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# Energy Consumption and Energy Efficiency Trends in the EU-28 2000-2014

*Efficiency Trends of Energy-related Products and Energy Consumption in the EU-28*


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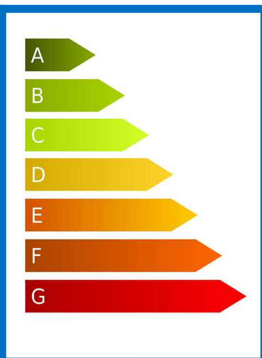
**2016**

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Abstract

**Title:** Energy Consumption and Energy Efficiency Trends in the EU-28 2000-2014

This report aims at showing the present status of energy consumption in the EU-28, in the four main energy consuming sectors: residential, tertiary, transport and industry. During the last years, there have been efforts by the European Union to cut down on energy consumption and improve energy efficiency. From 2000 to 2014, there have been various initiatives that aim at reducing final energy consumption. Therefore, the report demonstrates the energy consumption progress from 2000 to 2014 in the mentioned four sectors:

- The EU final energy consumption registered the lowest value over the period from 2000 to 2014 in 2014. Per first time the EU final energy consumption is below the EU energy targets for 2020.
- Energy indicators such as energy intensity and energy consumption per capita have reduced, turning the EU into a more competitive actor.
- Four EU Member States (i.e. Germany, France, United Kingdom and Italy) consumed over 50% of the final energy consumption and fourteen EU Member States consumed more than 90% of the total final energy consumption in 2014.

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# Executive summary

## Policy context

The report is set in the context of the legislative framework which relates to energy efficiency in the EU-28. The main horizontal policy measures implemented at European level that aim to directly or indirectly improve energy efficiency in the different covered economic sectors (i.e. residential sector, tertiary sector, transport sector and industry sector) are: the Energy Efficiency Directive, the Energy Performance of Buildings Directive, the Eco-design Directive, the Energy Labelling Directive, the Directives establishing an Emissions Trading Scheme in the European Union; the Effort Sharing Decision, the Renewable Energy Directive, the Industrial Emissions Directive, and the Regulation regarding $CO_2$ emissions of new passenger cars.

This report acquires its relevancy as it aims at: analysing the EU energy consumption, identifying the energy efficiency trends and including analysis of energy efficiency of energy-related products. All in the framework of the EU energy consumption targets within the Europe 2020 strategy.

## Key conclusions

In the period from 2000 to 2014, the European Union has reduced its energy consumption. This decrease has allowed reducing energy indicators such as energy intensity and energy consumption per capita, turning into a sign of higher competitiveness as global actor. In 2014, the EU has already met the target values set in the EED for 2020 in terms of final energy consumption (1,061 Mtoe in 2014 vs 1,086 Mtoe of the target) and it is on track to reach the target value for primary energy consumption (1,505 Mtoe in 2014 vs 1,483 Mtoe of the target; corresponding to a gap of 1.5% gap). Over this period, the financial and economic crisis has caused remarkable change in the dynamics and growth rates of the different economic sectors and in the EU Member States and it has contributed to get the energy consumption back on track towards the EU energy and environmental targets for 2020. Distinguishing by economic sectors, the tertiary sector is the only economic sector which has increased its final energy consumption over the analysed period; whilst the others (i.e. residential, transport and industry sectors) have declined it. The increasing trend in the tertiary sector is expected to continue as per the on-going tertiarization process in the EU. On the other hand, the decreasing trends in transport and industry sectors have been highly influenced, among others, by the financial and economic crisis. Regarding the greenhouse gas emissions, the transport sector has increased its emissions from 1990-2013. In the residential sector, the energy demand depends on weather and climate conditions, although there are multiple affecting factors in the energy consumption such as building characteristics (i.e. building envelope, insulation level, location, etc.) or social and cultural reasons (lifestyle, habits, etc.) among others. The analysis of residential Energy-related Products explains the trends in the energy consumption of these products. Therefore, the market monitoring is a supportive tracking tool which may enhance the impact assessment of the energy products policies in terms of market penetration, market sales and consumer purchasing habits.

## Main findings

The EU final energy consumption registered in 2014 was the second lowest value (after 1994) over the 25-years period from 1990 to 2014. When analysing the overall EU energy consumption trends, the individual growth rates of the EU-28 MSs may not be representative as 4 Member States (i.e. Germany, France, the United Kingdom and Italy) consumed over 50% of the final energy consumption and 14 Member States (half of the European Union States) consumed more than 90% of the total final energy consumption in 2014. By sectors: 2014 registered the lowest residential final energy consumption since 1990.

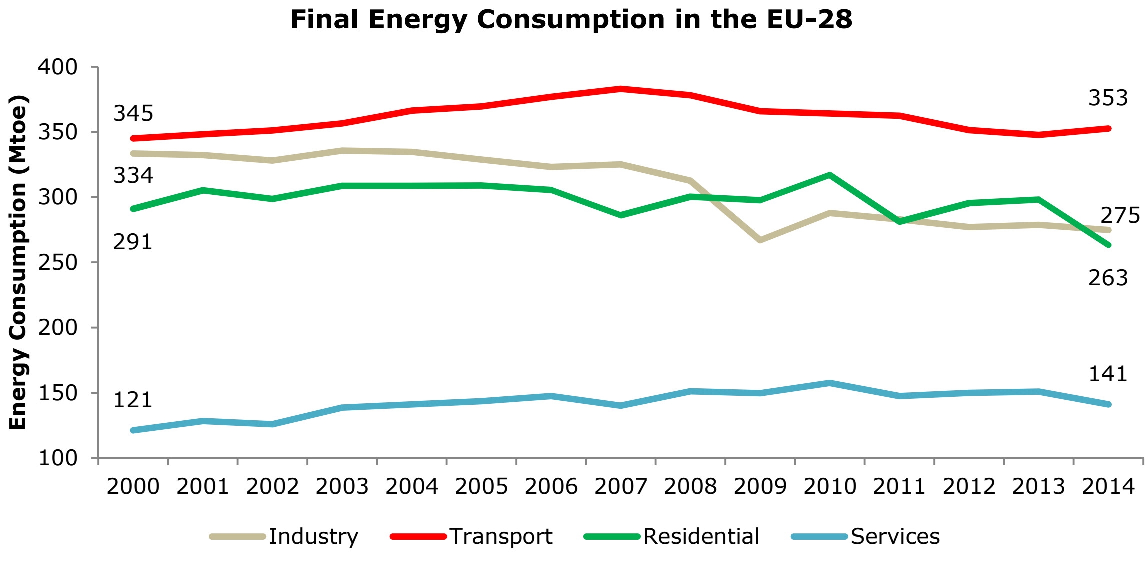


**Figure: Final energy consumption in the EU-28, 2000-2014**

The tertiary sector is registering the highest energy consumption values for the period 1990-2014 from 2008 onwards; with the exception of year 2014. The transport sector is registering the lowest energy consumption numbers for the period 1990-2014 since 2008 onwards. There has been a complete reverse in the energy consumption dynamics from 2008 for the period 2000-2014. It may be result of the impact financial and economic crisis. Road transport and within this cars represent the main consuming transport subsectors. The results show that biofuels (especially biodiesels) have highly developed from 2000 to 2014; while diesel and gasoline are the main fuel types. The industry sector registered the second lowest (after 2009) final energy consumption in 2014; and since 2008 onwards is registering the lowest values for the period 1990-2014. In overall, the industry reduction in final energy consumption has been mostly produced due to an output production reduction as show the trends of the Industrial Production Indexes and the sector's added value to GDP.

## Related and future JRC work

The report provides with an analysis of the energy consumption and energy efficiency trends with the latest available data. Therefore, future updates of this report are foreseen (e.g. analysis for the periods 2000-2016, 2000-2018 or 2000-2020). In addition, a more thorough analysis of each analysed economic sector and case studies of the EU28 Member States might be made, together with specific research topics on, for instance: EU District Heating Production or Energy-related Products (e.g. domestic/industrial appliances, electric motors and drives, etc.).

## Quick guide

This report presents the analysis of the energy consumption trends in the four main energy consuming sectors (i.e. residential, tertiary, transport and industry) in the EU for the period from 2000 to 2014[1]. During the last years, there have been efforts by the European Union to cut down and reduce on energy consumption and improve energy efficiency. Thus, this analysis is needed in order to evaluate whether the different policy actions have influenced the energy consumption patterns. The results and findings of the

[1] It has to be pointed out that Eurostat data considered for 2014 are preliminary data released as of March 2016. When writing this report, final Eurostat data for 2014 were expected to be released by April 2016. For some EU Member State these final data might in principle be slightly different from the preliminary data considered in this study.

report may be the starting point for further analysis such assumptions or projections on future energy consumption trends up to relevant dates (e.g. 2020, 2030 or 2050).

# 1. Introduction

One of the five ambitious objectives of the European Union regarding the strategy for *Europe 2020* focuses on climate and energy, and energy efficiency is at the heart of the EU's Europe 2020 Strategy for smart, sustainable and inclusive growth[2].

The EU sets three key targets based on climate change and energy sustainability for 2020 which are the so-called '20-20-20' targets:

- 20% cut in greenhouse gas emissions from 1990 levels;
- 20% of EU energy consumption share produced from renewable resources;
- 20% improvement in energy efficiency on the EU primary energy consumption[3].

Therefore, energy efficiency has become one of the main policy goals in the European Union and its objective of 20% reduction on primary energy consumption was identified in the Commission's Communication on *Energy 2020*[4] as a key step towards achieving our long-term energy and climate goals.

In order to achieve the EU energy targets set for 2020 and to continue the pathway to the EU energy targets for 2030[5] which are:

- 40% cut in greenhouse gas emissions compared to 1990 levels;
- at least a 27% share of renewable energy consumption;
- at least 27% energy savings compared with the business-as-usual scenario[6].

Many important EU directives and regulations to promote energy efficiency have been implemented or are in the planning phase just before implementation. Furthermore, the EU Member States (MSs) have been very active in the area of energy efficiency at the national level by implementing many policies and measures.

The EU 20% energy saving target for 2020 was first introduced by the European Commission (EC) in its 2005 Green Paper on Energy Efficiency or Doing More With Less[7], where it was indicated the cost-effective potential supported by several studies.

In 2006, the Action Plan for Energy Efficiency[8] proposed a set of energy efficiency policies at EU level to reach the 20% energy saving target by 2020. It was in March 2007 when the EU leaders committed themselves to transform Europe in a highly energy-efficient, low carbon economy and agreed on the above mentioned targets by 2020.

The Energy End-use Efficiency and Energy Services Directive[9] (ESD) introduced the indicative energy saving target of 9% over a 9 year period 2008-2016. Each MS had to adopt an indicative target for end-use efficiency of at least 9%. This target has been set and calculated in accordance with the method set out in Annex I to the Directive, i.e. it is based on the average final energy consumption of five past years (2001-2005). The target excludes some end-use sectors such as industry sector under ETS. A number of MSs introduced targets for 2016 higher than 9%. The target does not include efficiency improvements in the energy supply (e.g. generation), although some renewable energy sources and cogeneration were included.

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[2] COM(2010) 2020

[3] 7224/1/07 REV 1: Presidency Conclusions of the European Council of 8/9 March 2007. This objective translates into a saving of 368 million tons of oil equivalent (Mtoe) of primary energy (gross inland consumption minus non-energy uses) by 2020 compared to projected consumption in that year of 1842 Mtoe. This objective was reconfirmed by the June 2010 European Council (17/6/2010 Nr: EUCO 13/10).

[4] COM(2010) 639

[5] COM(2014) 15

[6] Business as Usual scenario modelled with Primes in 2007.

[7] COM(2005) 265

[8] COM(2006) 545

[9] Directive 2006/32/EC

The Directive introduced the framework of a National Energy Efficiency Action Plan (NEEAP) which each MS had to adopt in order to reach the 9% ESD energy saving target. At the time of the ESD adoption only a few MSs had the experience to prepare and adopt NEEAPs. Three NEEAPs were foreseen by the ESD, one in 2008, one in 2011 and a final one in 2014. The NEEAP[10] should be a strategic document showing a coherent set of policies and measures needed in a specific MS to reach the 9% target. In addition, the second and third NEEAP should include a thorough analysis and evaluation of the preceding EEAP. Each MS had also to appoint at least one new or existing independent public sector authority or agency to ensure overall monitoring of the process set up to achieve these targets.

In order to meet the EU 2020 target and given the somewhat slow progress by MSs in implementing energy efficiency policies to meet the 2020 target, the Commission proposed on 22 June 2011 a new Directive to step up Member States efforts to use energy more efficiently at all stages of the energy chain – from the transformation of energy and its distribution to its final consumption. That was the Energy Efficiency Directive[11] (EED) which was adopted in December 2012 and repealed the previous ESD. The EED contains a set of binding measures such as: legal obligations to establish energy saving schemes in Member States, public sector to lead by example, energy audits, energy services, energy efficiency funds, efficient CHP, metering and billing information, consumer behaviour, etc.

One of the key articles of the Directive is Article 3, setting the target values for 2020 in terms of energy consumption: the Union's 2020 energy consumption has to be no more than 1,483 Mtoe of primary energy or no more than 1,086 Mtoe of final energy[12]. Targets which have been already met for final energy consumption (1,061 Mtoe of final energy consumption in 2014); while the EU is very close to reach the primary energy consumption target (1,505 Mtoe of primary energy consumption in 2014; corresponding to a gap of 1.5%).

Another key article is Article 7, introducing Energy Efficiency Obligation schemes (EEOSs) mandating distributors and/or retail energy sales companies to reach energy savings targets or use alternative policy measures to deliver a targeted amount of energy savings amongst final energy consumers. The energy savings to be achieved by EEOs shall be at least equivalent to achieving new savings each year from 1 January 2014 to 31 December 2020 of 1.5% of the annual energy sales to final consumers of all energy distributors or all retail energy sales companies by volume, averaged over the most recent three-year period.

