary (65%) and Slovakia and Italy rank also above the UK.

Heat from district heating

Large fractions were typically found around the Baltic Sea (30-44% in 1997). In the former Eastern European countries the share has fallen most in Latvia (22%-point).

Wood/biomass

By far the largest share is found in Latvia (16%). The second largest share for Slovenia, in 1997, has disappeared completely by 2006.

Electricity

Extreme fractions regard Greece, Luxembourg, Norway (above 80%) and high fractions regard island states, like Cyprus and Malta, countries with need for air-conditioning (Spain) or nuclear electricity production (Sweden and Bulgaria).

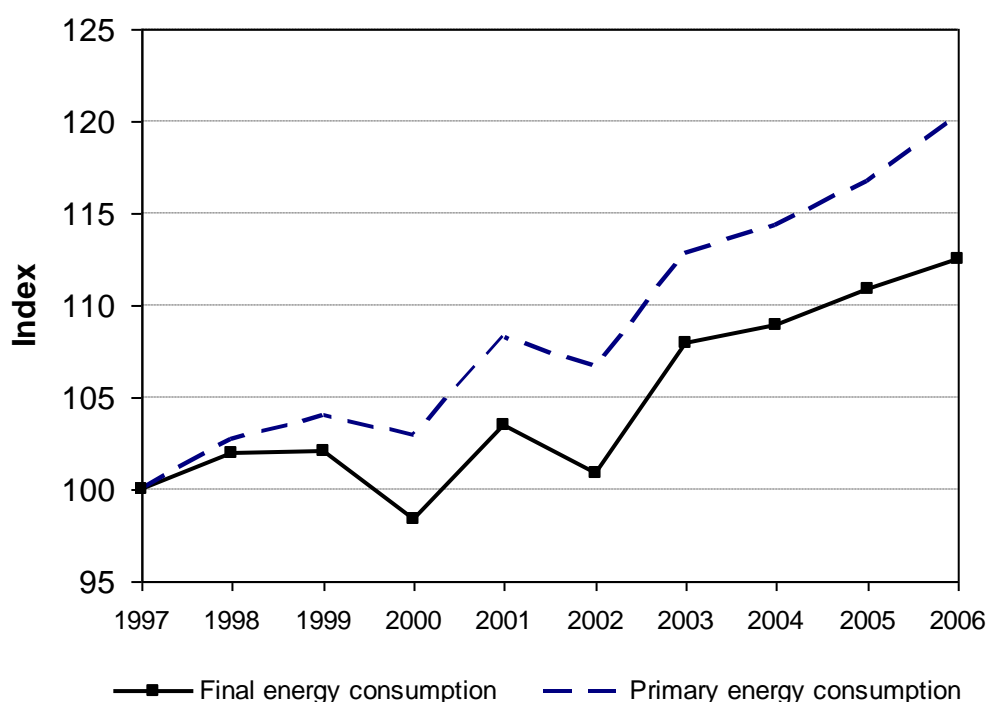
²² Statistical energy consumption (without climate correction)

Energy use in primary terms grows much faster due to more electricity use

Energy consumption²³ is converted into primary units by weighting electricity use with a factor 2.5^{Erreur ! Signet non défini.}

Figure 3-3 shows that primary energy consumption of services increases substantially faster (20%) than energy consumption itself (12-13%). This is because heavier weighted electricity use grows with 35%, while fuel use is stable.

Figure 3-3: Final and primary energy use trends for Tertiary (EU-27)



Share of Tertiary in total primary energy use for some new member states higher than for EU-15

At EU level primary energy consumption of services accounts for 13% of total primary energy consumption. The fraction increases slightly over the period 1997-2006. The share for EU-15 countries varies between 12% and 18% (Ireland), but for new member states the variation is much larger, from 7% (Romania) to 19% (Latvia). The high share for Latvia, Hungary, Cyprus and Malta is mainly due to the absence of a large industrial sector.

3.3. Energy intensity and unit consumption

²³ Statistical energy consumption (without climate correction)

Due to lack of data, no separate analysis of space heating and electrical appliances is executed, as it was the case for households.

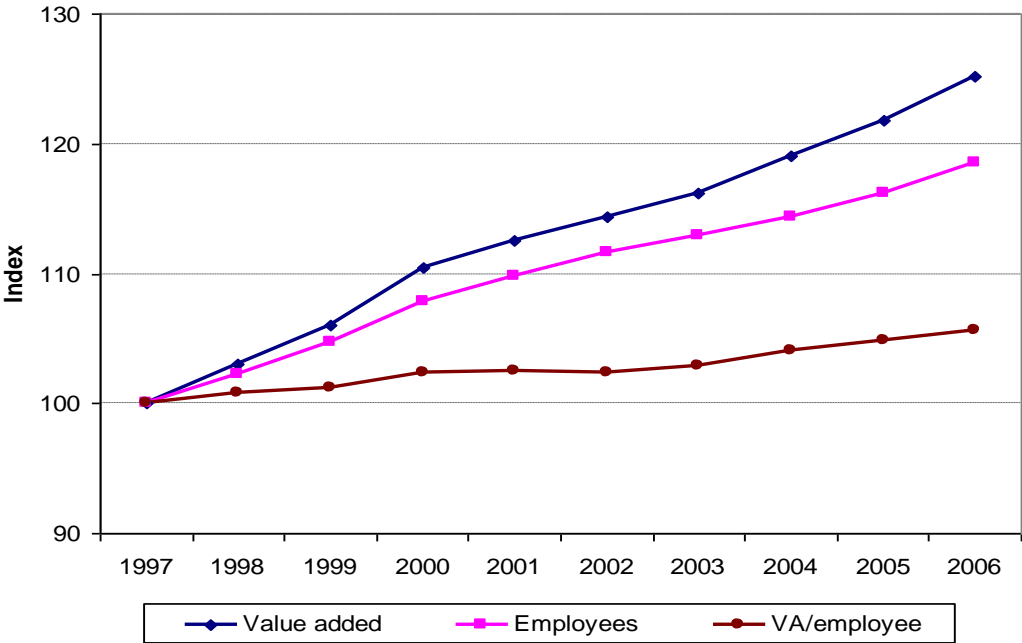
Value added grows not much faster than number of employees for Tertiary

For the analysis of energy use two main driving factors are used, value added²⁴ and employment²⁵. Value added increased by almost 25% from 1997 to 2006 and employment by 18 % (see **Figure 3-4**). The value added created per employee (labor productivity) thus increases only by 0.7 %/year on average.

New member states: fast growth of value added but slow growth for employees

For new member states value added has grown much faster (43%) but employment much slower (9%), resulting in a strong increase in labour productivity (3% per year).

Figure 3-4: Value added, employees and labour productivity for Tertiary (EU-27)



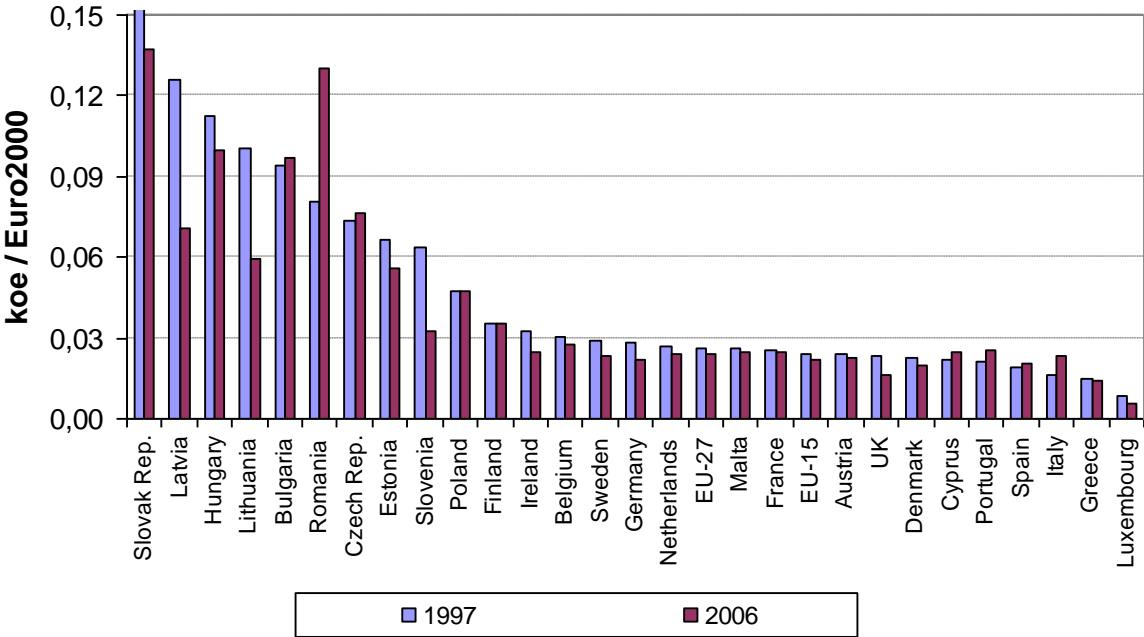
All eastern European countries have relatively high energy intensities

The energy intensity (in koe per €2000 value added) is shown in **Figure 3-5**. It appears that there is a clear division between the former eastern European countries and other EU countries (including Malta and Cyprus). The latter group has very comparable intensities. Generally the intensities decrease over the period but exceptions are

²⁴ Value added in €2000
²⁵ Floor space is not used as driver, because few data are available, especially for new member states.

southern EU-15 countries and some new member states (Czech Republic and Romania).

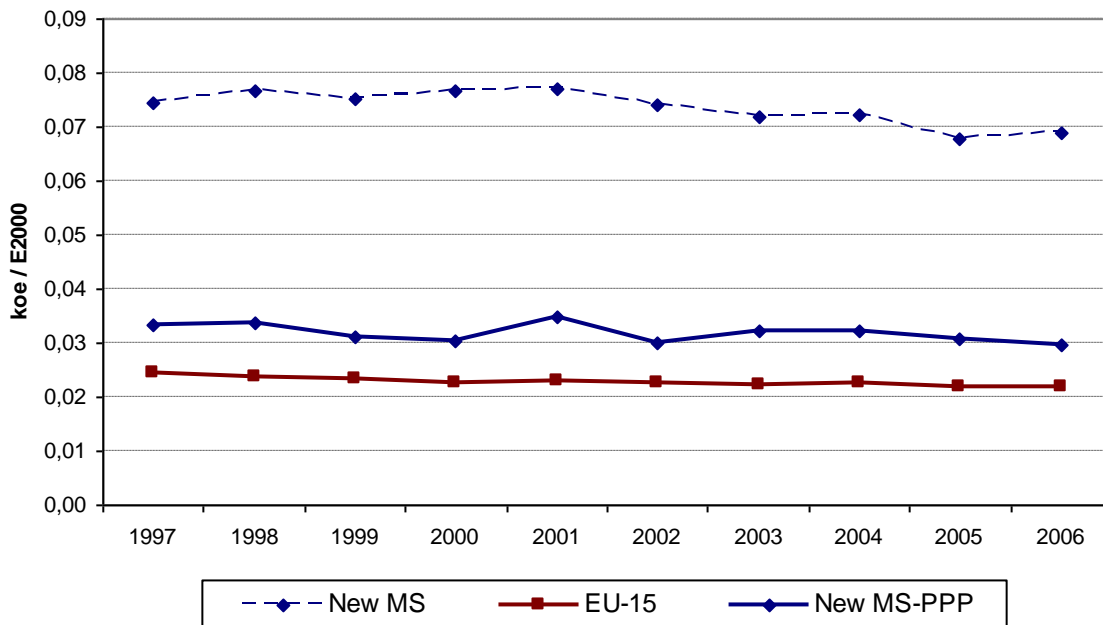
Figure 3-5: Energy intensity and change for Tertiary, per country and EU-27



Corrected energy intensity for new member states comparable with EU-15

The trend for energy intensity is shown in **Figure 3-6** for EU-15 and new Member States (MS). The upper trend for new MS lies far above the trend for EU-15 at the bottom. But this large difference, already mentioned earlier, almost disappears after correcting for power purchasing parity (PPP¹⁸, see also appendix).