Another important energy efficiency policy action at EU level has been the introduction of minimum efficiency requirements for products. The Eco-design Directive[13] is the EU framework legislation that allows the introduction of energy efficiency requirements for energy related products such as residential appliances, lamps, consumer electronics, ICT equipment, etc. Since the first Eco-design Directive[14] was introduced a number of implementing Regulations have been adopted introducing efficiency requirements for residential appliances (e.g. refrigerators, freezers, washing machines, dishwashers, etc.), lamps, televisions, air-conditioners, heaters and water heaters, power transformers and ventilation units among others[15]. Efficiency requirements have been

[10] The evaluation of the quality of NEEAPs and the saving reported is not in the scope of the present report.

[11] Directive 2012/27/EU

[12] The indicated value refer to EU-28. When the EED was introduced the values were referred to EU-27 and were: 1,474 Mtoe of primary energy or no more than 1,078 Mtoe of final energy.

[13] Directive 2009/125/EC

[14] Directive 2005/32/EC

[15] For the updated list of the Regulations adopted and the products covered by efficiency requirements under the Eco-design see: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf

complemented by mandatory energy labelling[16] use as established in the Energy Labelling Directive[17]. Energy labelling of residential equipment was first introduced in 1992[18], with the first energy label introduced in 1994 for refrigerators. Energy label has contributed to enlarge the market for efficient appliances[19] [1]. The combination of Eco-design and energy labelling has been successful in substantially improving energy efficiency of residential equipment and this result in energy savings compared to a business as usual scenario [2].

The main EU policy for both residential and non-residential buildings is the Energy Performance of Building Directive[20] (EPBD) which was introduced firstly in 2002 and then recast in 2010[21]. Under this Directive, Member States shall implement at national level a set of measures regarding: energy performance certificates to be included in all advertisements for the sale or rental of buildings; regular inspections of heating and air-conditioning systems; all new buildings must be nearly zero-energy buildings by 31 December 2020 (new buildings occupied and owned by public authorities by 31 December 2018); introduce a set of minimum energy performance requirements for new buildings, for the major renovation of buildings and for the replacement or retrofit of building elements (i.e. heating and cooling systems, roofs, walls, etc.); Member States have also to implement measures and other instruments of national financial incentives to improve the energy efficiency of buildings.

It is within this legislative framework where the present report acquires its importance, as it aims at showing the present status and existing trends in energy consumption along the EU-28 Member States, in the four main energy consuming sectors: residential, tertiary, transport and industry. In the residential sector, a special focus on the electricity consumption of main household appliances and equipment is carried out. Also, in the industry sector, an analysis of electricity consumption by electric motors and drives is provided. During the last years, there have been efforts by the European Union to cut down and reduce on energy consumption and improve energy efficiency.

From 2000-2014, there have been various policies that aim at reducing final energy consumption. Therefore, the present report demonstrates the energy consumption progress from 2000-2014 in the mentioned sectors. Besides the final energy consumption, electricity and gas consumption are analysed. In addition, the report summarises the most recent policy actions introduced at EU level regarding energy efficiency and energy consumption.

The report consists of eight chapters. The second chapter provides with data for gross, primary and final energy consumption such as energy supply composition and energy drivers as energy intensity and energy per capita across the EU-28 Member States. This comparison gives insights about energy consumption and efficiency level that take place throughout the delivery and transformation of the energy for the final end use. Chapter 3 introduces the main horizontal policy measures implemented at an EU level that aim to directly or indirectly improve energy efficiency in the main consuming economic sectors, i.e. residential, tertiary, transportation and industry. Chapter 4 analyses the final energy consumption in the residential sector. The analysis includes consumption drivers such as economic growth, population, heating demand, household's characteristics, energy prices with the aim of analysing their influences in the consumption trends qualitatively; it is also given an analysis of energy efficiency status in energy related products (i.e. domestic appliances and lighting). Chapter 5 focuses on the tertiary sector and provides

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[16] For the updated list of the Regulations adopted and the products covered by energy labelling see: https://ec.europa.eu/energy/sites/ener/files/documents/list_of_enegy_labelling_measures.pdf

[17] Directive 2010/30/EU

[18] Council Directive 92/75/EEC

[19] There is an on-going energy labelling directive revision process (see COM(2015) 341 final).

[20] Directive 2002/91/EC

[21] Directive 2010/31/EU

with an overview of the energy consumption changes. Chapter 6 analyses the energy consumption trends in the transport sector with a focus on the road sector and the $CO_2$ emissions produced by the sector. Chapter 7 provides with an overview of the main changes in the industry sector and subsectors regarding the energy consumption and production output. Last, chapter 8 corresponds to the conclusions and findings of the report.

## 2. Gross, Primary and Final Energy Consumption in EU-28

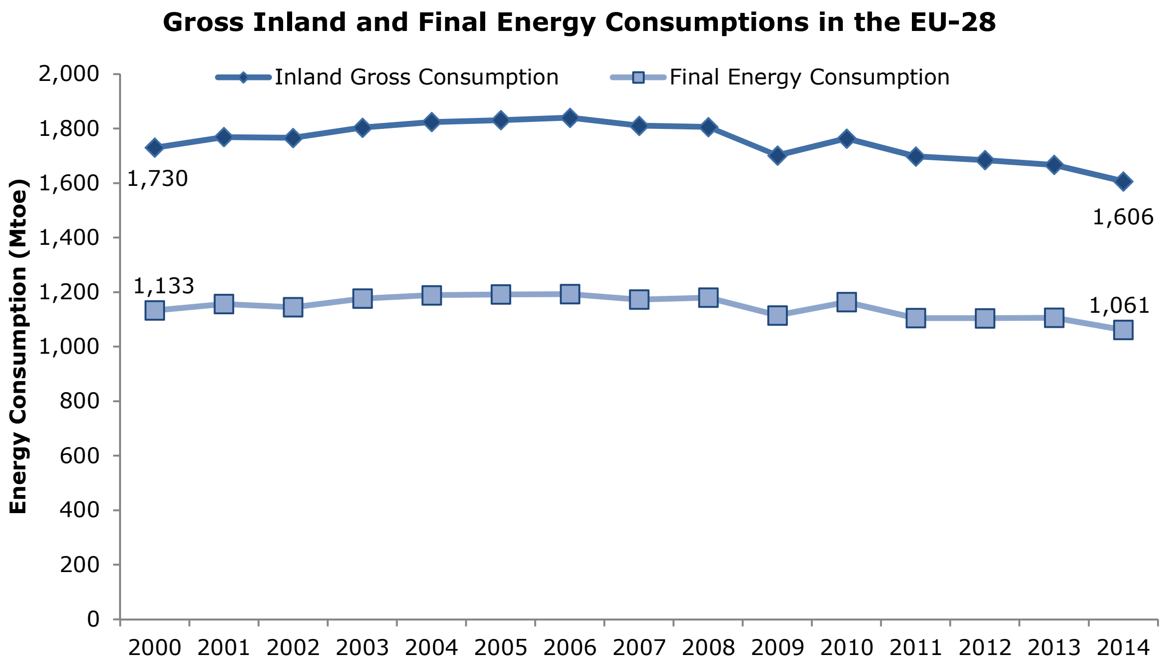
Gross inland consumption, also known as total primary energy supply, represents the quantity of energy necessary to satisfy inland consumption of a geographical entity under consideration [3]. It is formed by the final energy consumption and the energy that is consumed in the stages before the delivery to the final destination. Final energy consumption is the amount of energy that is actually consumed in the different sectors. In this report the main focus is based on the final energy consumption. However, gross inland consumption is also important in order to have an indication of the losses that occur throughout the transport, distribution and transformation stages in the delivery of the energy for final consumption.

This chapter covers the gross inland energy consumption and the final energy consumption in the EU-28 Member States. The share of the different sectors in the energy consumption and the contribution of the different fuel types are analysed, together with the growth rates in the EU-28 along the covered period.

### 2.1 Gross inland energy consumption

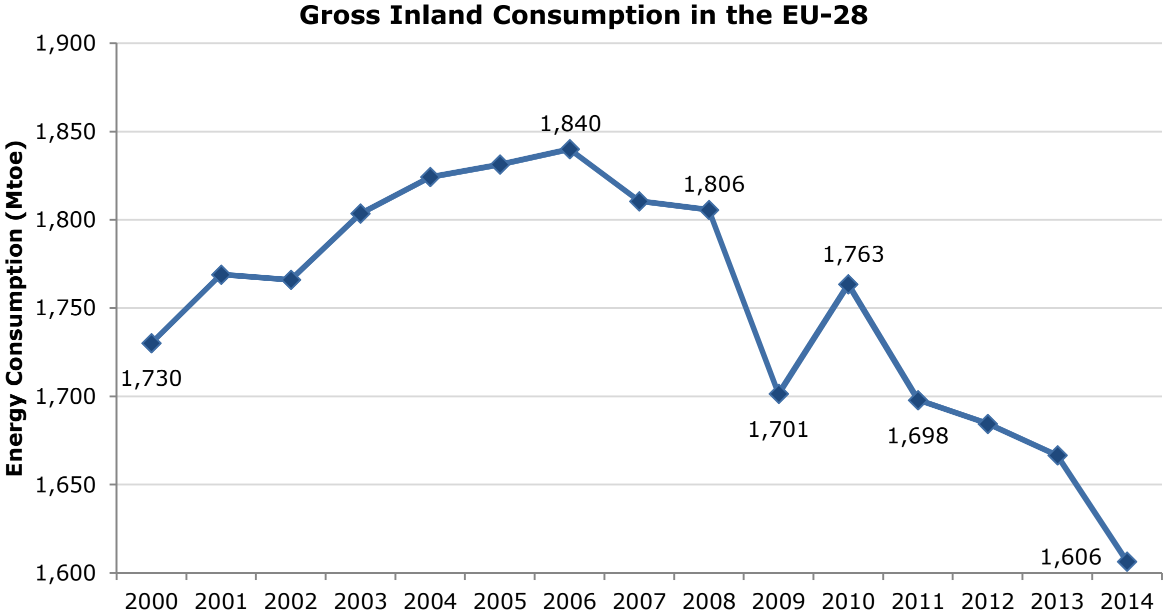
Gross inland consumption in the EU-28 declined from 1,730 Mtoe in 2000 to 1,606 Mtoe in 2014. Figure 1 shows how gross inland consumption and final energy consumption have evolved from 2000 onwards and it can be seen that both have declined. Final energy consumption represented the 65.9% of the gross inland consumption in 2014. That means that a large share 34.1% of energy is consumed during the process of the energy delivery to end-users, which is important to mention, for understanding the efficiency of the entire energy system.

**Figure 1: Gross inland energy consumption – Final energy consumption in the EU-28, 2000-2014. Source: Eurostat**



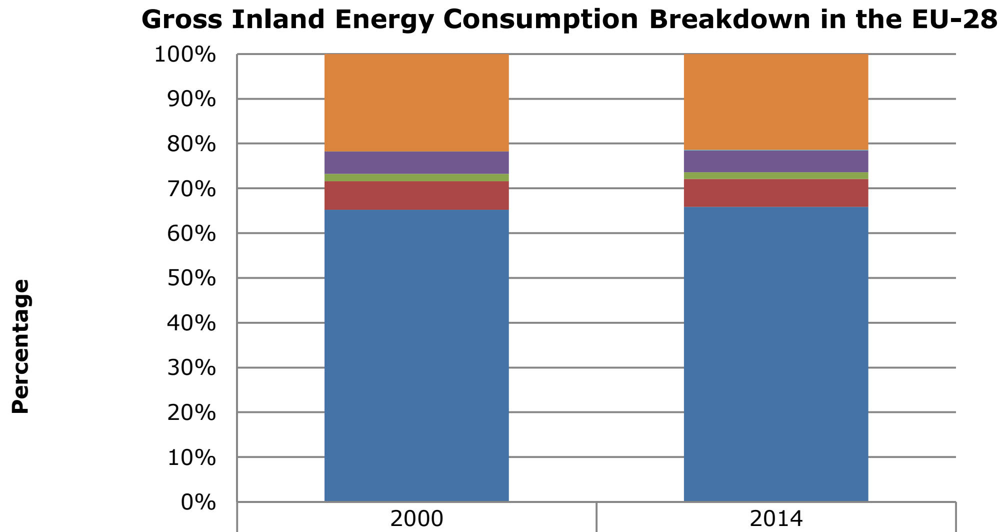

The gross inland consumption in the EU-28 reached a maximum of 1,840 Mtoe in year 2006. A significant drop by 6% took place in 2009 followed by 4% rise in 2010. Since then a decreasing trend has been undergone (Figure 2). In 2014, the gross inland consumption was 1,606 Mtoe which establishes the lowest value in the 25-years period from 1990 to 2014.

**Figure 2: Gross inland consumption in the EU-28, 2000-2014. Source: Eurostat**




The difference between gross inland and final energy consumption is due to transformation losses (21.42%), consumption in the energy sector (4.81%), final non-energy consumption (6.17%), distribution losses (1.55%) and other exchanges, transfers and returns (0.15%) - Figure 3. Compared to 2000, there has been a slight increase (+0.65%) of the share of the final energy to gross inland consumption. This is the result of the reduction of the share of the distribution losses, the final non energy consumption and also the share of transformation losses. However, these changes are very small and the main consumption patterns have remained the same.

**Figure 3: Gross inland energy consumption breakdown in the EU-28, 2000 and 2014. Source: Eurostat**



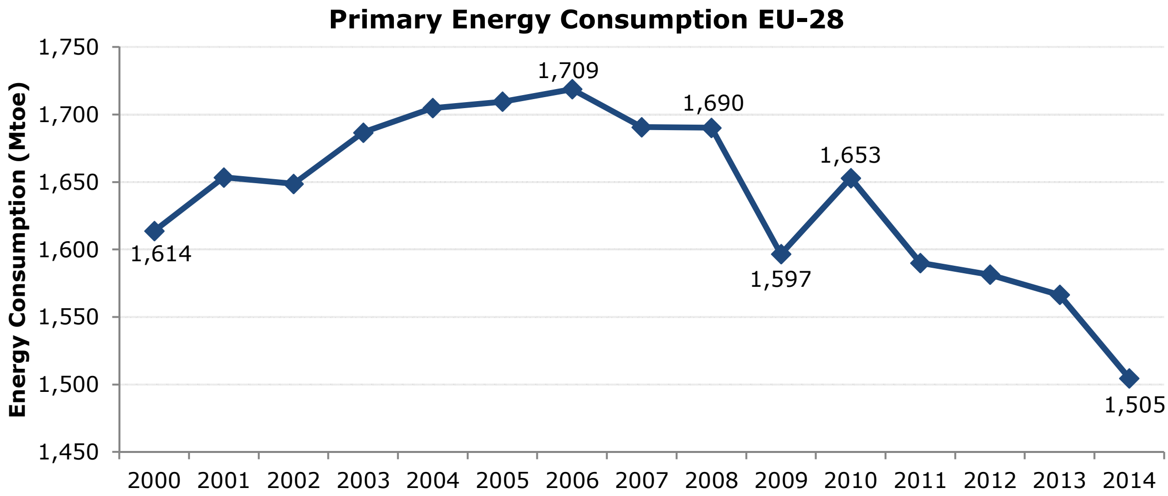

| | 2000 | 2014 |
|---|---|---|
| Transformation Losses | 21.74% | 21.42% |
| Exchange, Transfers, Returns | 0.03% | 0.15% |
| Consumption in Energy Sector | 5.01% | 4.81% |
| Distribution Losses | 1.61% | 1.55% |
| Final Non-energy Consumption | 6.37% | 6.17% |
| Final Energy Consumption | 65.24% | 65.89% |

## 2.2 Primary energy consumption

Primary energy consumption[22] in the EU-28 declined from 1,614 Mtoe in 2000 to 1,505 Mtoe in 2014; representing a drop by 6.8% over the period. The primary energy consumption registered an increasing trend from 2000 to 2006, reaching the maximum value over the analysed period in 2006 (1,709 Mtoe). In 2009, the maximum annual growth rate change was observed; when the primary energy consumption dropped by 5.5% in comparison to year 2008. In 2014, the EU primary energy consumption registered the lowest value over the analysed period (1,505 Mtoe); representing a fall by 3.9% in comparison to 2013.

As already mentioned, the EU target values for 2020 for the primary energy are set in 1,483 Mtoe. Therefore, the analysed data indicate that the EU is on track to achieve its goal in terms of primary energy consumption. The actual gap to accomplish the target is 1.5% as per the data corresponding to 2014.

**Figure 4: Primary energy consumption in the EU-28, 2000-2014. Source: Eurostat**

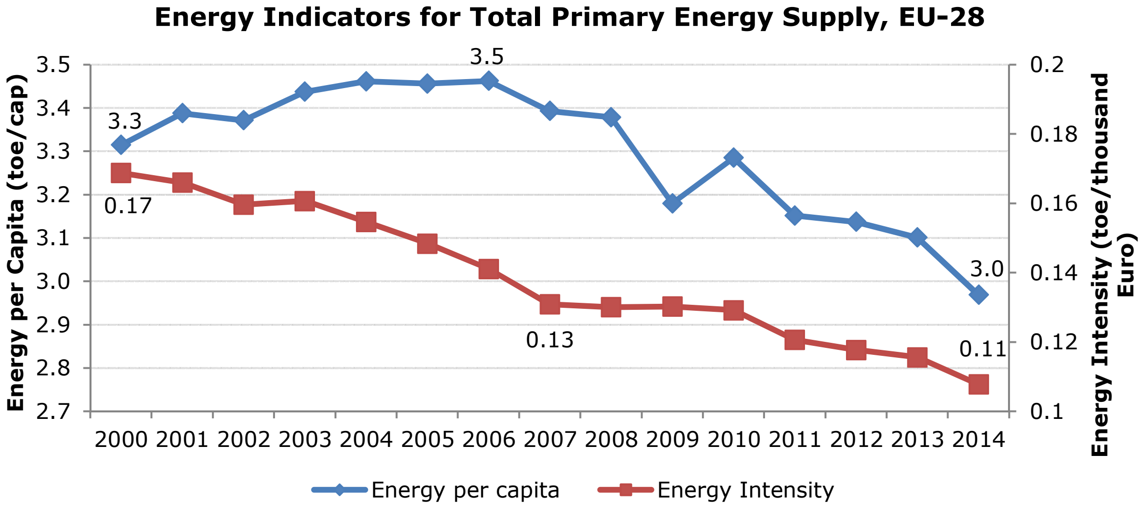



Looking at most representative energy indicators such as energy intensity[23] and energy per capita, it can be observed that energy intensity declined from 0.17 to 0.11 toe/thousand Euro in the period 2000-2014. From 2000 onwards, there has been a continuous gradual decrease of this indicator, with exception of year 2003; from 2007 to 2010, energy intensity remained quasi-constant with a value of 0.13 as illustrated in Figure 5. In general, this reduction is due to several factors such as structural changes in recent years in the overall economy and technological improvements, together with the positive impact of energy efficiency policies both at European and national level.

Regarding energy per capita, it has decreased 0.3 toe/cap during the analysed period. It reached a maximum in 2006 (3.5 toe/cap). Both, the European Union's population growth (Figure 35) and the gross inland energy consumption decrease have led to low this indicator.

[22] Primary energy consumption covers the consumption of the energy sector, losses during transformation and distribution of energy, and the final consumption by end users. It excludes energy used for non-energy purposes.
[23] Energy intensity is defined as the ratio between the primary energy consumption and Gross Domestic Product (GDP) calculated for a calendar year. Generally, the lower energy intensity, the higher competitiveness of the region or country analysed.

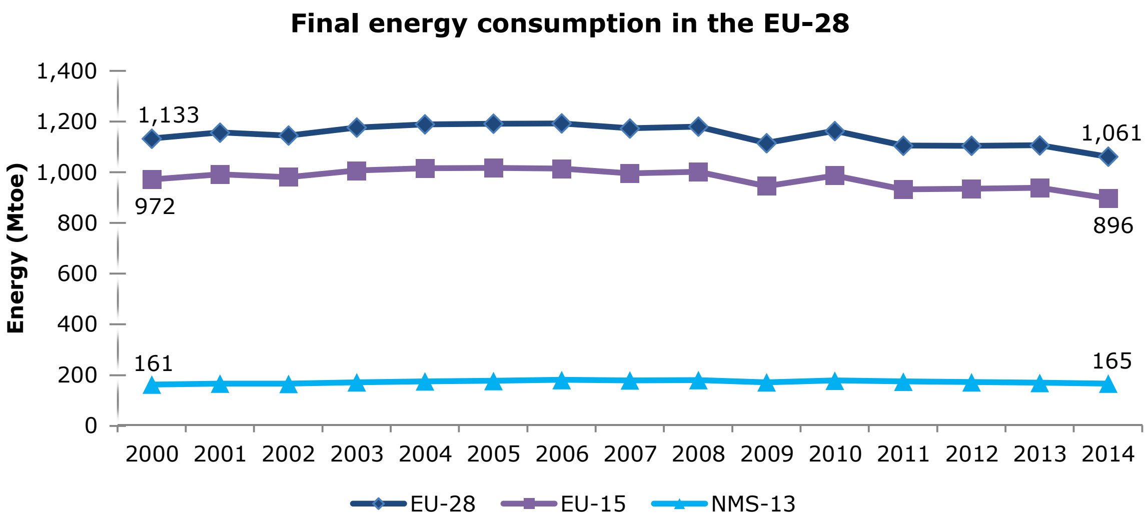
**Figure 5: Energy indicators for primary energy consumption: energy per capita and energy intensity[24] in the EU-28, 2000-2014. Source: Eurostat**




## 2.3 Final energy consumption in different sectors

In 2014 the total final energy consumption in EU-28 was 1,061Mtoe (Figure 6). This shows a decrease of 6.3% in comparison to year 2000, when the consumption was 1,133 Mtoe. Differentiating by MS groups, 84.4% (896 Mtoe) was consumed in EU-15 and 15.6% (165 Mtoe) in NMS-13. The EU-15 shows a decrease of 7.8% for the period 2000-2014. In contrast, NMS-13 increased their consumption by 2.4%, from 161 Mtoe to 165 Mtoe.

**Figure 6: Final energy consumption in the EU-28, 2000-2014. Source: Eurostat**




This energy was mainly consumed by four sectors as illustrated in Figure 7. In 2014, the sector with the largest share of final energy consumption is the transport sector, which consumed 33.22% of the total amount of final energy consumption. The industry sector is second, consuming 25.89%. Residential is third with the consumption reaching 24.80% and last, the share of the service sector is 13.31%.

[24] GDP values at market prices have been considered to calculate the energy intensity values reported in the graph..

Final energy consumption distribution by sector for five different years (i.e. 2000, 2004, 2007, 2010 and 2014) are shown in Figure 8, it can be observed that the shares have lightly changed during the period, and that the ranking of the sectors regarding final energy consumption has been often maintained.

**Figure 7: Final energy consumption breakdown into sectors in the EU-28, 2014. Source: Eurostat**

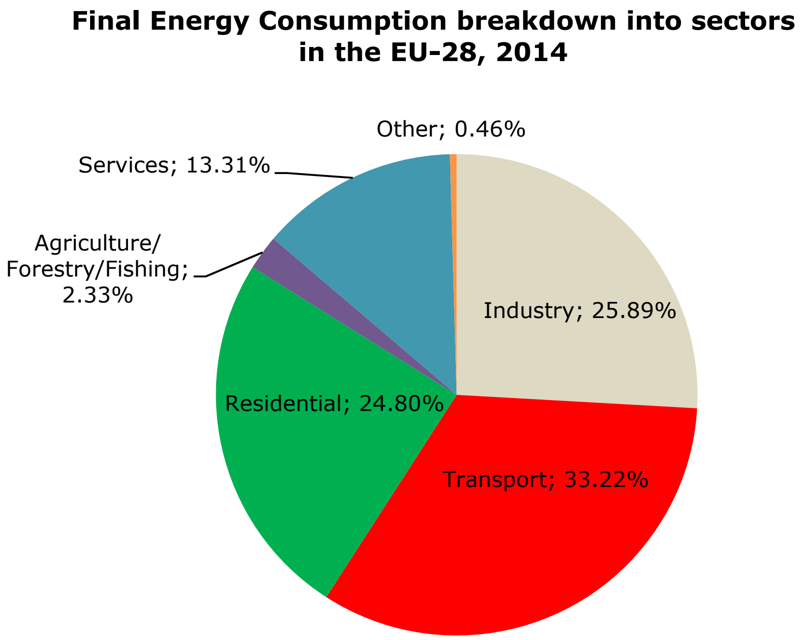



**Figure 8: Final energy consumption shares by sector in the EU-28, 2000, 2004, 2007, 2010 and 2014. Source: Eurostat**

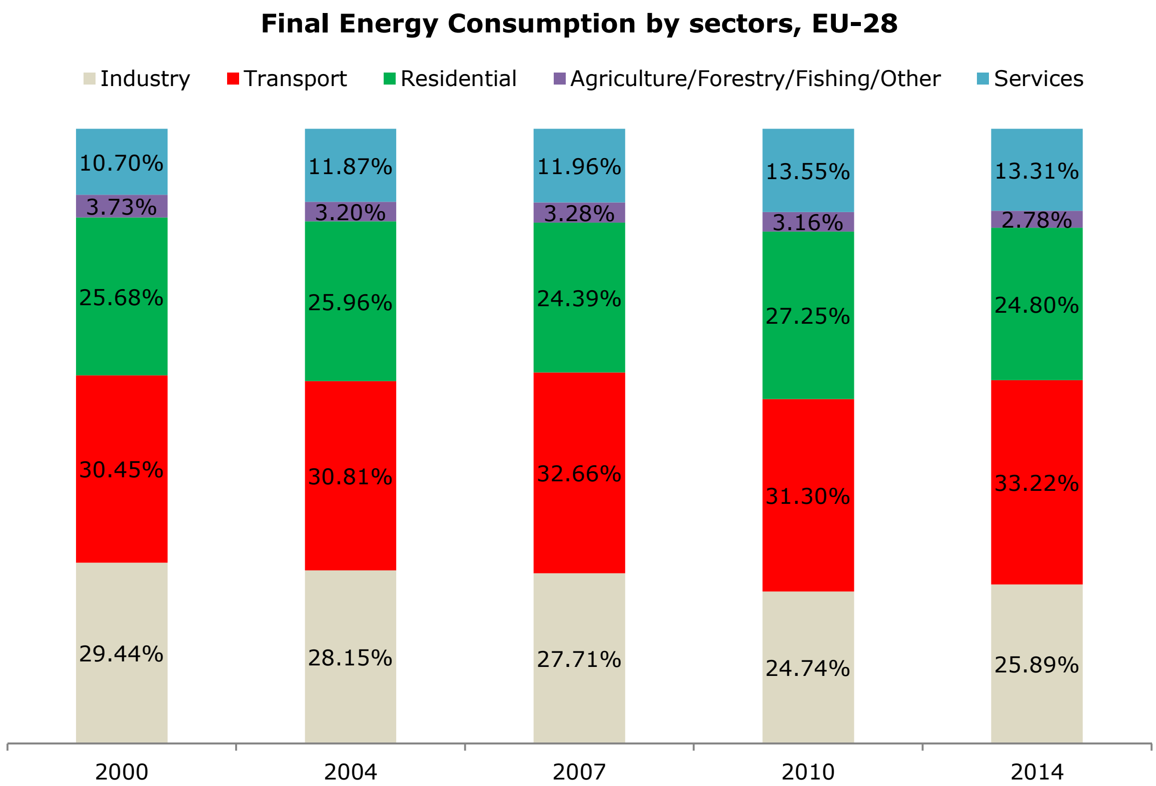


Figure 9 shows the final energy consumption per sector from 2000 to 2014. It can be observed how the final energy in industry and residential sector has notably varied throughout the different years (e.g. between 2008 and 2009 for the transport sector and between 2013 and 2014 for the residential one), while energy consumption of the transport and services sector has changed more gradually. The fact that energy consumption in transportation and service sector are growing, together with the decreasing trend at industry sector might be representative of an on-going tertiarization process in the European Union. In 2014, the final energy consumption at residential, industry and services sectors has decreased in comparison to year 2013. On the other hand, transport sector has increased by 1.3%.