Figure 3-6: Energy intensity trend for Tertiary, in EU-15 and new MS



Energy intensity trends remarkably stable, since 1997 also for new member states

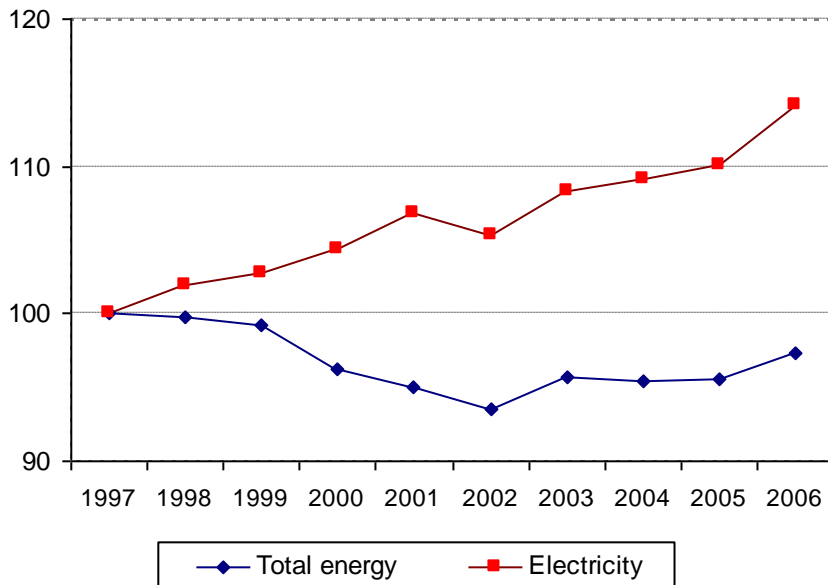
The trend for energy intensity for 1997-2006 is rather stable, both for EU-15 and new member states. For new MS it fell only by 7%; the intensity for EU-15 decreased faster with about 11%. However, for the years 1990-1997 the intensity for some new member states decreased rapidly, due to the large changes in the political-economic system.

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

Total energy consumption per employee decreased until 2002 but more or less stabilized afterwards (see

Figure 3-7). The overall decrease (-3%) is in contrast with the substantial increase in electricity consumption per employee (+14%). Per European employee 600 extra kWh were used in 2006 compared to 1997 (from 4520 to 5160 kWh/employee). These developments suggest that increased productivity of labour (see **Figure 3-4**) is accompanied by more electricity using appliances and systems.

Figure 3-7: Total energy and electricity use per employee for Tertiary (EU-27)



Fuel consumption per employee is not easily related to the climate or economy in the countries

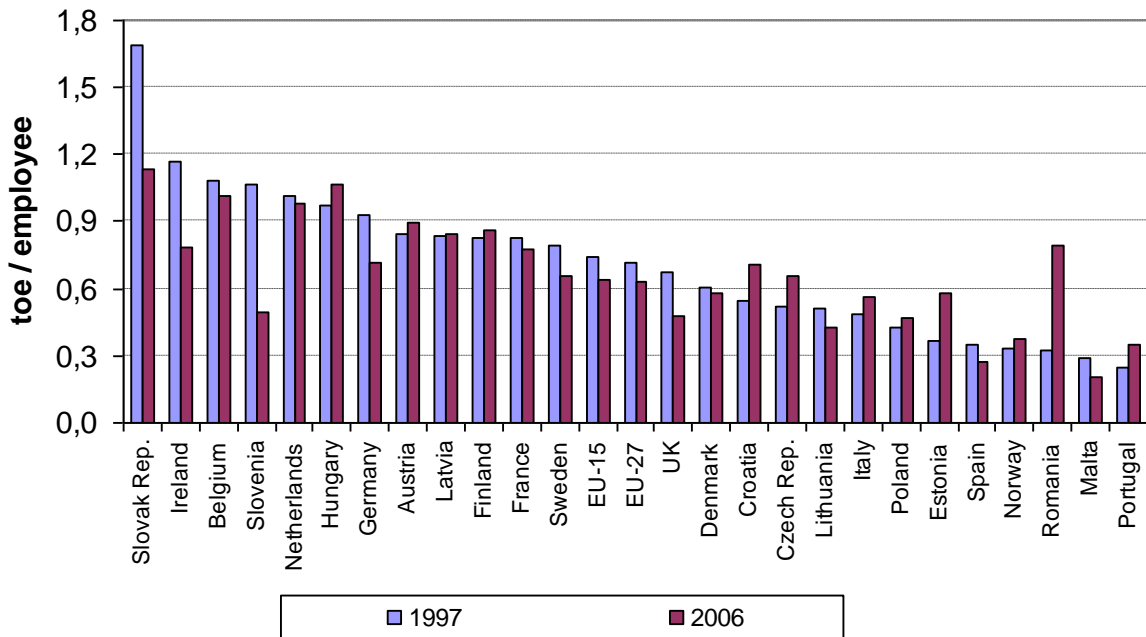
The fuel consumption (including heat) per employee in

Figure 3-8 shows differences between countries that are not easy to explain. Countries with moderate winters, like Belgium and Ireland, show higher values than countries with cold winters (e.g. Sweden). The values for Eastern European countries, with a comparable economic development, are sometimes rather high and sometimes rather low.

Both increasing and decreasing fuel use per employee in EU countries

Between 1997 and 2006 fuel use per employee (climate corrected) for EU-27 decreases slightly (see **Figure 3-8**). A decrease is visible for about half of the countries, among which mostly EU-15 countries (e.g. Germany, Ireland, Spain and UK). One-third shows an increase, mainly new member states or southern European countries. For new member states very large differences occur with regard to changes, e.g. twice as low (Slovenia) versus twice as high (Romania). It must be remarked that statistical figures on energy use for services are relatively uncertain compared to other sectors.

Figure 3-8: Fuel consumption per employee in 1997 and 2006 for Tertiary



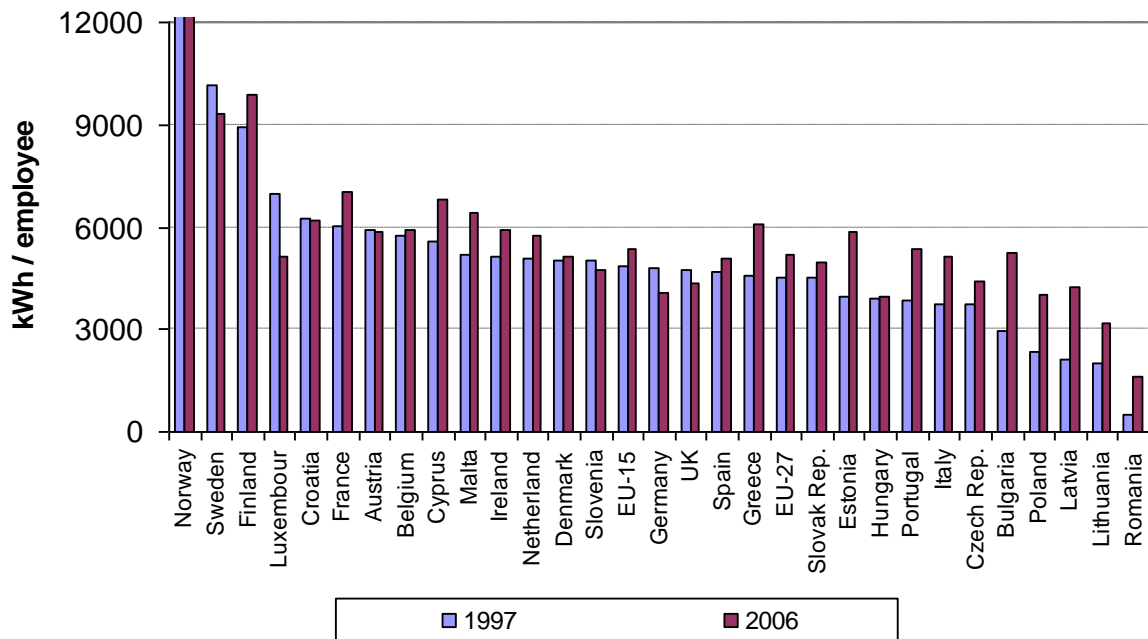
Electricity use in Scandinavian countries is not comparable due to use for space heating

Norway, Sweden and Finland use by far the largest amount of electricity per employee, which probably has to do with electric heating (see **Figure 3-9**). This could also be the case, for some degree, for France but not for Malta. There other causes, such as air-conditioning, are responsible for the relatively high use.

Fast take-up by eastern European countries from 1997 on

The new member states used only about half the amount used in EU-15 countries. However, in 2006 the difference has narrowed considerably (3900 kWh versus 5300 kWh).

Figure 3-9: Electricity use per employee and change, per country for Tertiary



Increase in electricity use per employee due to air-conditioning or strong growth

Generally electricity consumption per employee is increasing, except in Germany, UK and Slovenia. Large increases can be observed for all southern countries, probably due to the penetration of cooling in summer. The high growth for Ireland and eastern European countries is probably due to fast economic growth.

Rich countries show saturation for electricity use per employee

For the EU-15 countries with a sustained high level of economic welfare, electricity use per employee is stable or sometimes decreasing. This could signal that electricity use reaches a saturation level after the “computerisation” of offices, shops, schools, etc. since the eighties. However, saturation will not be reached if these countries apply air-conditioning at a larger scale in buildings, for instance due to warmer summers. Also the strong growth in ICT networks could lead to the continuation of the trends for increased electricity use (see also report on ICT²⁶)

For tertiary sectors no ODEX for overall efficiency improvement available

Due to lack of data for the tertiary sector, it is not possible to analyse developments per subsector or targeted energy use (space heating, appliances). Therefore overall energy efficiency improvement, in the form of an ODEX-Tertiary, cannot be calculated. Energy efficiency progress can only be estimated from the trends of energy use per employee.