**Figure 9: Final energy consumption dynamics through main sectors in the EU-28, 2000-2014. Source: Eurostat**

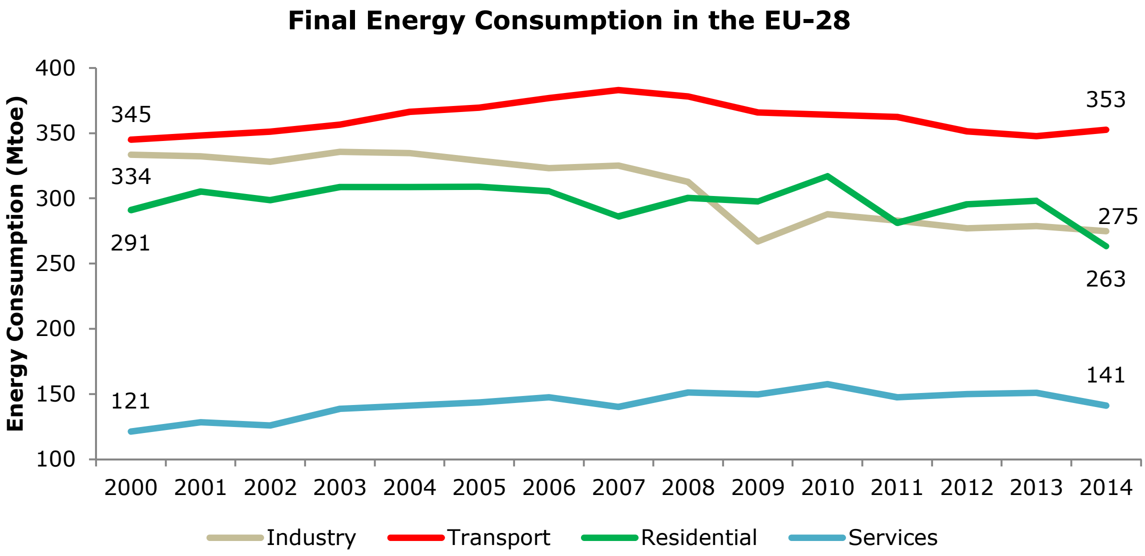
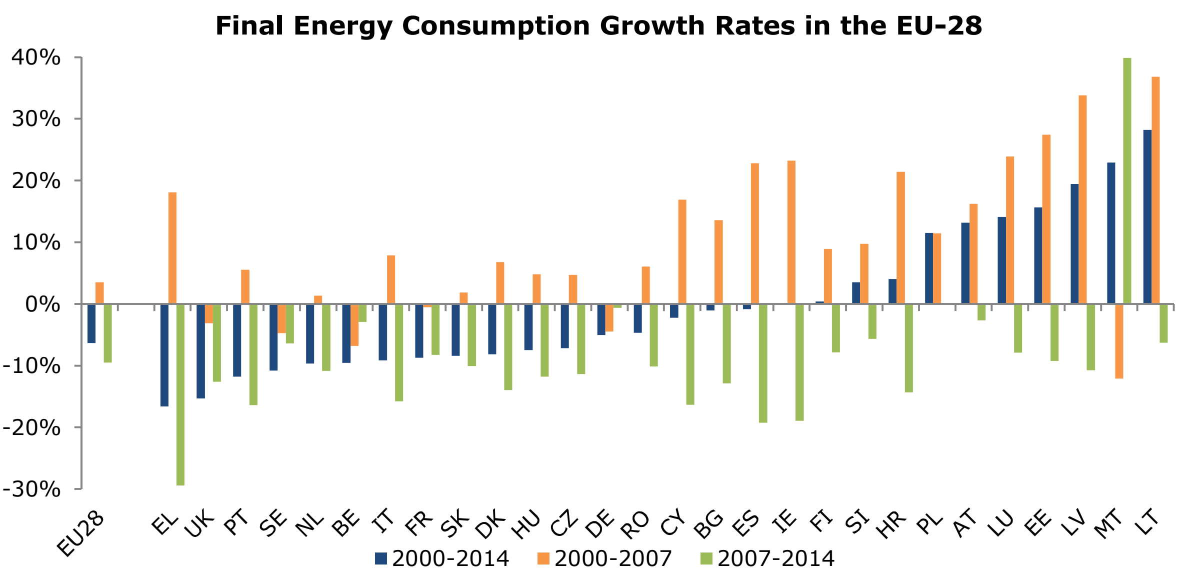



Figure 10 shows the changes of final energy consumption per member states. For the analysed period, final energy consumption growth rate varies considerably among the Member States of the European Union. Overall, the EU-28 countries underwent a growth rate of -6.3%.

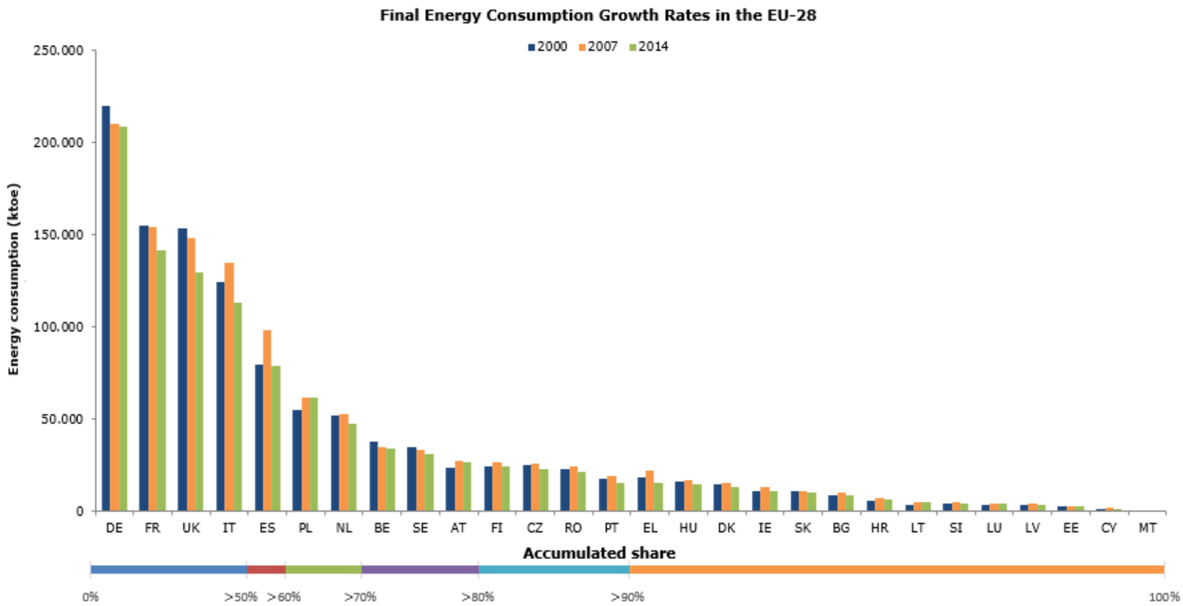
**Figure 10: Final energy consumption growth rate by EU-28 Member State; 2000-2014, 2000-2007 and 2007-2014. Source: Eurostat**



In the period 2000-2014, twelve Member States underwent higher reduction rates than the average European value. The highest reduction rate was made by Greece (-16.6%), followed by UK (-15.3%) and Portugal (-11.8%). In contrast, Lithuania (28.2%), Malta (22.9%) and Latvia (19.4%) were the MS where the final energy consumption most rose in comparison to year 2000. Ten MSs, eight of which NMS-13 and two of which EU-15, experimented an increasing of the final energy consumption, that is, a positive growth rate. Slovakia, Hungary and Czech Republic are the only New Member States where the final energy consumption declined below the average European level.

In 2014, Germany was the Member State with the highest final energy consumption (208.9 Mtoe) reaching the share of 19.7% of the total final energy consumption. Together with France (141.8 Mtoe; 13.4%), the United Kingdom (129.8 Mtoe; 12.2%) and Italy (113.4 Mtoe; 10.7%) account for more than 55% of the European final energy consumption. The following figure shows the ranking most final energy consuming states as well as the accumulated share of the total final energy consumption. It can be observed how fourteen Member States consumed more than 90% of the total energy consumption.

**Figure 11: Final energy consumption per Member State in the EU-28 with accumulated share (2014) of the total final energy, 2000, 2007 and 2014. Source: Eurostat**




The decline of 6.3% in the European final energy consumption, for the period 2000-2014, has not been gradual. Until 2010, final energy consumption was higher every year compared to 2000, with the exception of the year 2009. From 2003 to 2006 there was a constant growth (Figure 12) reaching a maximum in 2006 with 1,193 Mtoe. During the period 2011-2013, the final energy consumption has remained nearly constant. Final energy consumption in 2014 has significantly dropped by 4% in comparison to 2013 (Table 1), establishing the minimum consumption of the whole period.

Figure 12: Final Energy Consumption in the EU-28, 2000-2014 (Detailed). Source: Eurostat

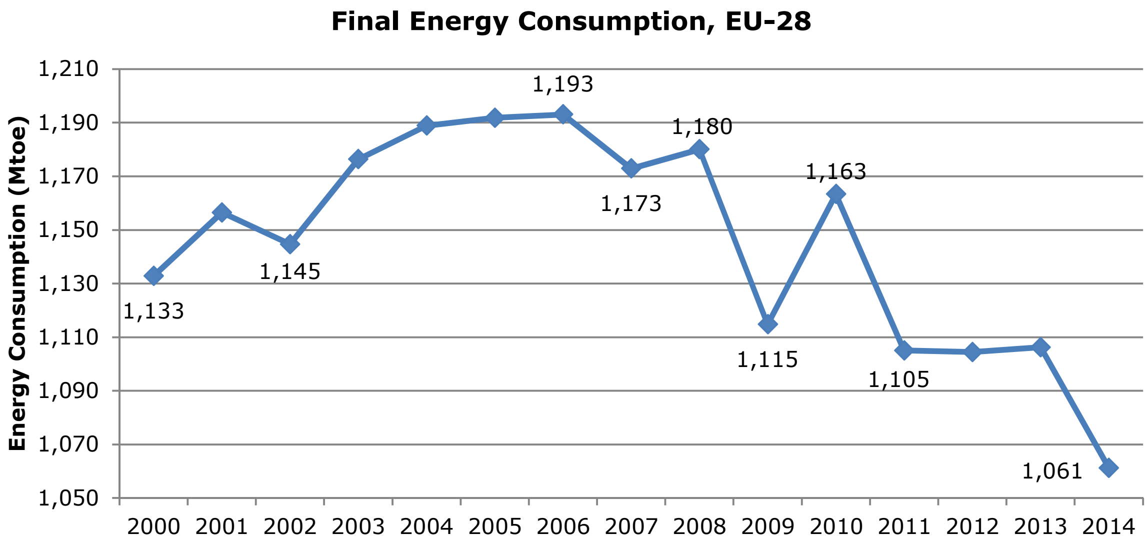
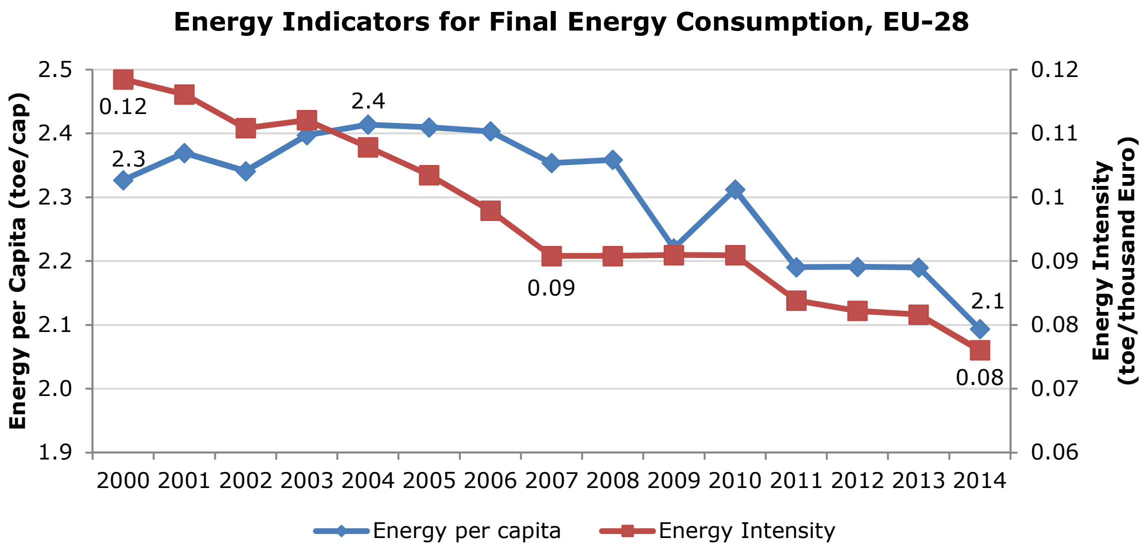



Figure 13: Energy indicators for final energy consumption: energy per capita and energy intensity[25] in the EU-28, 2000-2014. Source: Eurostat




Energy intensity (EI) and energy per capita can be also analysed for Final Energy (Figure 13). From 2000 to 2014, the energy intensity in the EU-28 was reduced in 0.04 toe/thousand Euro, reaching a value 0.08 toe/thousand Euro in 2014. Energy per capita was 2.1 toe/capita in 2014 which represents the lowest value in the analysed period. Energy per capita indicator is highly influenced by the final energy consumption as the growth rates between years have higher changes than population growth rate.