²⁶ Energy Efficiency Trends of IT Appliances in Households, Monitoring of Energy Efficiency in EU 27, Norway and Croatia (ODYSSEE-MURE), Fraunhofer ISI, Karlsruhe, September 2009

3.4. Policy measure developments

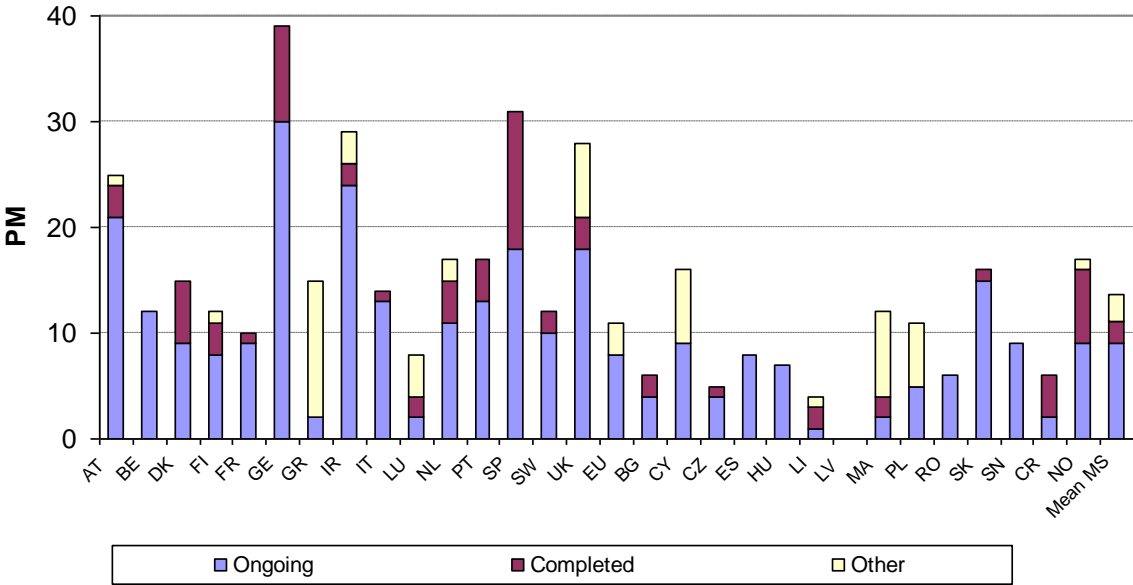
On average ten policy measures to stimulate energy savings in Tertiary sectors

On average European countries deploy almost ten policy measures to stimulate energy efficiency in tertiary sectors (see right and side of **Figure 3-10**). Moreover, two completed policy measures could still contribute to energy savings and two planned policy measures will do so in the future. Germany has the largest total number of measures, as was the case for households. Austria, Ireland, Spain and UK have substantial numbers as well

Policy measures for tertiary lagging behind that for households a matter of time?

The EU average number of ongoing policy measures is only two-third of that for households (see **Figure 2-23**). Most new member states lag behind with tertiary measures, but some countries, all EU-15, have more tertiary than household measures. This suggests that more policy measures for tertiary could be a matter of grown-up savings policy in due time.

Figure 3-10: Policy measures and status for tertiary sectors (2006)

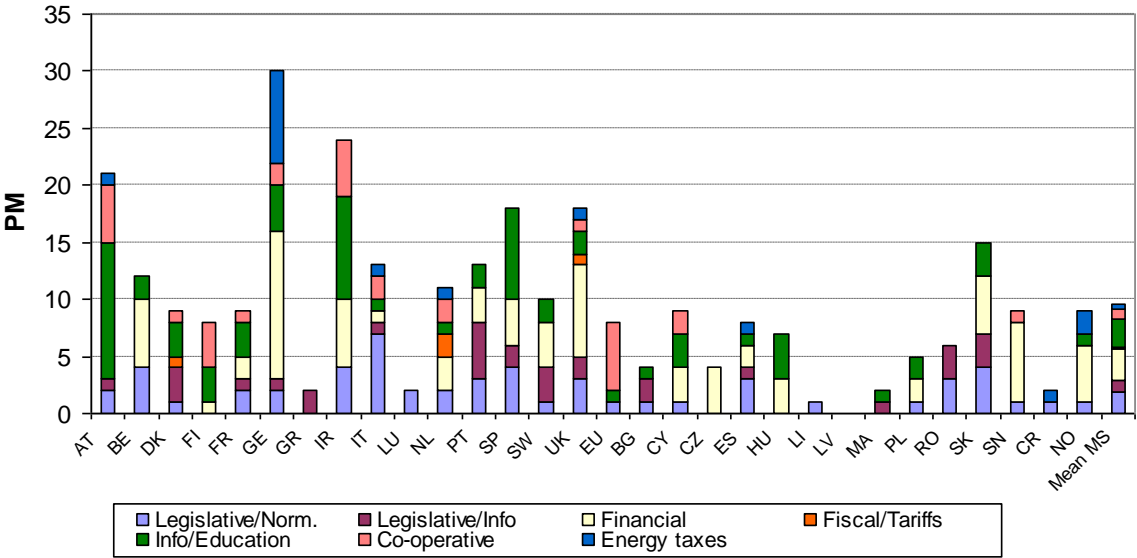


New member states have restricted set of policy measure types

Figure 3-11 shows the ongoing policy measures for the seven measure types. Eight countries, almost all new member states, deploy only one or two types of policy measures. The application of at least five measure types is mainly restricted to EU-15 countries. Standards (legislative/normative), financial support (financial/fiscal) and

information are most applied, but energy taxes and voluntary agreements (cooperative) are hardly used (see also Box on extreme packages).

Figure 3-11: Policy measure per type for tertiary sectors (ongoing, 2006)



In tertiary sectors more “softer” policy measure types than for households

In comparison to households not all countries have standards (legislative-normative). The type legislative/informative is also used less, mainly because appliance labels play a minor role in tertiary sectors. The policy measure types information/education and voluntary agreements (cooperative) are more often applied (see also **Box 3-2**).

Box 3-2: Extreme policy measure choices per country for Tertiary

Austria
More than half are of the type “information/education”, focusing on professionals

Bulgaria, Cyprus, Croatia
No policy measures before the year 2004

Finland
Half of policy measures of the type “co-operative”, e.g. voluntary agreements

Germany
About half of policy measures are “financial”, sometimes overlapping. The large amount for “taxes” is due to two policy measures.

Czech Republic
In 2006 only financial policy measures

Slovenia
Almost all policy measures are of the type “financial” and very recent (2008)

Romania
Only mandatory measures: standards and mandatory information

Many policy measures have a broad scope

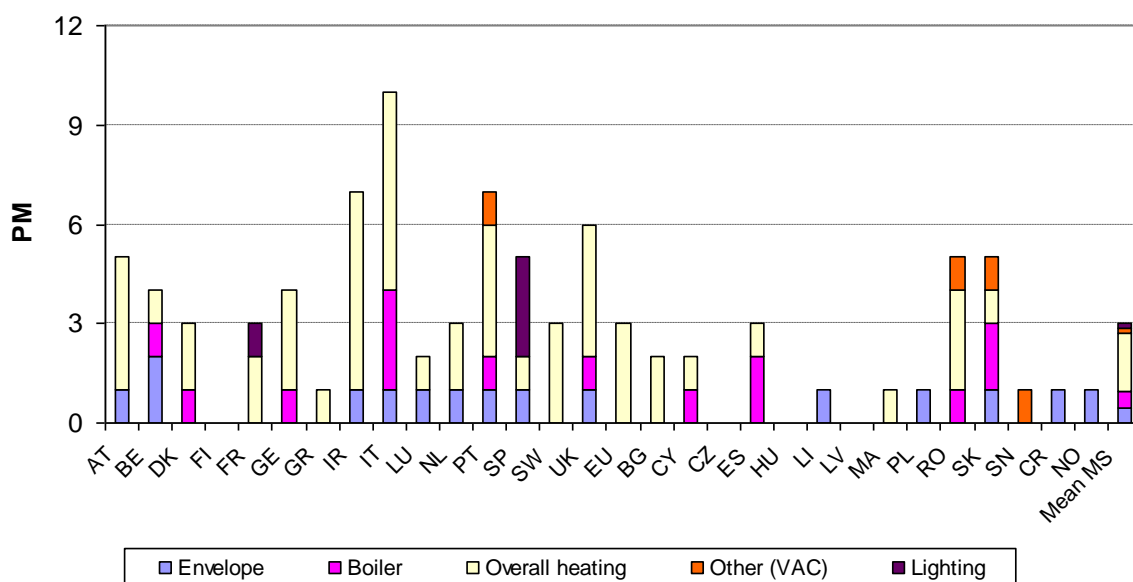
EU wide about half of all policy measures for the tertiary sectors has a broad scope, covering many parts of total energy use. These comprise mandatory audits, financial support for non-specified saving measures, voluntary agreement and energy taxes.

For buildings the scope of policy measures is much more on the whole building than specifically on the shell or the heating system (see “Overall heating” in **Figure 3-12**).

Very few policy measures are targeted at lighting in buildings

From the policy measures targeted at buildings almost none are specifically focused on the lighting system²⁷ or ventilation/air-conditioning (see “Mean MS” in **Figure 3-12**). However, it is possible that the amply available performance standards also provide energy efficient lighting and air-conditioning.

Figure 3-12: Policy measures targeted at building related uses (2006)



Few policy measures are targeted at the public sector

Specific measures for the public sector regard public lighting standards, mandatory action plans and reporting of municipalities and governing by example. On average countries only deploy 0.6 policy measure and two-third of the countries deploy none.

²⁷ The policy measures on lighting for Spain regard street lighting

3.5. EU based policy measures

For tertiary sectors the most important policy measures of the EU are:

- Directive on combined heat and power (CHP)
- Energy Performance of Buildings directive (EPBD)
- Energy Service directive (ESD)
- Ecodesign directive.

The **CHP directive** asks from countries to remove barriers for the implementation of combined production of electricity and heat. This is especially important for the smaller CHP units in tertiary sectors. The **EPBD directive** demands certificates for buildings to be sold or rented, which should lead to retrofit measures (see **Box 2-5**). The **ESD** expects from countries that they will realise 9% energy savings in the period 2008-2016, partly to be realised in Tertiary sectors. Although the ESD does not introduce specific policy measures it will probably have much influence on the introduction of (new) policy measures by countries. The **Ecodesign directive** will introduce minimum efficiency standards for energy using appliances/systems, partly used in offices or installed in buildings (see **Box 2-6**).

EU policy effects not yet to be expected in savings trends up to 2006

The EPBD directive was not yet transposed into national legislation in 2006. The ESD regards the period 2008-2016 and the Ecodesign directive on minimum efficiency standards still has to be set in force. Apart from the CHP directive, EU policy cannot have had much effect on the energy savings, analysed here.

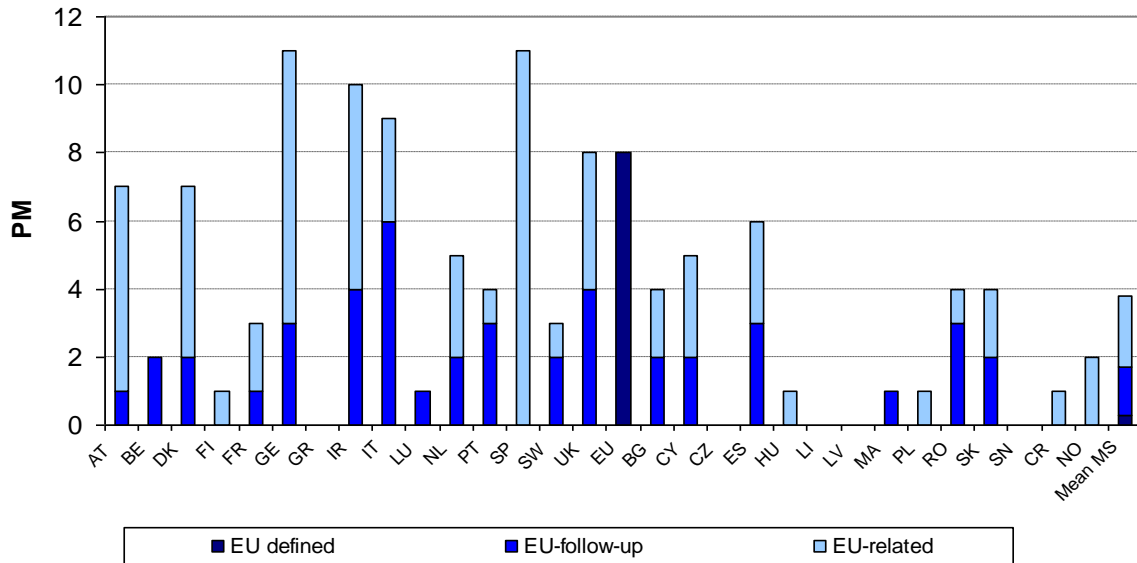
Substantial part of national policy measures due to EU policy

The EU can influence energy efficiency in countries:

- directly by EU policy measures, e.g. covenants with European appliance manufacturers (EU-defined),
- transposition of EU directives into national policy, e.g. labels for appliances (EU-follow-up)
- national measures stimulated by EU policy, e.g. municipal action plans or regional information centres (EU-related).

From **Figure 3-13** it appears that there are eight EU-defined policy measures. On average countries have two policy measures due to transposition, and two related to EU policy. In total about 40% of all national policy measures is due to EU policy.

Figure 3-13: EU policy influencing national policy measures for tertiary sectors



The number of EU-defined policy measures for tertiary sectors (8) is considerably lower than for the sector households (40, see **Figure 2-28**). Part of the difference is due to the many EU policy measures on labels for different household appliances. The four measures transposed or coupled to EU policy compare to that of households.

3.6. Impact of policy measures

The saving effect of each policy measure in the EU countries has been estimated and given a qualitative value “High”, “Medium” or “Low”. From the impact values the overall impact of all policy measures has been calculated (see **Box 2-7**).

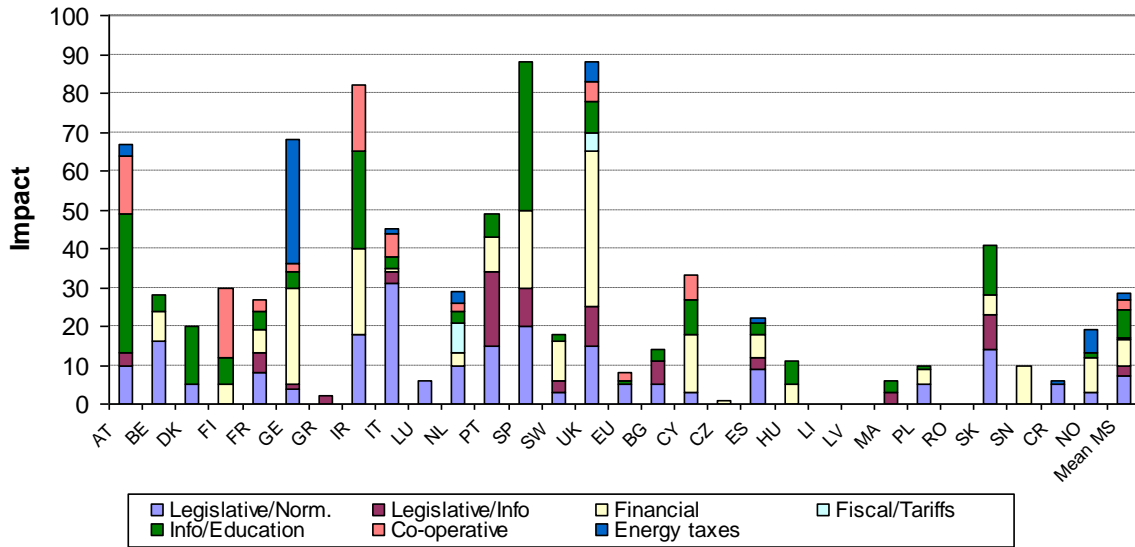
For all EU countries together more than one-third of the ongoing policy measures is rated High and a quarter is rated Low; about 10% has not been rated.

Highest impact not for countries with most policy measures

The total impact per country is the highest for Spain and UK (see

Figure 3-14), which are countries with a high number of policy measures. But Germany, Ireland and Austria, with higher numbers, show a relatively lower total impact. The total impact is generally lower for new member states.

Figure 3-14: Total impact of policy measures, split per type, for tertiary (2006)



Most impact from standards, financial support and information/education

The measure types legislative/normative (standards), financial and info/education all contribute about 25 % to the total impact (see “Mean MS” in

Figure 3-14). The policy measure type fiscal/tariffs hardly contributes to total impact. Examples of high impact policy measures are shown in **Table 3-1**.

Table 3-1: Examples of high impact measures for tertiary sectors

Country	Measure title	Measure type
Austria	Special energy commissioners of Federal Government	Info/education
Austria	Federal building contracting	Co-operative
Various	Energy performance standards for new buildings	Legislative /normative
Netherlands	Energy Investment Tax deduction (EIA)	Fiscal/tariffs
Germany	Special fund for energy efficiency in SMEs	Financial
Spain	Energy conservation and efficiency plan (EECP)	Financial
Various	Energy labelling of buildings	Legislative- Informative
UK	Climate Change Levy (CCL)	Taxes + Financial
Finland	Energy auditing programme Service sector	Info/education

Although the policy measure type “Info/education” provides on average a quarter of total impact, it is difficult to find these high-impact measures in the database. It seems that many policy measures of this type are applied, but with medium impact.

3.7. Analysis of drivers and factors behind trends and differences

Value added and number of employees most important drivers for energy use

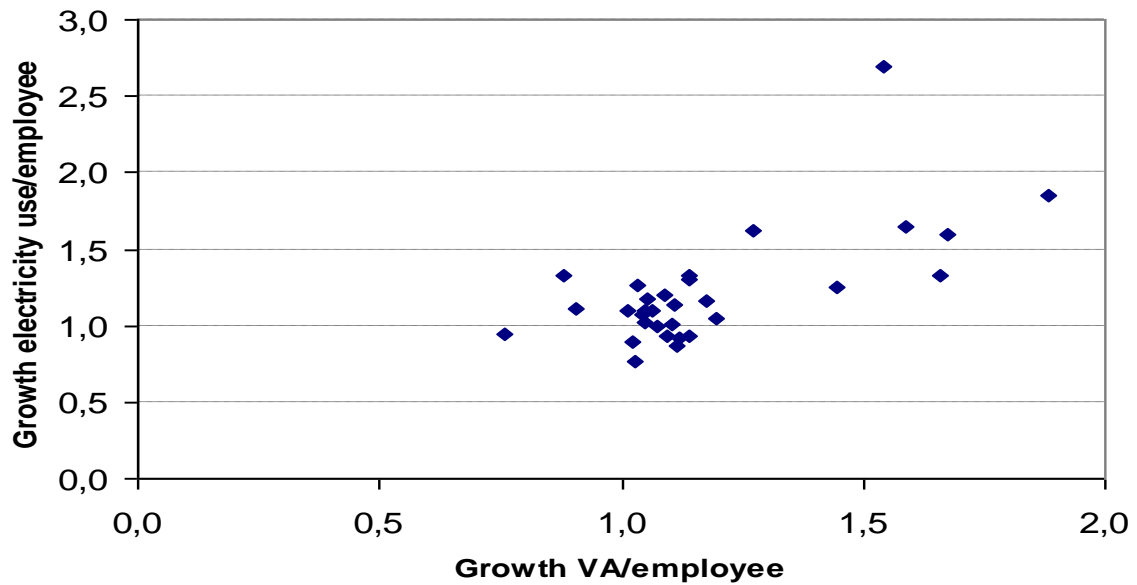
Drivers are explanatory factors that have a direct physical relationship with energy use, such as floor area in buildings and the penetration of air-conditioning or office appliances. Because no information is available for these most suitable drivers, the analysis uses production (value added or VA) and number of employees as drivers. The effect of drivers can be shown in so-called decomposition analyses, where the change for energy use is attributed to changes for the drivers.

Explaining variables are the factors that influence energy consumption indirectly, e.g. energy prices and savings policy. This influence can only be analysed by comparing visually the relationship between the values, or changes, for energy and explaining variables.

Growth in electricity use per employee is coupled to growth in VA per employee

An increase in labour productivity, i.e. VA per employee, will often be accomplished by using more technical systems that use energy, in particular electrical appliances. In the service sector this can regard appliances, such as computers and communication devices, and air-conditioning and lighting systems that provide a better working environment. The relation between increased VA and increased electricity use, both per employee, is visible in **Figure 3-15**. Further analysis reveals that for fuel/heat use per employee and VA per employee no such relationship exists.

Figure 3-15: Value added versus electricity use, per employee, for services

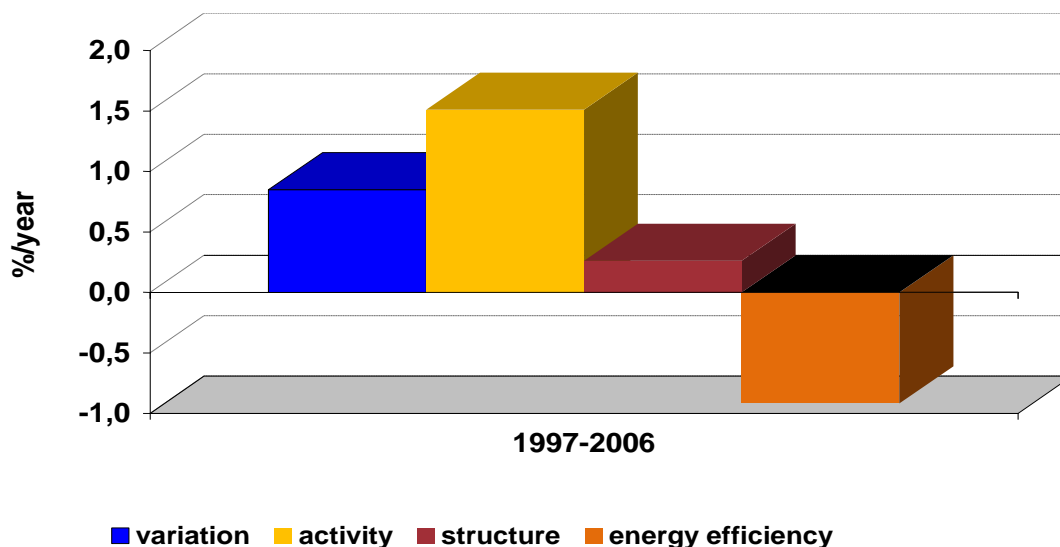


Sector structure often contributes to higher energy use

The service sector consists of subsectors, such as hotels & restaurants, healthcare, education, government administration, trade and commercial services. Some subsectors are more energy intensive than others, e.g. retail-food (with much product related lighting and cooling) versus schools (only used for a limited part of the year). If activities in these subsectors grow faster than on average it will further increase total energy consumption of services.