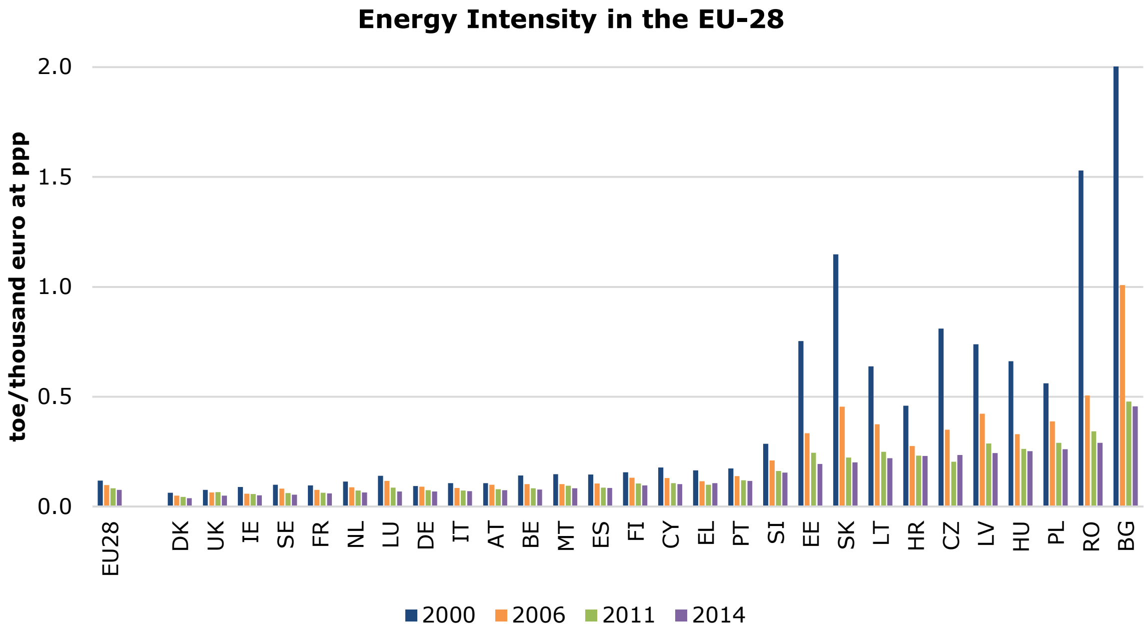
When analysing the energy intensity per EU-28 Member States, in 2014 the state with the lowest Energy Intensity was Hungary (0.82 koe/thousand Euro at ppp), followed by Denmark (5.2 koe/thousand Euro at ppp) and Sweden (6.0 koe/thousand Euro at ppp). On the other hand, the MSs with the highest Energy Intensity for the same year were Latvia (0.24 toe/ thousand Euro at ppp), Bulgaria (0.23 toe/ thousand Euro at ppp) and

[25] GDP values at market prices have been considered to calculate the energy intensity values reported in the graph..

Lithuania (0.22 toe/ thousand Euro at ppp). In 2014, fifteen European countries had below average European energy intensity (<0.08 toe/ thousand Euro).

The highest reductions in the Energy Intensity values during the 15-years period from 2000 to 2014 have been found in Slovakia which have undergone a growth rate of -82.5%, Romania (-81.0%) and Bulgaria (-77.2%). Germany, Austria and Portugal are the countries were the energy intensity has reduced the least during this period (-26.5%, -30.1% and -32.5% respectively). Overall European EI trends can reflect the interest and efforts made by the European Union states to increase their levels of competitiveness as the average EU reduction rate has been -35.8% (2000-2014).

**Figure 14: Energy intensity in the EU-28 (GDP at Purchase Power Parities), 2000, 2006, 2011 and 2014. Source: Eurostat**




Following table provides with an overview of the final energy consumption for the EU-28. It provides with data of the main consuming sectors, as well as growth rates expressed in percentage to year 2000 and percentage to the previous year. When focussing in growth rates to year 2000 of the total final energy consumption, it can be observed that from 2001 to 2008 the consumption was higher that is a positive value; in contrast, from 2009 onwards, only 2010 had higher energy consumption than year 2000. Specific insights of the main consuming sectors are given in each of the subsequent chapters.

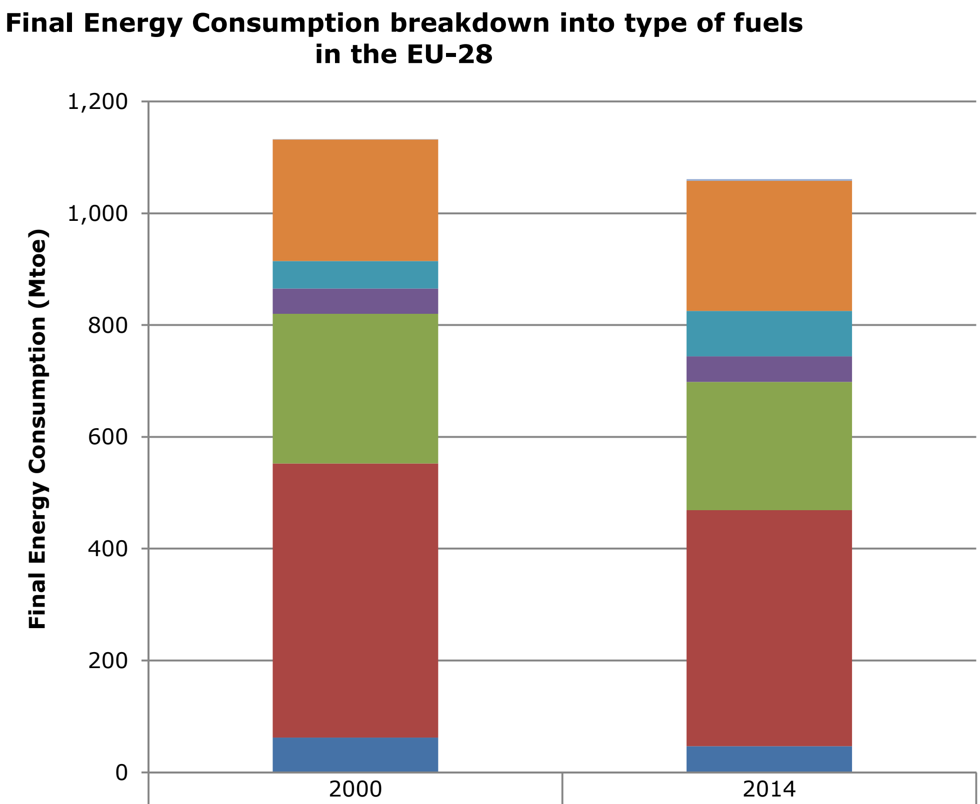
**Table 1: Overview of final energy consumption changes for different sub-sectors, EU-28. Source: Eurostat**

| Final Energy Consumption per Sector, EU-28 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **(Mtoe)** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** |
| **Total** | 1132.794 | 1156.479 | 1144.637 | 1176.348 | 1188.905 | 1191.813 | 1193.037 | 1172.895 |
| **Industry** | 333.517 | 332.166 | 328.075 | 335.577 | 334.717 | 328.898 | 323.280 | 325.028 |
| **Transport** | 344.893 | 348.207 | 351.165 | 356.632 | 366.293 | 369.448 | 376.816 | 383.047 |
| **Residential** | 290.928 | 305.261 | 298.631 | 308.681 | 308.680 | 308.832 | 305.503 | 286.088 |
| **Services** | 121.244 | 128.380 | 125.895 | 138.535 | 141.133 | 143.666 | 147.495 | 140.222 |
| **(Mtoe)** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | |
| **Total** | 1180.039 | 1114.736 | 1163.328 | 1105.045 | 1104.453 | 1106.207 | 1061.237 | |
| **Industry** | 312.631 | 266.998 | 287.844 | 282.847 | 277.156 | 278.693 | 274.759 | |
| **Transport** | 378.059 | 365.896 | 364.086 | 362.412 | 351.359 | 347.822 | 352.501 | |
| **Residential** | 300.340 | 297.642 | 316.989 | 281.120 | 295.394 | 298.092 | 263.222 | |
| **Services** | 151.147 | 149.730 | 157.660 | 147.395 | 149.945 | 150.880 | 141.223 | |
| **% Growth rate to year 2000** | | | | | | | | |
| **(%)** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | |
| **Total** | 2.09% | 1.05% | 3.84% | 4.95% | 5.21% | 5.32% | 3.54% | |
| **Industry** | -0.40% | -1.63% | 0.62% | 0.36% | -1.38% | -3.07% | -2.55% | |
| **Transport** | 0.96% | 1.82% | 3.40% | 6.20% | 7.12% | 9.26% | 11.06% | |
| **Residential** | 4.93% | 2.65% | 6.10% | 6.10% | 6.15% | 5.01% | -1.66% | |
| **Services** | 5.89% | 3.84% | 14.26% | 16.40% | 18.49% | 21.65% | 15.65% | |
| **(%)** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | |
| **Total** | 4.17% | -1.59% | 2.70% | -2.45% | -2.50% | -2.35% | -6.32% | |
| **Industry** | -6.26% | -19.94% | -13.69% | -15.19% | -16.90% | -16.44% | -17.62% | |
| **Transport** | 9.62% | 6.09% | 5.56% | 5.08% | 1.87% | 0.85% | 2.21% | |
| **Residential** | 3.24% | 2.31% | 8.96% | -3.37% | 1.54% | 2.46% | -9.52% | |
| **Services** | 24.66% | 23.50% | 30.04% | 21.57% | 23.67% | 24.44% | 16.48% | |
| **% Growth rate to previous year** | | | | | | | | |
| **(%)** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | |
| **Total** | 2.09% | -1.02% | 2.77% | 1.07% | 0.24% | 0.10% | -1.69% | |
| **Industry** | -0.40% | -1.23% | 2.29% | -0.26% | -1.74% | -1.71% | 0.54% | |
| **Transport** | 0.96% | 0.85% | 1.56% | 2.71% | 0.86% | 1.99% | 1.65% | |
| **Residential** | 4.93% | -2.17% | 3.37% | 0.00% | 0.05% | -1.08% | -6.35% | |
| **Services** | 5.89% | -1.94% | 10.04% | 1.88% | 1.79% | 2.67% | -4.93% | |
| **(%)** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | |
| **Total** | 0.61% | -5.53% | 4.36% | -5.01% | -0.05% | 0.16% | -4.07% | |
| **Industry** | -3.81% | -14.60% | 7.81% | -1.74% | -2.01% | 0.55% | -1.41% | |
| **Transport** | -1.30% | -3.22% | -0.49% | -0.46% | -3.05% | -1.01% | 1.35% | |
| **Residential** | 4.98% | -0.90% | 6.50% | -11.32% | 5.08% | 0.91% | -11.70% | |
| **Services** | 7.79% | -0.94% | 5.30% | -6.51% | 1.73% | 0.62% | -6.40% | |

## 2.4 Final energy consumption per fuel types

The main energy fuels of final energy consumption are petroleum products, electricity and gas, which provide with the 39.8%, 21.9% and 21.6% of the final energy consumption in 2014 respectively (Figure 16). Renewables[26], solid fuels and derived heat, have a total share of around 16%. The drop of 72 Mtoe in final energy consumption from 2000-2014, is the result of 122 Mtoe reduction in solid fuels, petroleum products and gas, while derived heat, renewables, electricity and waste grew by 50 Mtoe. This shows that the final reduction of energy consumption is the result of diverse changes in the energy type mixture. For instance there has been decline of 38 Mtoe in gas consumption but part of this energy gap has been covered by the increase of other energy types such as renewables, electricity and heat. In the same way, increases in electricity can be due to the substitution of gas or other energy sources, rather than a direct increase of electricity consumption for the same type of service. In fact, electricity share is expected to grow in the future as renewable energy sources are integrated into electrical grids once generated in renewable power plants such as hydroelectric power plants, wind farms or PV power stations.

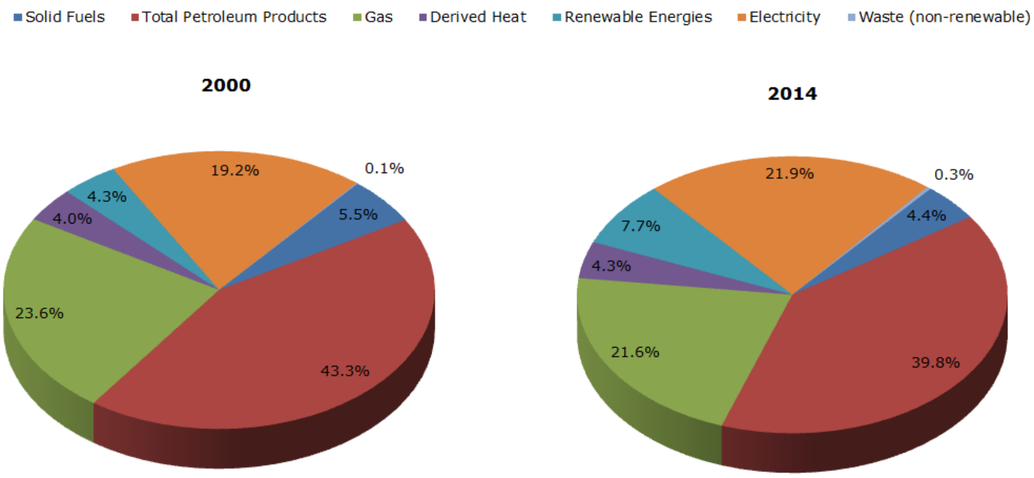
**Figure 15: Final energy consumption by energy types in the EU-28, 2000 and 2014. Source: Eurostat**




| | 2000 | 2014 |
|---|---|---|
| Waste (non-renewable) | 1,039.2 | 3,261.7 |
| Electricity | 217,449.0 | 232,700.8 |
| Renewable Energies | 48,870.4 | 81,378.0 |
| Derived Heat | 45,333.9 | 45,544.5 |
| Gas | 267,682.9 | 229,264.1 |
| Total Petroleum Products | 490,476.8 | 422,522.3 |
| Solid Fuels | 61,941.7 | 46,566.0 |

[26] Renewable energy sources other than Hydro power, Wind power, Tide, Wave and Ocean and Solar photovoltaic. These sources are accounted under the contribution generated by electricity consumption.