An example for Denmark is provided in **Figure 3-16**. Energy consumption grows by 0.8% (“variation”). This is the combined result of growth of value added (“activity” +1.5%), the shift between subsectors leading to increased energy consumption (“structure” +0.2%) and energy efficiency gains (-0.9%).

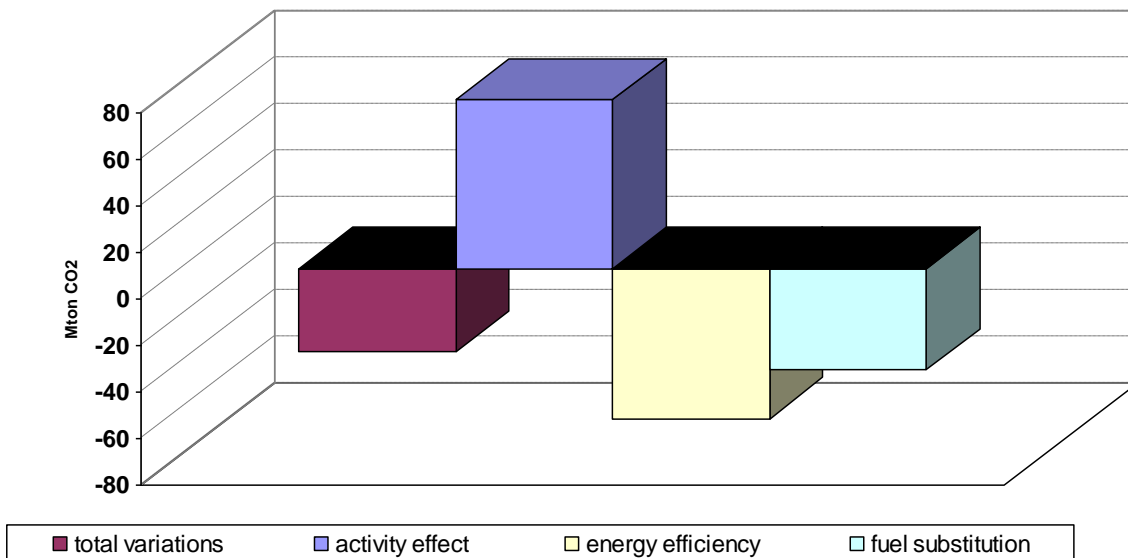
Figure 3-16: Decomposition of energy use for services in Denmark (1997-2006)



Fuel substitution also important for lower CO₂ emissions

Tertiary represents 8 % of CO₂ emissions in the EU-27 in 2007. From 1996 to 2007, the direct CO₂ emissions have decreased by 18% (see “variation” in **Figure 3-17**). The value added has increased by 36 %, which would have implied an increase of 73 Mton CO₂ (see activity effect”). The reduction of CO₂ emissions by energy efficiency and fuel substitution has more than offset the effect of economic growth. Nearly 40 % of these reductions are linked to a switch to natural gas and the increased use of electricity. However, if the indirect CO₂ emissions from electricity production are also taken into account the emissions increase substantially.

Figure 3-17: Decomposition of change in direct CO₂ emissions for Tertiary (EU-27, 1996-2007)



High impact of policy measures probably related to lower unit consumption

For Tertiary sectors no explicit comparison of impact of policy measures and energy efficiency improvement can be made due to lack of data. However, the change in fuel and electricity consumption per employee (see section 3.3) can be compared with the total impact of policy measures (see section 3.6). Best performing countries on unit consumption match more or less the countries with a relatively high total impact of policy measures.

3.8. Observations and lessons learned

- Energy consumption for Tertiary sectors grows in the period 1997-2006, but there is no clear pattern for EU countries. Some new member states (e.g. Romania, Croatia and Bulgaria) show very high growth rates, but the same is true for some EU-15 countries (e.g. Portugal and Greece). Various EU-15 countries show a decrease in energy consumption (UK and Germany), but again the same is true for new member states (e.g. Slovakia and Slovenia).
- The growth rate of EU-27 energy consumption accelerates around 2000. The effect is moderate for most EU-15 countries but substantial for some new member states.
- Coal has virtually disappeared as energy carrier; the contribution of oil has decreased and electricity is becoming the main energy carrier.
- Energy consumption in primary terms increases substantially faster (20%) than final energy consumption itself (12-13%). This is because electricity, which weights heavier in primary terms, increases by 35% while fuel use is stable.
- Value added grows only slightly faster than the number of employees for EU-27. But new member states show a stronger increase in labour productivity (3%/year) which is accompanied by a relatively high primary energy growth.
- With regard to energy intensity, in toe per € value added, there is a clear division between the Eastern European countries and other countries (including Malta and Cyprus). However, if a correction is made for power purchasing parity the intensities come much closer.
- The decrease in energy use per employee (-3%) is in strong contrast with the substantial increase in electricity consumption per employee (+14%). In 1997 new member states used only about half the amount used in EU-15 countries. In 2006 the difference has narrowed considerably (3900 kWh versus 5300 kWh).
- Large increases in electricity use are probably due to the introduction of cooling in summer (all southern countries) or to strong economic growth (Ireland and eastern European countries).
- For the EU-15 countries with a sustained high level of economic welfare the growth in electricity per employee is stable or sometimes decreasing. This could signal that electricity use reaches a saturation level.
- The fuel consumption (including heat) per employee shows differences between countries that are not easily explained, taking into account the type of winter climate or stage of economic development. For changes between 1997 and 2006 the same erratic picture emerges when comparing countries.
- On average European countries deploy ten policy measures to stimulate energy efficiency in tertiary sectors.
- New member states often lag behind with respect to the package of policy measures. Eight countries, almost all new member states, deploy only one or two types of policy measures. The application of at least five measure types is mainly restricted to EU-15 countries.
- Standards (legislative/normative), financial support (financial/fiscal) and information are most applied, but energy taxes and voluntary agreements (cooperative) are hardly used.

- EU wide about half of all policy measures has a broad focus, e.g. general financial support, voluntary agreements or taxes. Less than one-third is targeted at buildings specifically. From these measures almost none are focused at the lighting system or ventilation/air-conditioning.
- Much less EU policy measures are available compared to households (8 versus 40), which is partly due to the EU focus on labels for household appliances.
- On average countries have two policy measures as a result of transposition of EU directives, and two policy measures related to EU policy. In total about 40% of all national policy measures is due to EU policy.
- The EPBD directive was not yet transposed into national legislation in 2006. The Energy Service directive regards the period 2008-2016 and the Ecodesign directive on minimum efficiency standards still has to be set in force. Therefore, apart from the CHP directive, the effect of EU policy has still to be awaited.
- The total impact of all policy measures is the highest for Spain and UK. Germany, Ireland and Austria, with higher numbers of measures, show a relatively lower total impact. The total impact is generally lower for new member states.
- The measures related to standards, financial support and info/education all contribute about 25 % to the total impact. The fiscal/tariffs measure type hardly contributes to total impact.
- The production level (value added) and the number of employees are regarded as the main drivers for energy use. When countries are compared on the increase in VA per employee and the increase in electricity use per employee, a reasonable relationship is visible.
- The Service sector consists of several subsectors, with a different intensity of energy consumption and growth of activity. Available results for a few countries indicate that the shift between production of subsectors (value added) leads to extra energy consumption. However, a firm conclusion is not possible due to lacking data for most countries.
- There probably is a link between the total impact of policy measures for countries, and their decrease in unit consumption or fuel and electricity for 1997-2006
- The data situation generally is fairly poor in the tertiary sectors, in particular for floor area and for data on type of energy use. Therefore no ODEX index for overall efficiency increase could be calculated.

4. Innovative policy measures

4.1. What are innovative measures?

EU countries have introduced a large number of policy measures on energy efficiency in the last decades. Some were quite successful but others were abandoned due to lack of success or high costs. The best practice approach, stimulated by the European Commission, assumes that countries could learn from each others successes. The MURE database on policy measures has been used to find these best practice or innovative policy measures.

Innovative policy measure constitutes more than a new approach

In **Table 4-1** a number of criteria for innovative policy measures on energy savings have been formulated. Representing a new approach is not enough as the innovative policy measure should have the potential to contribute substantially to the savings targets (large savings) in an effective way (effective) but at not too high costs for government (efficient). Moreover, the savings should not disappear after some time (lasting), not lead to extra energy use (rebound effect) and preferably have positive side effects.

Table 4-1: Criteria and selection of innovative policy measures

Criterion	Selection in MURE database
New approach	Analyse items on new approach
Large savings	Select items with high impact
Effective	Test items on meeting the conditions for implementing saving measures
Efficient	Check on financial measure types
Long lasting	Check resulting saving measures on lifetime, select on maintenance or continuous incentive to save
Few rebound effects	Test on type and on profitability of measures
Side effects	Analyse items on non-saving effects

A **new approach** that should work better than conventional policy measures, such as information and subsidy schemes. Examples of a new approaches found in the database are provided in **Table 4-2**. For households chimney sweepers provide a new way of regularly approaching households on energy saving measures. In intelligent homes the (mis)functioning of household electric appliances could be monitored and replacement advised. Mandatory solar water heaters in new dwellings are an alternative to the subsidy schemes applied so far.

Table 4-2: Examples of policy measures using a new approach

Country	Policy measure
<i>Households</i>	
Austria	Chimney sweepers as energy advisers
Denmark	Intelligent home (appliances)
Greece, Italy	Mandatory solar boilers
<i>Tertiary</i>	
Bulgaria, Estonia, Slovakia	Mandatory local program
Denmark	Stop (increasing) trend for electricity

For the public sector an alternative for (voluntary) agreements can be mandatory local energy efficiency programs, coupled to access to financial support, such as in Bulgaria (see **Box 4-1**). Finally, the new Danish approach regards an absolute target, stabilizing the level of electricity use, instead of a relative target (lowering the growth with a certain amount).

Box 4-1: Mandatory Energy Efficiency Action Plans for Municipalities

In Bulgaria the Energy Efficiency Act, adopted in 2004, foresees that the regional governors shall organize the development and implementation of regional programs of energy efficiency and shall carry out interaction with the bodies of the local independent governments and local administrations.

Article 9 describes types of the energy efficiency programs which shall be adopted by the municipal councils (rehabilitation of housing, administrative and utility buildings, introduction of energy saving street lighting and lighting in public buildings and other measures). The mayors shall develop and implement the measures foreseen by the municipal programs for energy efficiency, providing into their budgets objective-oriented resources for their implementation.

Article 11 orders that the central bodies of the executive authority, the regional governors and the other state bodies shall annually draw up expedient programs for implementing measures for energy efficiency and submit them to the Executive Director of the Bulgarian Energy Efficiency Agency.

Policy measures with a **large savings** potential can be found by selecting the high impact measures in the database. Generally high impact policy measures focus on insulation, high efficiency boilers or the combination of the two.

Effectiveness regards the way potential savings are actually realised. Effective policy measures have influence at the right moment (e.g. deciding on renovation of buildings) and the right place (information on efficient appliances in the shop). They address the right target group (manufacturers for minimum efficiency of appliances) or an intermediate party (social housing organisations) and provide the right incentive (social recognition for early adopters and financial savings for laggards).

The most important aspect of effectiveness is meeting all conditions for implementing energy saving measures: *availability* of suitable saving technologies, *knowledge* on these technologies by the appliers, lifting of *restrictions* such as the split incentive between landlord and renter of houses and sufficient *incentive* to choose the saving measure (see **Table 4-3**).

Effective implementation of saving measures demands combinations of policy measures

Policy measures can address the conditions for implementation as follows. *R&D* stimulation can provide the needed saving technologies, with a proper design. *Taxes* only provide an incentive and *agreements* can lift restrictions on implementation (e.g. for housing corporations the split incentives for renters and landlord). *Subsidies* for specific saving measures provide an incentive and turn the attention of energy users to these saving measures. *Information* highlights saving possibilities and can provide an social incentive by informing about the environmental problems it can solve. *Regulation* in the form of mandatory implementation of saving measures addresses (in principle) all conditions for implementation (see forced replacement of the incandescent lamp as part of Ecodesign directive regulation).

Table 4-3: Influence of policy on conditions for implementing saving measures²⁸

<i>Conditions</i> >	Technology available	Known to applier	Restrictions lifted	Incentive to choose
<i>Policy types</i>				
Regulation	x	x	x	x
Subsidies		x		x
Information		x		x
Agreements			x	
Taxes				x
R & D	x			

It can be concluded that often a combination of policy measures is needed to effectively realise saving measures. The exception is regulation, but this is not always applicable when there is a large variation in energy use situation, appliers and conditions.

Efficient policy measures have a reasonable ratio between costs and realised savings. As to costs for appliers of saving measures, all policy measures can lead to high or low costs, depending on the saving measures chosen, the level of energy prices, etc. Therefore these costs are not taken into account when rating policy measures.

²⁸ Actual interaction effects between policy measures for energy efficiency - A qualitative matrix method and quantitative simulation results for households, P.G.M. Boonekamp, Energy (Elsevier), 2006, Volume 31, Issue 14, p.2848-2873.

As to the costs for government, policy measures on financial support for saving measures count the most. Policy measures in the form of energy taxes can compensate for these subsidies. Other policy measures, such as regulation, can have administrative costs. Examples of efficient policy measures are:

- temporarily financial support that leads to new technologies becoming the standard in the market,
- regulation of efficient appliances, heating systems, etc. where everyone can save costs (e.g. stand-by regulation).

Lasting savings come from innovative policies for market transformation

Lasting savings are needed to structurally lower energy consumption. New low energy dwellings or insulation for existing buildings provide lasting savings due to their long lifetime. Therefore innovative policy measures should focus on these saving measures. (see **Table 4-4**). For information campaigns that focus on saving behaviour a lasting effect is not guaranteed. The same can be true for cogeneration as in the Netherlands part of the savings has disappeared due to changing market prices for fuel and electricity. For efficient appliances with a short life time, e.g. computers, a lasting effect can only be attained if efficient versions become the new standard (see market transformation in the UK).

Table 4-4: Policy measures examples on (non) lasting saving measures

Country	Policy measure
<i>Non-Lasting</i>	
Austria, Finland, Germany, Ireland, UK	Information campaign on behaviour
Netherlands	Cogeneration
<i>Lasting</i>	
Various	Standards for new dwellings (100 years)
All countries	Retrofit insulation (> 30 years)
UK	Efficient appliances +market transformation

Financial incentives can lead to rebound effects that erode the initial savings.

Rebound effects erode the initial savings when much money is saved and this money is spent on extra energy using systems or behaviour (e.g. higher thermostat setting after insulation of the house)²⁹. **Table 4-5** shows examples of policy measures with few or much rebound effects. Free CFLs, subsidies for profitable saving measures and energy efficient new dwellings at no extra costs decrease the total energy bill; this creates room for new energy using activities. Energy taxes lead to a small, or even negative, rebound effect when the higher costs due to the tax are not (fully) compensated by the net (money) savings in reaction to the tax. Strict standards that only allow to recover

²⁹Harald Throne-Holst, From energy efficiency to efficiency of consumption?, ECEEE 2005 Summer Study Proceedings. What works & Who delivers? 3 (2005), June 2005, Side: 1205–1210

the investment costs over the life time will not cause a rebound effect either (e.g. an energy neutral new dwelling nowadays).

Table 4-5: Examples of policy measures with different rebound effects

Country	Policy measure
<i>Large rebound</i>	
Italy	Efficient bulbs (CFL) for free
Various	Subsidizes state-of-the-art equipment
Various	Very cost-effective standards for new buildings
<i>Small rebound</i>	
Denmark, UK, Netherlands	Substantial energy taxes
Various	Standards based on life cycle costs

Positive side effects can stimulate implementation of saving measures

Side effects regard positive effects other than improved energy efficiency, e.g. raising the comfort level, increasing traffic safety or strengthening competitiveness (see **Table 4-6**). Positive side effects can stimulate the implementation of saving measures.

Table 4-6: Policy measures in EU-countries with positive side effects

Country	Policy measure	Side effect
<i>Households</i>		
Denmark, Ireland, Slovakia, UK	Focus on saving measures for poor households	Mitigating energy poverty
Various	Forced ventilation with heat recuperation	Improved indoor climate
All countries	Labels on efficient appliances	Saves time to collect information on efficiency
<i>Services</i>		
Various	Daylight sensors in offices	Improved labor productivity
Ireland, Malta, Spain	Efficient street lighting	Lower maintenance costs

4.2. Innovative policy measure types for Households

The following criteria has been used in the selection of most innovative measures:

- Providing large energy savings
- Effective: meeting the conditions for implementing saving measures
- Small rebound effect, lasting savings and positive side effects.

The resulting innovative policy measures are shown in **Table 4-7**.

Standards on (new) dwellings have evolved from prescribing the thickness of wall insulation to overall performance standards. In this way the same savings can be realised in a more cost-effective way, depending on the actual circumstances. Due to the introduction of the Energy Performance of Buildings directive of the EU (EPBD, see box in section 2.9) the few countries without own (performance) standards were forced to introduce them. Strict standards for new dwellings are a powerful tool to realise savings, provided that compliance with the standards is assured. However, the total amount of savings is dependent on the number of new dwellings built (see section 2.4, figure 2.12).

Minimum efficiency standards on appliances can only be formulated at the EU level, due to the international market for electric appliances. The first standard only regarded refrigerators. The Ecodesign directive of the EU will formulate a large number of minimum efficiency standards for all kind of energy using systems and appliances in the coming years (see box in section 2.9). In this way a market transformation is accomplished, with savings at almost no extra costs, and without bothering the consumers with decisions on more or less efficient appliances.

Table 4-7: Innovative policy measure types for households

Country	Policy measure
	Standards on energy using systems
All countries	- dwellings (EPBD)
Various	- appliances (Ecodesign)
Ireland, Italy	- lighting
	Performance programs
Italy, France, Poland	- White Certificates
UK, Belgium	- Commitments
Denmark, Estonia, Greece, Netherlands, Portugal, Spain	Broad action plans
Austria, Denmark, Germany, Hungary, Latvia, Netherlands, Slovakia, Slovenia	Energy or CO ₂ taxes
UK, Ireland, Slovakia, Denmark, Netherlands	Fuel poverty schemes
Denmark, Czech republic, Estonia, Finland, Italy, Latvia	Obligatory inspection / maintenance

The EU now has formulated **minimum efficiency standards for lighting** that forces manufacturers to only offer compact fluorescent lamps (CFLs) instead of incandescent bulbs. Some countries, such as Italy and France had already planned comparable legislation and Ireland planned a levy on incandescent lamps. Here, the same advantages are present as for appliances.

Performance programs oblige parties in the energy field to realise energy savings at the place of energy users. Presently two forms are deployed, a **White Certificate system** and an **Energy Efficiency Commitment** (see **Box 4-2**). In both cases it is believed that these performance programs will deliver more savings at lower costs than with conventional policy measures, like subsidy schemes from the government.

National **Energy Efficiency Action Plans** have been drawn up in 2007 in response to the demands of the directive on Energy End Use Efficiency and Energy Services (ESD). These plans often contain a set of policy measures to stimulate energy saving measures in the different sectors (households, industry, transport and tertiary sectors). Most of the plans are based on, or even equal to, already formulated national action plans (see table). As highlighted in the first section a well designed combination of policy measures will be more effective than individual policy measures.

Box 4-2: White certificate systems and other performance programs

The key players are:

Government

The government sets targets for energy savings and defines the rules of the system. For instance, how energy savings are calculated, who can deliver savings and whether savings are transferable between parties and over time.

Obligated Parties

The suppliers (or distributors) of gas and electricity have an obligation set by the responsible authorities, to save a certain amount of energy within a specified period (by their own actions or by other parties). In case of White Certificate systems they have to surrender certificates to prove the obliged savings.

Eligible Actors

In case of White Certificate systems these actors have no obligations, but can obtain certificates for their realised savings and participate in trading. These actors can be ESCOs, local authorities, large consumers, etc.

Examples of performance programs:

UK, Energy Efficiency Commitment (EEC)

It is structured in three obligation periods, each lasting three years (2002-2005, etc.). The systems does not use tradable certificates but savings are transferable over time. The system also has a special focus on alleviation of Fuel Poverty.

Italy, White Certificate

Electricity and natural gas distributors must demonstrate that they have directly or indirectly achieved the energy savings according to annual targets. The current phase of the scheme runs from 2005 to 2009.

France, White Certificates

The obligation is imposed on suppliers of electricity, gas, heat, cold and domestic heating oil. Eligible savings regard cumulative savings over the lifetime of the measure, but future savings are discounted.

A number of countries has introduced **energy and/or CO₂ taxes** (e.g. the Netherland, Denmark and, more recently, UK) that increase energy prices for end-users. Especially the shifting of taxes on labor to a tax on energy use is innovative as it does not decrease the income of households and companies. A large advantage of substantial

taxes is that it also steers the economy in a less energy intensive direction and stimulates innovation on energy efficient technologies.