**Figure 16: Share of energy source to final energy consumption in the EU-28, 2000 and 2014. Source: Eurostat**




With regard to the shares of the different energy sources, from 2000 to 2014 the electricity has raised its share (by 2.7%); the renewable energy sources share has notably augmented (nearly doubled). Petroleum and oil products have remained almost stable as well as derived heat. Solid fuels and gas shares have reduced during the same 15-years period.

## 2.5 Final electricity and gas consumption in different sectors

This subchapter covers the analysis of electricity and gas consumptions in the different sectors along the period from 2000 to 2014 in the 28 countries of the European Union.

### Final Electricity consumption

In 2014, total electricity consumption across the EU-28 countries was 2,706.310 TWh. It corresponds to an increase of 7% in comparison to year 2000, when the electricity consumption was 2,528.932 TWh (Figure 17). 86.5% of the total electricity consumption was made by EU-15, while NMS-13 consumed 13.5% (2,340 TWh) of electricity.

**Figure 17: Final electricity consumption in the EU-28, 2000-2014. Source: Eurostat**

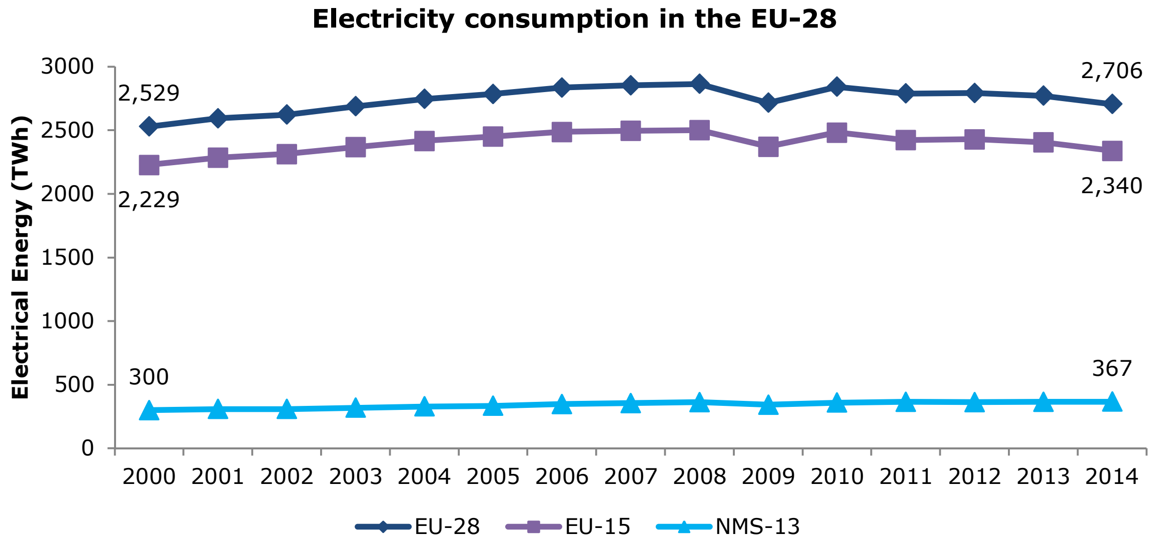


**Figure 18: Electricity consumption in the EU-28, 2000-2014. Source: Eurostat**

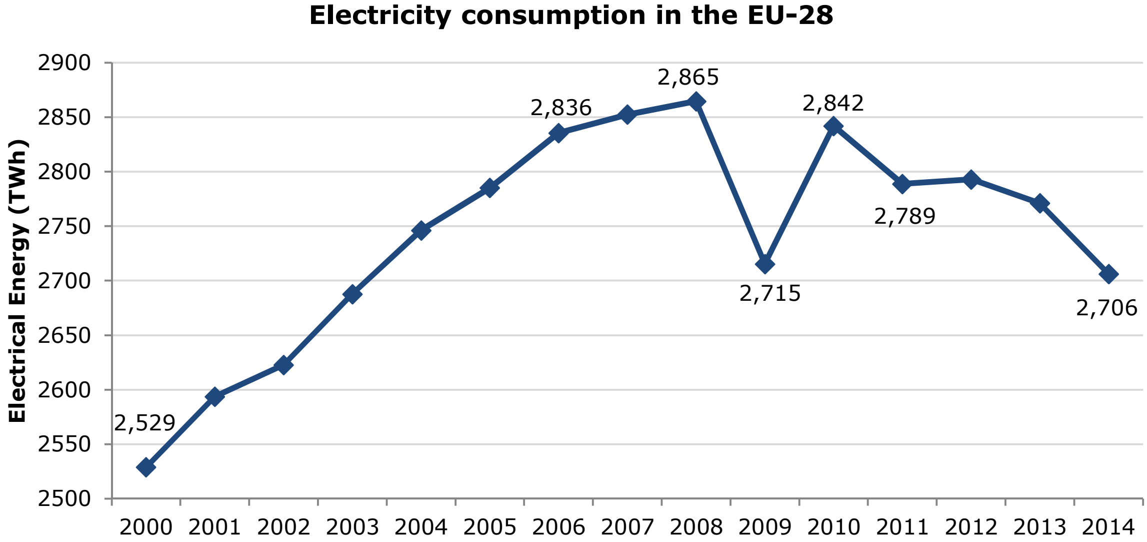
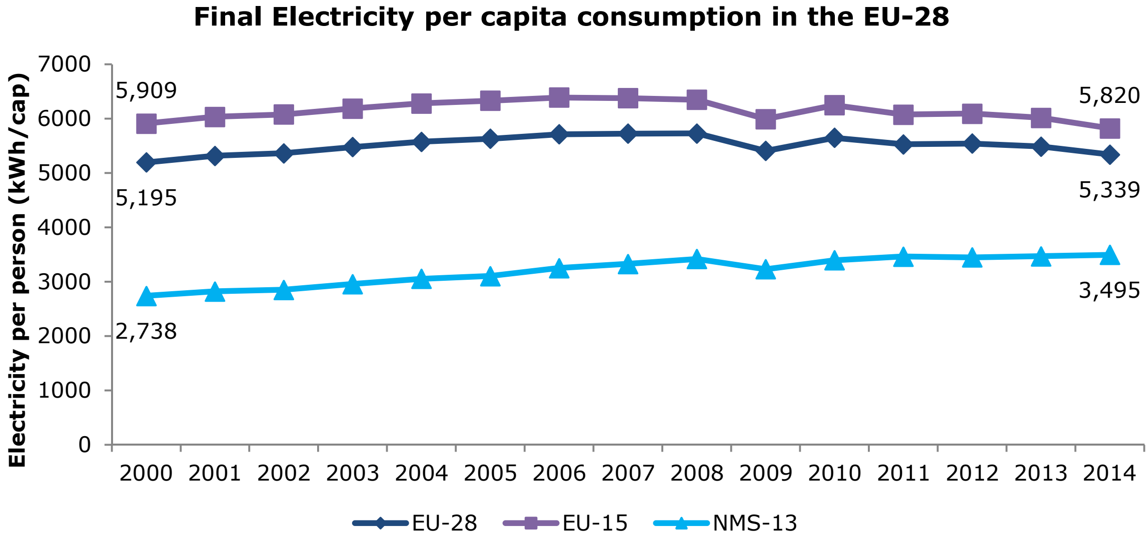



Figure 18 provides with a better visualisation of the electricity consumption trend at European level. It is observed the continuous growth of around 1-2.5% per year in period from 2000 to 2006. After 2006 the growth rate per year decreased although with a positive growth until reaching a maximum in 2008 (2,865 TWh). A fall by 5.2% occurred in 2009, followed by an increase of 4.66% in 2010. Since then, the electricity consumption has been reducing its value. In the period 2010-2014, electricity has undergone a drop by 4.8%.

**Figure 19: Final electricity per capita consumption in the EU-28, 2000-2014. Source: Eurostat**




In 2014, final electricity per capita consumption was 5,339 kWh, this value represents a rise by 2.8% in comparison to year 2000. There is a marked difference within the EU-28 as an average person living in NMS-13 consumes 1.66 times less energy than an average person living in EU-15. Despite this fact, the final electricity per capita consumption in NMS-13 has grown by 27.6% in the analysed 15-year period, while EU-15 has reduced its consumption by -1.5% (Figure 19).

Three sectors account over 95% of the electricity consumption in EU-28, industry sector with 36.86% is first, followed by service sector representing 29.81% and residential sector with 29.01% (Figure 20). In the period 2000-2014, the industry sector has always been the sector with highest electricity consumption, reaching a maximum of 4,109,216 Terajoules in 2007. For the same sector, a dramatically drop in the electric consumption of 14% took place between 2008 and 2009, as a result of the impact on the economy and production of the financial crisis. Since 2011, it can be observed a slight lowering trend in the electricity consumption at European level. Residential and Service sectors had different growth rates from 2000 to 2008. Since then these sectors have undergone analogous trends as illustrated in Figure 21.

**Figure 20: Electricity consumption breakdown into sectors in the EU-28, 2014. Source: Eurostat**

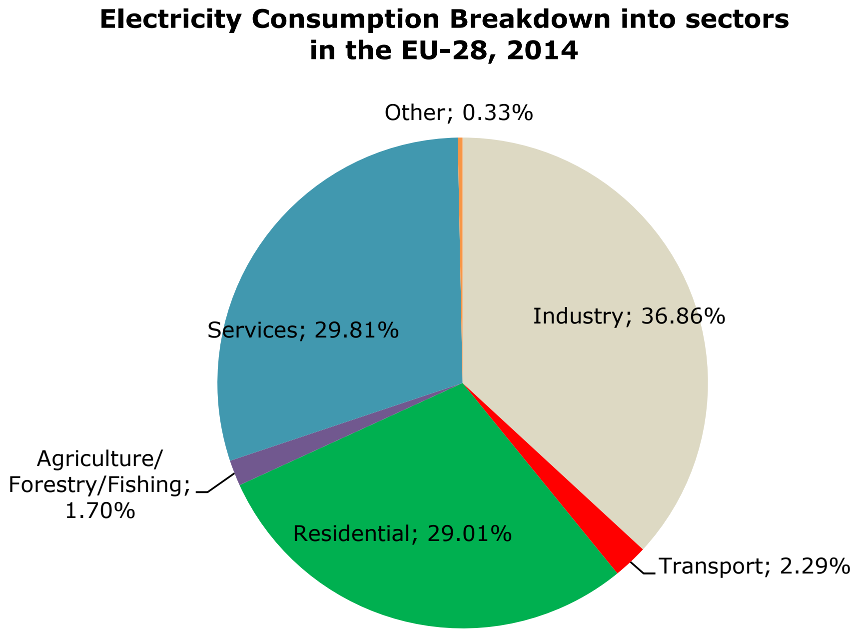



**Figure 21: Final electricity Consumption dynamics through main consuming sectors in the EU-28, 2000-2014. Source: Eurostat**