Far reaching policy on energy savings can lead to **energy poverty**, high costs that are difficult to cope with by poor families. Moreover, poor families pay relatively much money for energy due to the low quality of the houses. Therefore a specific policy on poor household must be part of savings policy. Some countries already have (conventional) policy measures in place that combat energy poverty as well. Examples are the UK fuel poverty schemes and the Scheme for households with low income from Slovakia.

Finally policy measures on **inspection and maintenance** are needed, in order to assure that the potential savings of efficient systems are realised in the longer term. The EPBD asks for regular inspection and maintenance of boilers and air-conditioning.

4.3. Innovative policy measure types for tertiary sectors

About the same criteria as for households are valid for tertiary sectors. But here less attention is needed for rebound effects and more to tailor-made solutions that fit the large diversity in energy use. The innovative policy measures are shown in **Table 4-8**.

Table 4-8: Innovative policy measure types for tertiary sectors

Country	Policy measure
	Standards on energy using systems
All countries	- buildings (EPBD)
Ireland, Germany	- appliances (Ecodesign)
	Performance programs
Italy, France	- White Certificates
Austria, Hungary, Poland, Slovenia	- Energy Performance Contracting
Austria, Ireland, Malta, Netherlands, Portugal, Spain	Broad action plans
Austria, Croatia, Denmark, Estonia, Germany, Hungary, Latvia, Netherlands, Slovakia, Slovenia, UK	Energy or CO ₂ taxes
UK, Netherlands	CO ₂ emission trading (non-ETS)
Denmark, Finland, Ireland, Slovakia	Obligatory inspection / maintenance

Standards for buildings are requested by the EPBD and taken up by all European countries as described for households. **Standards for appliances** regard only some office appliances but the Ecodesign directive could be extended to all energy using systems. The existing **White Certificate systems** do focus also on tertiary sectors; it regards mainly the public sector. For commercial sectors **Energy Performance**

Contracting is a new way of realising energy savings. In both cases an **ESCO** (see **Box 4-3**) can play a role in providing a tailor-made approach. This last property is generally not valid for the **broad action plans** of governments and agencies. That's possibly the reason that national action plans focus relatively less on tertiary sectors with their very diversified energy use and characteristics. **Energy or CO₂ taxes** for tertiary sectors do not affect competitiveness because the companies are not energy intensive and most do not compete in the international market. But so far substantial tax levels that really count have been applied in a few countries only. A very new and promising policy measure is **national emission trading** for energy users that are not part of the European emission trading scheme. The Dutch horticulture sector itself has proposed such a scheme, probably because it fits better to their needs and possibilities. In the UK the CO₂ Reduction Commitment demands from actors to reduce emissions, possibly by energy savings. Finally, for **inspection and maintenance** the same holds as for households, i.e. safeguarding the potential savings from new systems.

Box 4-3: Energy Service Company (ESCO)

The Energy Service directive (ESD) promotes ESCO's as a way to obtain more energy savings. Realising energy savings by end-users themselves is often difficult due to lack of knowledge on saving options, no guaranteed savings, problems with financing and split incentives. Government agencies, information centres, installation companies, distribution companies, etc. can only partly solve these problems. The idea is that energy savings are a market where specialised actors (ESCO's) can earn money by offering energy efficiency services to energy users.

An ESCO saves energy at the site of the energy user according to an agreement. The ESCO can deliver various "products":

- energy scan or audit
- development of investment plan
- providing finance (from ESCO or third party, e.g. bank)
- implementation of saving measures
- monitoring & optimisation

In return for the "product" energy savings the ESCO will get a fee. For Energy Performance Contracting (EPC) the fee is dependent on the (cost) savings realised. In case of the ESCO making the investments, the contract defines the pay back of investment.

Currently there is a market for energy efficiency services in several countries (see survey on ESCO's by Bartoldi). Most ESCO's focus on the public sector, e.g. street lighting or office buildings, but some save energy in industrial companies.

4.4. Conclusions

For innovative policy measures in residential and tertiary sectors it can be concluded:

- Innovativeness of policy measures means more than a new, not yet applied, approach. It should regard a substantial energy savings potential and effective realisation. Therefore innovative policy measures should meet all conditions for implementing saving measures: make saving technologies available and known to the appliers, lift restrictions and provide sufficient incentives to actually implement them. Savings policy should not have too high costs (cost efficient) which is relevant for financial support and energy taxes. The innovative policy measures should also focus on lasting savings, without too much rebound effects that erode initial savings. Finally, they should take account of the social problems (energy poverty) and preferably attain positive side effects, such as a better indoor climate.
- Many of the policy measures in the MURE database do not fulfil the criteria for innovativeness. One important reason is that they do not constitute a coherent combination that addresses all conditions for implementing saving measures mentioned above.
- For household the most innovative and effective policy measures are performance standards on new dwellings and appliances, performance programs such as White Certificate systems and broad action plans with the right combination of policy measure types. However, the effectiveness and (cost) efficiency will depend on a suitable set-up of the programs, continuation for years and thorough monitoring & evaluation.
- Taxes on energy or CO₂, policy measures to combat energy poverty and policy measures on inspection and maintenance should complement the innovative policy measures. In this way daily energy behaviour can be influenced, negative side effects removed and new energy-intensive activities discouraged.
- For the tertiary sectors more or less the same innovative policy measures are valid. Here Energy Performance Contracting using ESCOs (Energy Service Companies) is of importance because the whole process of implementing saving measures can thus in one hand. A proposal for emission trading (besides the European ETS) connects energy savings explicitly to the greenhouse problem.

5. Glossary of calculations issues

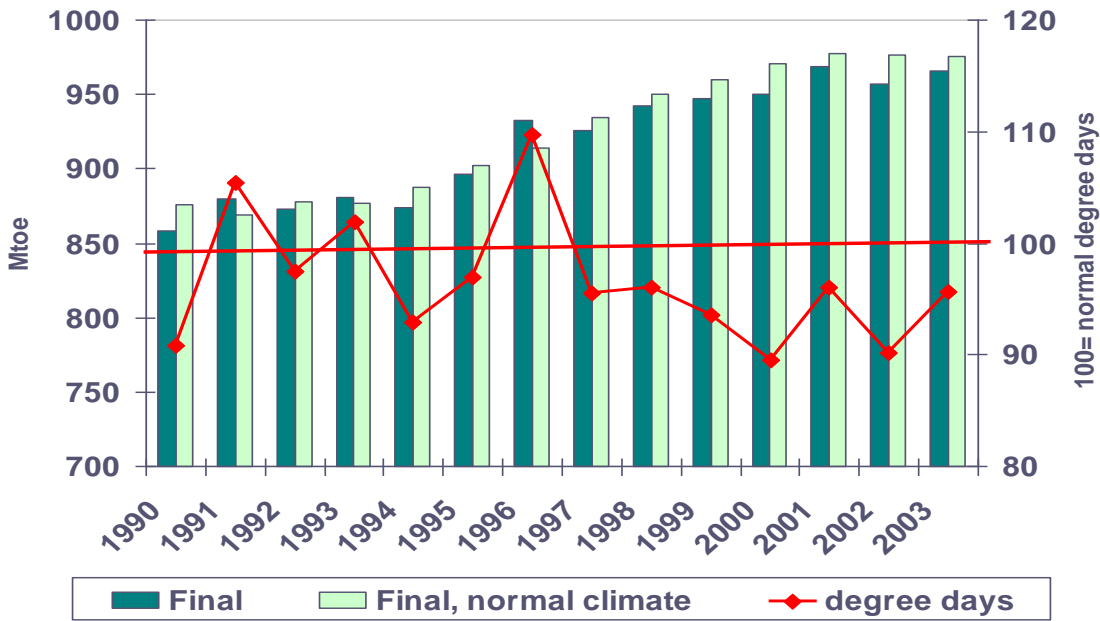
- **Yearly climatic corrections**

The average outdoor temperature during the heating season varies from year to year. This distorts the analysis of the influence of man-made factors, which is the purpose of the analysis. Therefore, climatic corrections are necessary before that any interpretation can be made. The correction only regards energy use for space heating; other energy use is not influenced by temperature differences. The yearly energy consumption is corrected for variations in year-to-year average temperature, expressed in HDD (Heating Degree Days), where a day with an average temperature x degrees below the threshold of 18 degrees counts as x HDD. The correction factor is equal to total HDD in a year against a 30-year average.

In ODYSSEE, climatic corrections are carried out for all countries using the same methodology, even if climate corrected national data exist (e.g. France, Denmark). For each country the correction is done on their ratio between the 30-year average and the actual degree-days.

Figure 5-1 shows how the methods works. The red line denotes the number of HDD against the average for EU-27. It appears that since 1990 there were only three years with relative cold winters. For these years corrected energy consumption is lower than the actual value. For the other years the corrected value is higher than the observed figure. The bars in the figure show that yearly fluctuations in energy consumption are smaller after correction.

Figure 5-1: Yearly HDD and (climate corrected) energy consumption (EU-27)

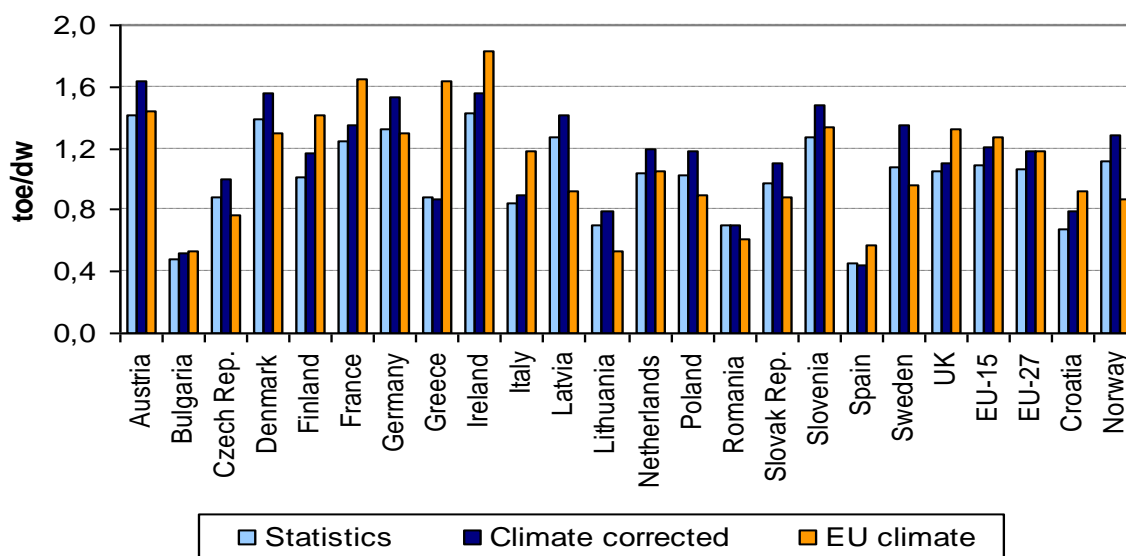


- **Climatic corrections for differences between countries**

Countries with cold winters will often show higher energy use than countries with mild winters. In order to make a “fair” comparison of energy consumption per country these differences should be removed. The (climate corrected) energy use for a country is corrected in conformity with the difference in HDD over a 30-year period between the country and EU-27. The correction is applied on energy use for space heating only, as was also the case for yearly variations.