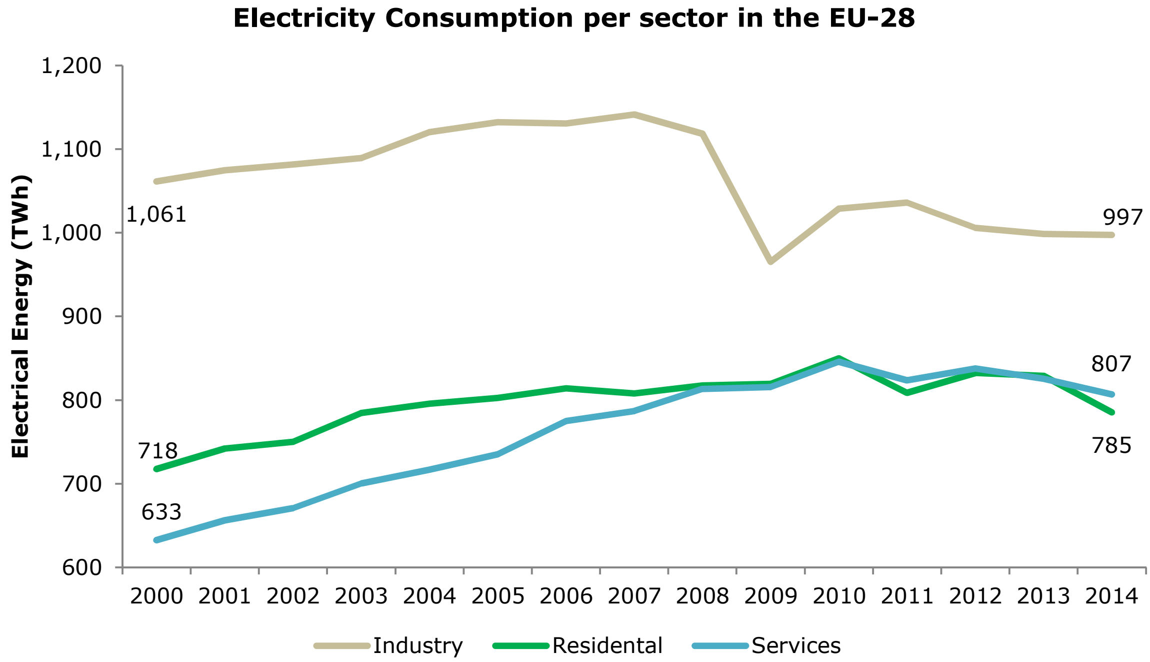
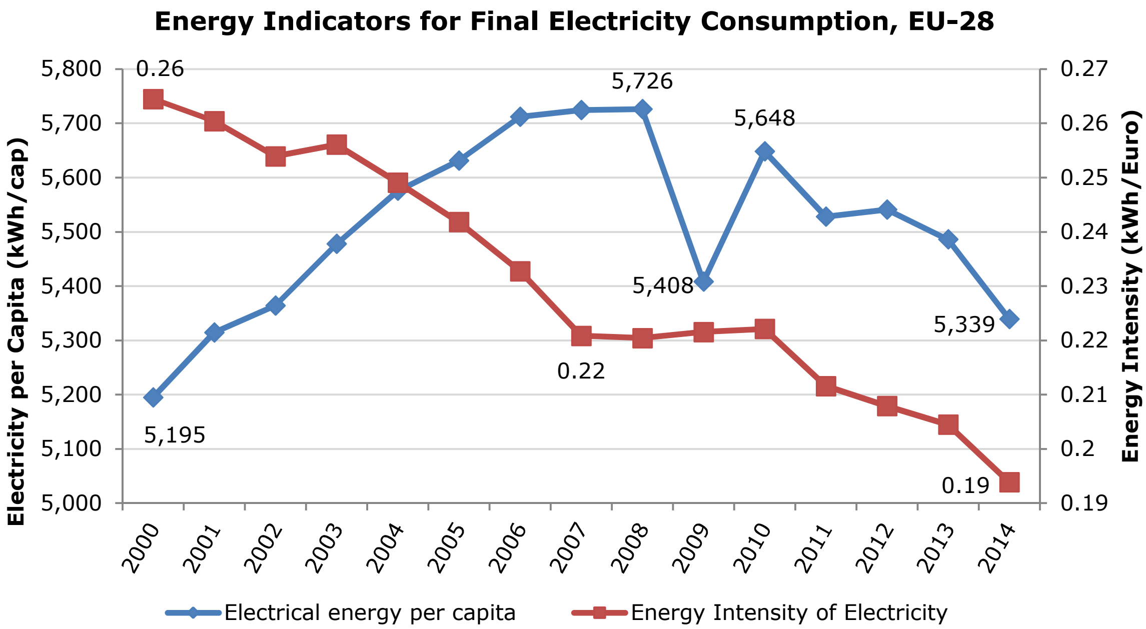


**Figure 22: Energy indicators for final electricity consumption: electricity per capita and electrical energy intensity[27] in the EU-28, 2000-2014. Source: Eurostat**




In 2014, the energy intensity of the final electricity consumption was 0.19 kWh/Euro; this value represents the lowest during the analysed 15-years period. In the period from 2000 to 2014, the energy intensity of the final electricity has gradually dropped by 0.7 kWh/Euro. Between 2007 and 2010, the value remained stable in 0.22 kWh/Euro. In the period 2000-2014, the per capita final electrical energy has grown by 144 kWh/cap. This indicator reached a maximum in 2008 with 5,726 kWh/cap, followed by a fall of 318 kWh/cap in 2009. From 2010 to 2014, the per capita final electricity consumption has continuously dropping with the exception of year 2012 as illustrated in Figure 22.

[27] GDP values at market prices have been considered to calculate the energy intensity values reported in the graph.

## Final Gas Consumption

In 2014, the total gas consumption of the EU-28 countries reached 229,264 ktoe. This establishes a drop of 14.4% in comparison to level of year 2000 when the consumed gas was 267,683 ktoe. 86.1% of the total gas consumption was made by EU-15, while NMS-13 consumed 13.9% (31,979 ktoe) of gas (Figure 23). In 2014, the final gas per capita consumption in the EU-28 was 5,260 kWh, this value represents a drop by -17.7% in comparison to year 2000. The overall trend shows a decreasing in the gas consumption; this drop has been more representative in the EU-15 where the gas consumption per capita has been reduced by -20% as shows Figure 24. As it occurs in the final electricity per capita consumption, there is a notable dispersion across the EU-28 Member States as an average person in NMS-13 consumes 1.60 times more than an average person in EU-15.

**Figure 23: Final gas consumption trends in the EU-28, 2000-2014. Source: Eurostat**

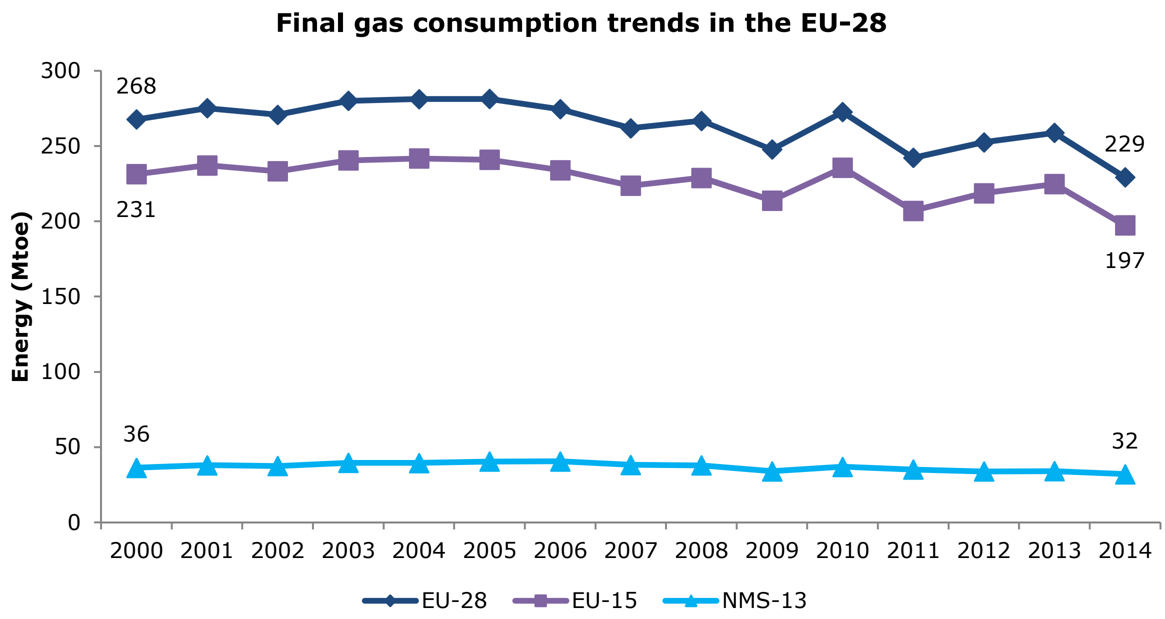
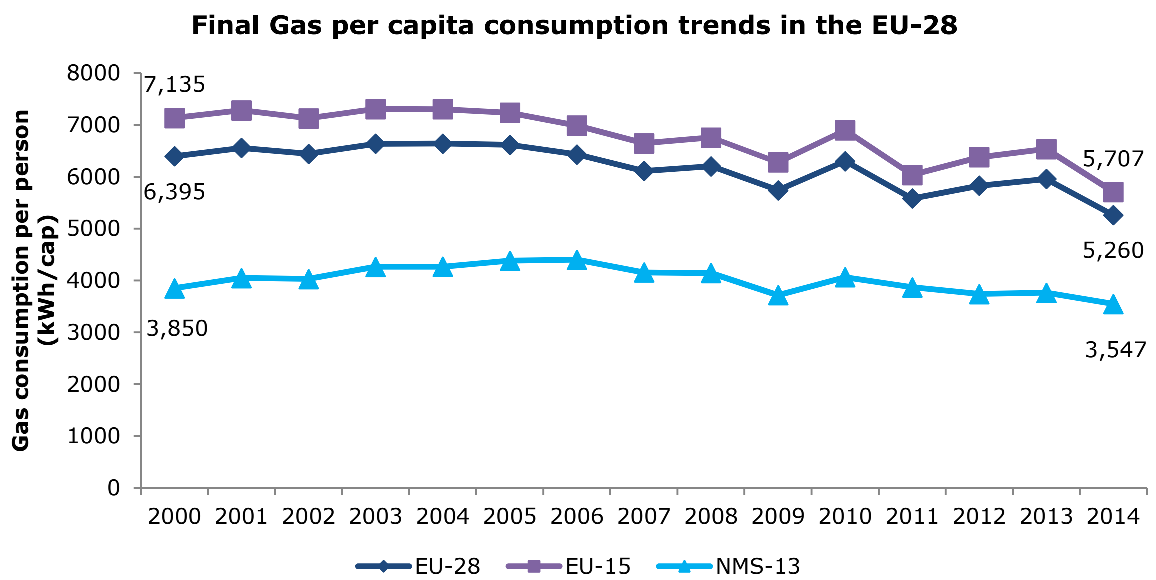



**Figure 24: Final gas per capita consumption trend in the EU-28, 2000-2014. Source: Eurostat**



Alike the final electricity consumption, the gas consumption is mainly in three sectors. Residential sector is the highest consumer of gas with 40.20%, followed by industry sector with 38.05% and service sector which accounts 18.26%; all three account over 96% of the gas consumption of the European Union as illustrated in Figure 25.

**Figure 25: Gas consumption breakdown into sectors in the EU-28, 2014. Source: Eurostat**

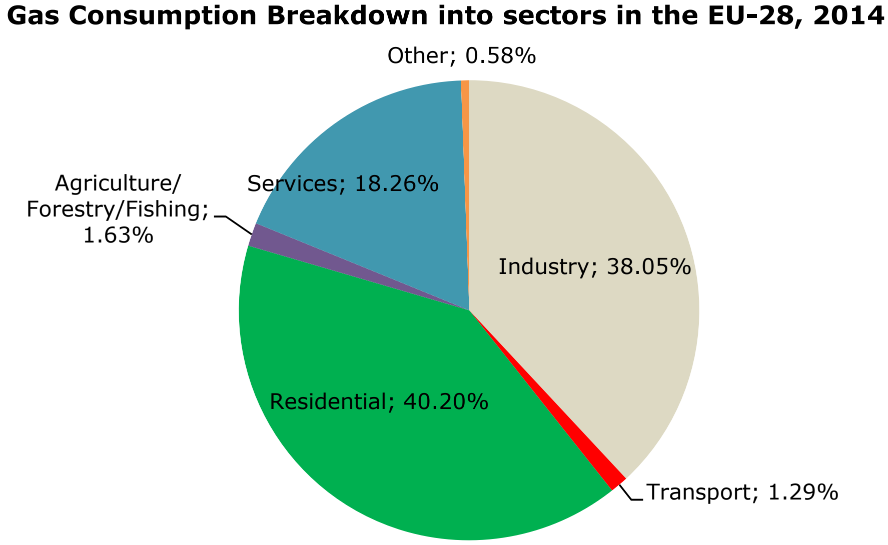



Figure 26 shows the gas consumption trend through the period from 2000 to 2014 for the three mentioned sectors. Back in 2000, industry and residential sectors had the highest shares and consumptions of gas, 112,735 ktoe (42.1%) and 108,805 ktoe (40.7%) respectively. Along the period, the trends have reversed and their positions have alternated. Both sectors have occasionally experienced high changes in comparison to previous year, e.g. between 2008 and 2009 industry sector declined by 14.6% or between 2010 and 2011 residential sector dropped by 11.3%. In general terms both sectors have undergone a reduction of the gas consumption, while service sector has experienced a gradually increasing trend for the same period. To be noted, that gas consumption in all three sectors has decreased from 2013 to 2014.