Energy use per dwelling for space heating is presented for all countries in **Figure 5-2**. Countries in southern Europe show relatively low energy use (see “Statistics”). After correcting for variations in yearly climate all country figures increase because the winter in 2000 was relatively mild in Europe (see “Climate corrected”). The adjustments to average European climate (see “EU climate”) leads to a substantial shift in relative positions. Energy use of Latvia increases and energy use of Sweden decreases, resulting in about the same level of energy use for space heating.

Figure 5-2: Energy use for space heating per dwelling (2000): statistics, climate corrected and for EU-27 climate



- **Primary energy consumption**

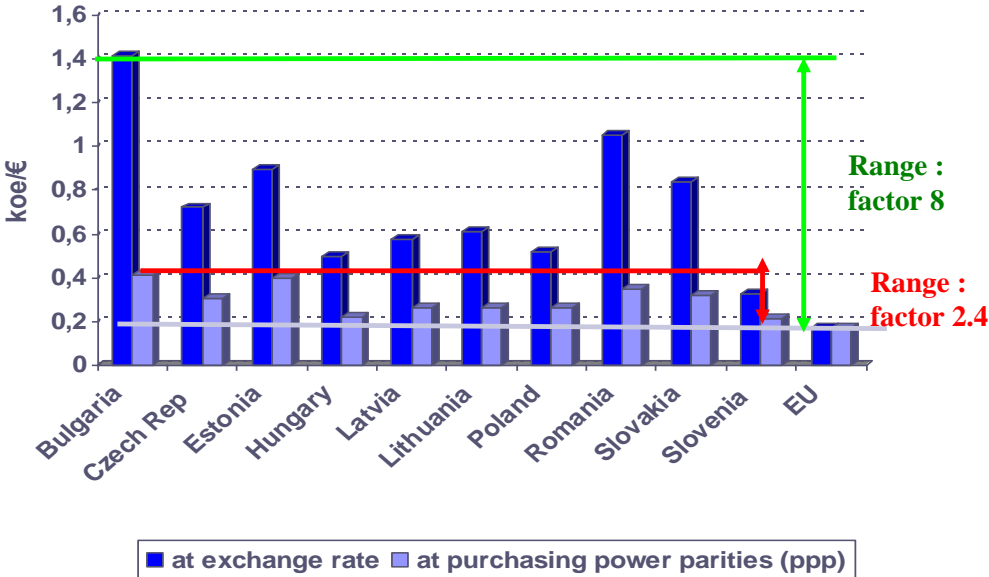
Total energy consumption is the sum of the heat content of all energy carriers used. Electricity is treated in the same way as fuels although it can be used more efficiently than fuels. For instance, electric room heating has a conversion efficiency of 100% while the efficiency of stoves or boilers is (much) lower. But the use of one unit of electricity demands about 2.5 units of fossil fuel when produced in thermal power stations based on fossil fuels (with about 40% conversion efficiency). Delivery of

fuels, such as oil or gas, to end-users causes much less conversion losses. Thus, energy consumption figures, based on heat content only, do not show the real burden on energy supply. To provide a more realistic picture of energy use trends, the energy consumption figures should be converted into primary energy units. This is done only for electricity delivered to end-users. The EU wide electricity production system is mainly based on fossil fuels but also deploys nuclear power, with a higher primary factor than fossil, and hydro/wind with a lower primary factor than fossil. Therefore here is an average factor of 2.5 is used for electricity.

- **Correction of economic performance**

The economic performance of EU countries, e.g. GDP/capita or income per household, differs substantially between EU-15 and new member states. Given comparable energy consumption this leads to large differences in energy intensity values (see **Figure 5-3**). However, in practical life the differences in production and income are not always experienced as such, because prices of goods and services are relatively low in the new member states. Therefore, economic quantities are adjusted for power purchase parity (PPP) for reasons of comparability. If the PPP correction is applied to the new member states the energy intensities decrease and the difference with EU-15 is much smaller (see **Figure 5-3**).

Figure 5-3: Energy intensity of new member states with/without PPP correction



The PPP correction can be applied to EU-15 countries as well, but the effect on energy intensity is small or absent due to the “normal” and comparable price level in these economies.

- **Overall energy efficiency index ODEX**

The energy efficiency trends by subsector or type of end-use are aggregated into a single indicator called ODEX (“ODyssee indEX”) by main sector (industry,

households, transport and services). From the ODEX per end-use sector an overall ODEX is derived which represents the total efficiency improvement. The ODEX values are calculated from the indicator values (unit consumption indices), weighting them by the corresponding energy use. The weighting factors, equal to the fraction of each end-use category in total energy use, are calculated for each year.

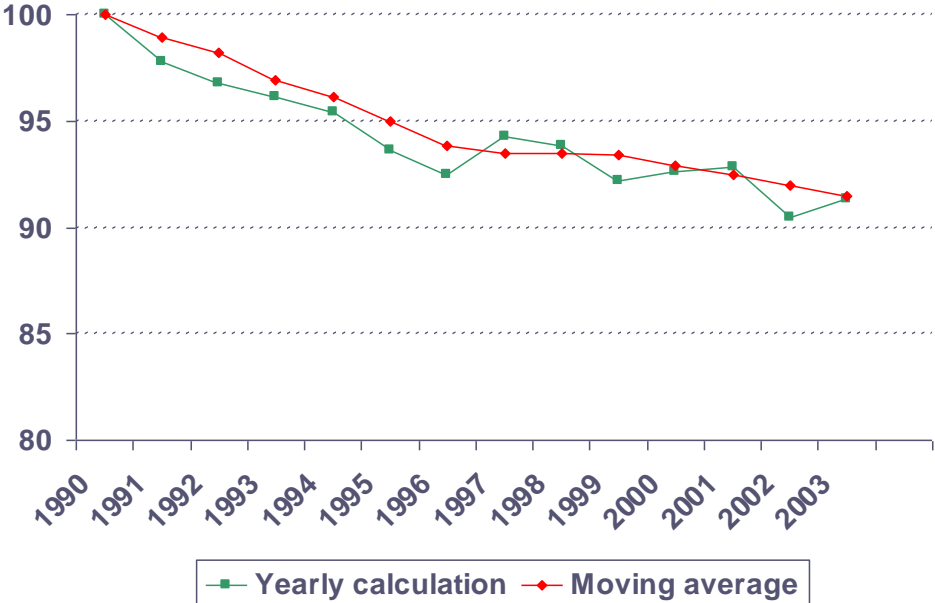
As indices are used, it is possible to combine different units for unit consumption to provide the best proxy of energy efficiency, e.g. toe/dwelling, koe/m², or kWh/appliance for households. A decrease in the index means an energy efficiency improvement: a value of 85 in 2004, for instance, means a 15 % efficiency improvement compared to the base year (1990). ODEX provides an alternative indicator for energy intensities (industry and transport) or unit consumption (per dwelling for households) to describe the overall trends by sector.

Energy efficiency gains are measured in relation to the previous year, and not to a fixed base year to avoid having results influenced by the situation in the base year. It is calculated as a 3 years moving average to avoid short-term fluctuations (imperfect climatic corrections, behavioural factors, business cycles).

- **Moving average indicators**

Year-to-year values of indicators can fluctuate due to the limited accuracy of the input data used. Moreover, the value for the most recent year is often uncertain due to the preliminary character of statistical data. The presented yearly figures could lead to ill-conceived conclusions on year-to-year trends of cumulative changes over the period. To avoid this, the yearly figures are converted into three-year moving average values. The example in *Erreur ! Source du renvoi introuvable.* shows that the trend is more stable and is less influenced by (uncertain) changes for the end year.

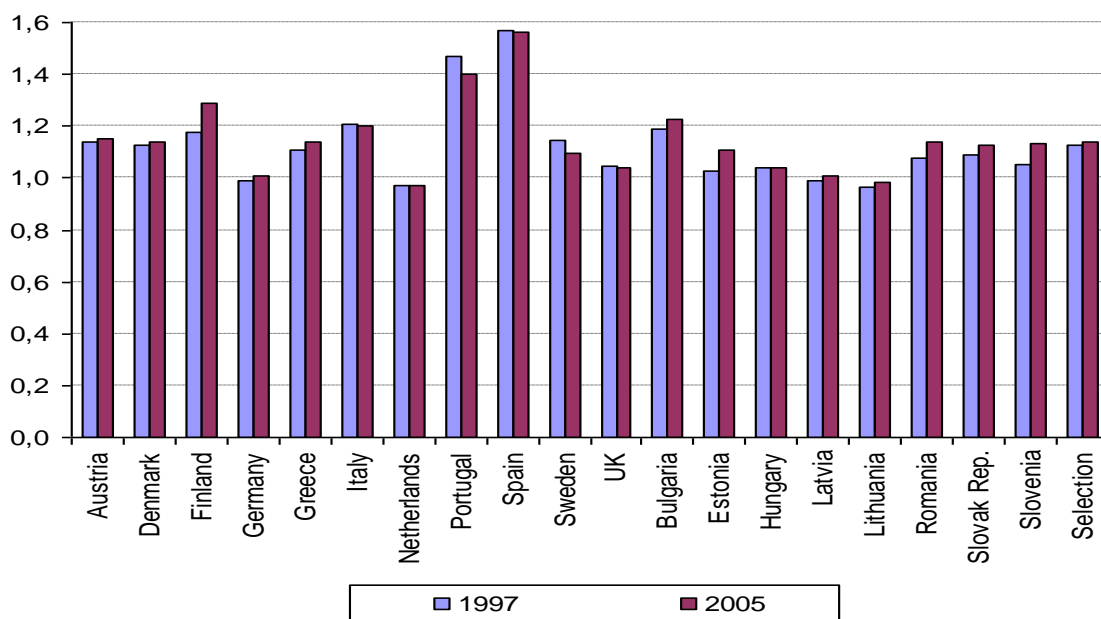
Figure 5-4: ODEX-Households, yearly and 3-years moving average values



- **Differences between numbers of dwellings and households**

Due to second dwellings the number of dwellings per household is >1 for many countries (see **Figure 5-5**). The very high number for Spain and Portugal is probably due to (privately owned) holiday dwellings. The Dutch number < 1 is due to households living in other buildings than dwellings. Because the occupation rate of second dwellings is quite low, the analysis focuses on continuously occupied dwellings. The number of occupied dwellings is about equal to the number of households.

Figure 5-5: Ratio of dwellings to households (selected countries)



- **List of energy indicators for households**

It regards the following set of indicators:

- Space heating: unit consumption per m² floor area at normal climate
- Water heating: unit consumption per household
- Cooking: unit consumption per household
- Electricity use per refrigerator
- Electricity use per freezer
- Electricity use per washing machine
- Electricity use per dishwasher
- Electricity use per clothes dryer
- Electricity use per TV.