**Figure 26: Final gas consumption dynamics through main consuming sectors in the EU-28, 2000-2014. Source: Eurostat**

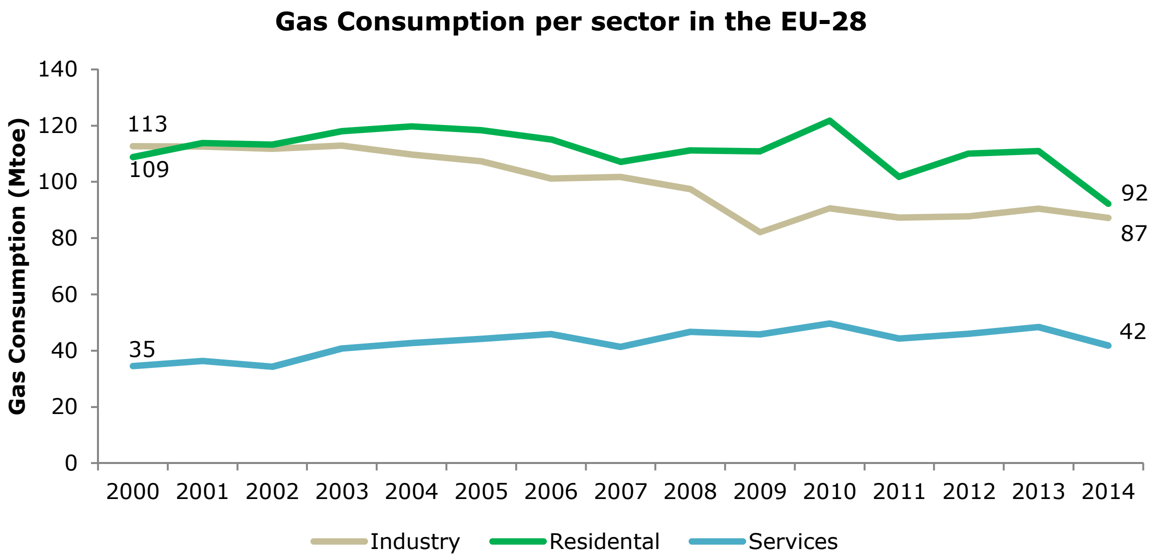
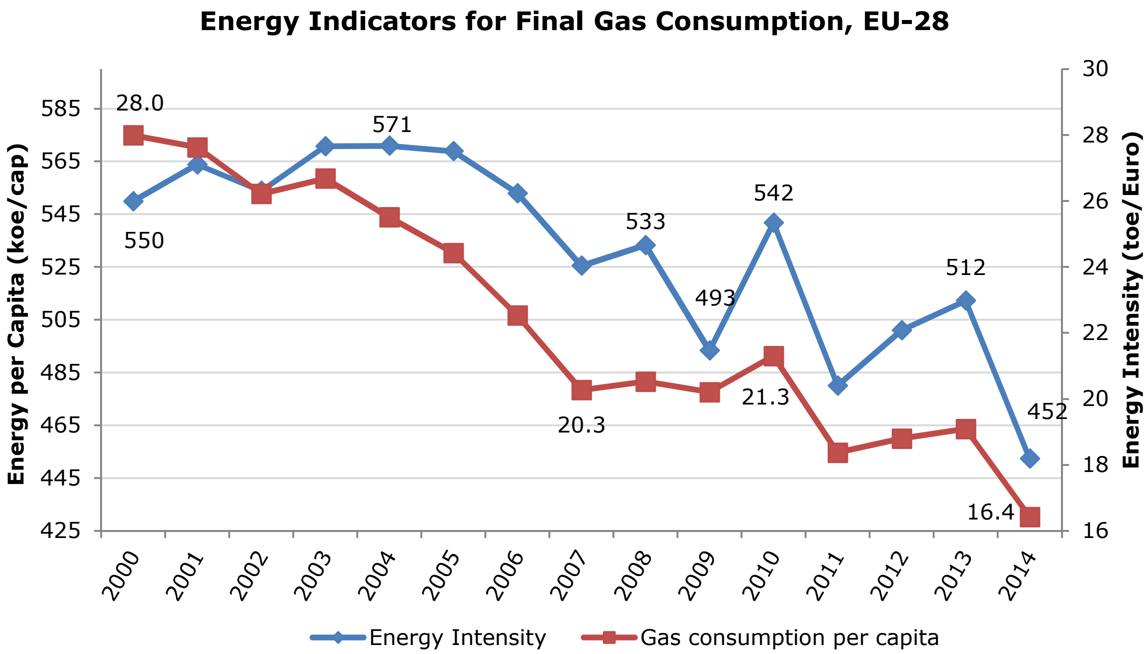


**Figure 27: Energy indicators for final gas consumption: gas consumption per capita and gas energy intensity[28] in the EU-28, 2000-2014. Source: Eurostat**




In 2014, the energy intensity of the final gas consumption was 16.4 toe/Euro; this value represents the lowest during the analysed 15-years period. In the period from 2000 to 2014, the energy intensity of the final gas has gradually dropped by 11.6 toe/Euro. Between 2007 and 2010, the value remained stable in 20.3 toe/Euro. In the period 2000-2014, the per capita final electrical energy has grown by 98 koe/cap. This indicator reached a maximum in 2004 with 571 koe/cap. Since 2007, this indicator has been continuously fluctuating and reversing the trend from the previous year. In 2014, the per capita gas consumption registered the lowest value of the analysed period as illustrated in Figure 27.

[28] GDP values at market prices have been considered to calculate the energy intensity values reported in the graph.

# 3. Overview of the current EU legislation on energy efficiency

This chapter provides with an overview on the legislative framework which relates to energy efficiency in the EU-28.

The main horizontal policy measures implemented at an EU level that aim to directly or indirectly improve energy efficiency in the sectors[29] which are responsible for most of the energy consumption of EU Member States sectors are: 1) the Energy Efficiency Directive (EED); (2) the Energy Performance of Buildings Directive (EPBD); (3) the Eco-design Directive; (4) the Energy Labelling Directive; (5) the Directives establishing an Emissions Trading Scheme (ETS) in the European Union; and (6) the Effort Sharing Decision.[30]

The **Energy Efficiency Directive**[31] (EED) was adopted in December 2012 and repealed and repeals the Cogeneration Directive (2004/8/EC) and the Energy End-Use Efficiency and Energy Services Directive (2006/32/EC). The EED establishes a set of binding measures to help the EU reach our 20% energy efficiency target by 2020. Under the EED, the EU States are required to use energy more efficiently at all stages of the energy chain from its production to its final consumption.

The EED introduces strategies and measures with regard to eligibility of measures for the energy end-use savings target, public building renovations, energy efficiency in public procurement, energy audits, energy efficiency services, supply side efficiency and demand response. All these measures are established in order to reach the targets for energy consumption by 2020.

For instance, under the Energy Efficiency Directive regarding the energy consumption of buildings:

- EU countries make energy efficient renovations to at least 3% of buildings owned and occupied by central government
- EU governments should only purchase buildings which are highly energy efficient
- EU countries must draw-up long-term national building renovation strategies which can be included in their National Energy Efficiency Action Plans (NEEAP).

The **Energy Performance of Buildings Directive**[32] (EPBD) was adopted in May 2002 and the recast in 2010. In January 2012, the Delegated Regulation No 244/2012 supplementing the recast EPBD established a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and buildings elements.

Under the Energy Performance of Buildings Directive:

- Energy performance certificates are to be included in all advertisements for the sale or rental of buildings.
- EU countries must establish inspection schemes for heating and air conditioning systems or put in place measures with equivalent effect.
- All new buildings must be nearly zero energy buildings by 31 December 2020 (public buildings by 31 December 2018).
- EU countries must set minimum energy performance requirements for new buildings, for the major renovation of buildings and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls, etc.).

[29] These sectors include the residential sector, the public sector, the tertiary sector, the industry sector and the transport sector.

[30] Other legislations (e.g. Directive on promotion of clean and energy-efficient road transport vehicles or Renewable Energy Directive) are introduced along the chapter. However, these legislations have not been listed because of the specific focus made in the particular economic sector where are introduced. This list intends to focus on the legislations which may be applied to all or most of the economic sectors.

[31] Directive 2012/27/EU

[32] Directive 2010/31/EU

- EU countries have to draw up lists of existing and proposed national measures to improve the energy efficiency of buildings.

The **Eco-design Directive**[33] for energy-using products (EuP) was adopted in 2005, and was revised in 2009[34]. The most important amendment in the new Directive concerns its scope, which has been extended from energy-using products (EuP) to so-called energy-related products (ErP). It is an important instrument of environmental product policy. A major goal of the directive is to improve energy efficiency levels of ErPs throughout their entire life cycle as every good has an impact on environment and energy consumption during its life-cycle.

The Eco-design Directive is a framework directive. This means that the directive does not provide directly specific eco-design requirements for specific products but gives a general framework for specific requirements. In the Eco-design Directive the conditions and criteria for the eco-design requirements through subsequent implementation measures are defined. On the other hand, in the last 6 years, the European Commission has implemented several regulations which regard different products groups[35]. This type of implementation takes direct legal effect in all Member States.

Another key framework directive which complements the eco-design directive is the **Energy Labelling Directive**. The first Directive[36] on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances was introduced the European energy labelling scheme in 1992. The directive applied to the following appliances:

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

Directive from 1992 was replaced by a new Directive[37] in 2010 which became effective in June 2011. According to the new labelling directive, new energy efficiency classes in addition to the already existing classes (A-G) on the basis of the Energy Efficiency Index (EEI) can be added (e.g. A+, A++, A+++) and the coverage is extended also to non-residential equipment. The maximum of seven energy classes must be kept.

In July 2015, the European Commission transmitted to the Council and to the European Parliament a proposal[38] for a regulation setting a framework for energy efficiency labelling and repealing the current Directive 2010/30/EU. The proposal is based on a review of the Energy Labelling Directive in order to further exploit the potential of the energy efficiency for the moderation of the energy demand and consequent reduction of the energy dependency of the European Union.

The proposal retains the main principles of the current legislative framework, but further clarifies, strengthens and extends the scope of the current rules. It allows for the

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[33] 2005/32/EC

[34] 2009/125/EC

[35] According to the Article 16 of the eco-design directive 2009/125/EC, the Commission has to establish Working Plans which determine the list of products for which a preparatory study will be conducted during a given period and eventually Implementation Measures that will be adopted for these products. So far, working plans for specific products have been produced for the transitional period starting in 2005 and for the periods 2009-2011, 2012-2014, 2015-2017.

[36] 1992/75/EC

[37] 2010/30/EU

[38] 2015/0148 (COD)

periodic rescaling of labels to encourage the production of ever more efficient product and avoid the overpopulation of higher efficiency classes. The proposal introduces returning to a classification using letter from A to G, as it has proved to be most effective for customers. The newly rescaled label should have empty top classes to encourage technological progress and enable ever more efficient products to be developed and recognised [4]. It also aims to improve enforcement mechanisms and transparency towards customers and the public by creating a database of products covered by energy labelling obligations, and clarifying the obligations of market actors and Member States [5].

The **EU emissions trading scheme** (ETS) is basically governed by two Framework Directives[39]. The EU ETS is the world's largest trading system and the first of its kind for $CO_2$ emissions trading. When it was introduced, the EU ETS covered about 50% of Europe's $CO_2$ emissions and 40% of its total greenhouse gas emissions[40].

The Directive's scope reaches heavy energy-using installations in power generation and manufacturing industry, together with aircraft operators performing aviation activities in the EU and EFTA states.

Launched in 2005, the EU ETS is now in its third phase, running from 2013 to 2020. A major revision approved in 2009 in order to strengthen the system means the phase 3 is significantly different from phases 1 and 2 and is based on rules which are far more harmonised than before.

The first phase ran from 2005 to 2007. It was a three-year period of 'learning by doing' to prepare for phase two, when the EU ETS would need to function effectively to help ensure the EU and Member States met their Kyoto Protocol emission targets. The first phase succeeded in establishing a price for carbon, free trade in emission allowances across the EU and the necessary infrastructure for monitoring, reporting and verifying actual emissions from the businesses covered.

The second phase ran from 2008 to 2012, the three EEA-EFTA states – Iceland, Liechtenstein and Norway – joined the EU ETS at the start of phase two. At the same time, the scope of the system was marginally widened through the inclusion of nitrous oxide emissions from the production of nitric acid by a number of Member States. Phase two coincided with the first commitment period of the Kyoto Protocol, which required the EU and Member States to meet their emission targets. From the launch of the EU ETS in January 2005, national registries ensured the accurate accounting of all allowances issued. This task was taken over during 2012 by the single Union registry operated by the Commission, which also covers the three EEA-EFTA states. From 2012 the Union registry includes accounts for aircraft operators.

During phase two the national and Union registries recorded:

- National allocation plans;
- Accounts of companies or physical persons holding those allowances;
- Transfers of allowances ("transactions") performed by account holders;
- Annual verified $CO_2$ emissions from installations;
- Annual reconciliation of allowances and verified emissions, where each company must have surrendered enough allowances to cover all its verified emissions.

The third phase, currently ongoing, brings significant changes which are:

[39] Directive 2003/87/EC and Directive 2009/29/EC

[40] For further information regarding EU ETS, regulatory updates and documentation see: http://ec.europa.eu/clima/policies/ets/index_en.htm

- A single, EU-wide cap on emissions applies in place of the previous system of national caps;
- Auctioning, not free allocation is now the default method for allocating allowances. In 2013 more than 40% of allowances were auctioned, and this share is supposed to rise progressively each year;
- Some more sectors and gases are included;
- 300 million allowances set aside in the New Entrants Reserve to fund the deployment of innovative renewable energy technologies as well as carbon capture and storage through the NER 300 programme[41].

The **Effort Sharing Decision**[42] (ESD) is a European Parliament and Council decision on the effort of Member States to reduce their greenhouse gas emissions to meet the EU GHG emission reduction targets up to 2020. The Decision is part of a set of policies and measures on climate change and energy whose aim is helping move Europe towards a low-carbon economy and increase its energy security.

The Decision concerns emissions from most sectors not included in the EU Emissions Trading System (EU ETS), such as transport (except aviation and international maritime shipping), buildings, agriculture and waste. The GHG emissions of land use, land use change and forestry (LULUCF) and international shipping are not included.

The Effort Sharing Decision sets national emission targets for 2020, expressed as percentage changes from 2005 levels. There are set binding annual greenhouse gas emission targets for Member States for the period 2013–2020. Member States' reduction efforts are based on the principle of solidarity between Member States and the need for sustainable economic growth across the Community. The relative wealth (measured by Gross Domestic Product per capita) has been the basis set for the emission reduction targets.

The EU ETS and the ESD targets can be met by Member States by implementing energy efficiency improvement actions and can therefore be considered as legislative measures that indirectly foster energy efficiency in the EU-28.

[41] NER 300 programme legislative framework: Commission Decision 2010/679/EU and Commission Decision 2015/191/EU
[42] Decision No 406/2009/EC

## 3.1 Legislation in the residential sector

As already mentioned, the main EU horizontal legislative measures directly affecting the residential sector are the Directive on Energy Efficiency (EED), the Directive on Energy Performance of Buildings (EPBD), the Directive 2010/20/EU on Energy Labelling and the Directive 2009/125/EC on Eco-design.

EU energy efficiency regulations focusing on specific products commercialised in the residential sector are presently mainly implemented through the jus mentioned directives on energy labelling and eco-design.

The following table lists the different eco-design regulations presently in force for products categories commercialised in the residential sector

**Table 2: Overview of eco-design regulations for residential products, 2016. Source: EC**

| Product group / lot | Eco-Design Regulation | |
|---|---|---|
| | Publication Date | Regulation in force |
| Air conditioners and comfort fans | 03/2012 | 206/2012 |
| Computers and Servers | 06/2013 | 617/2013 |
| Domestic Coffee Machines | 09/2013 | 801/2013 |
| Directional Lighting | 12/2012 | 1194/2012 |
| Domestic Lighting | 04/2009 | 244/2009 |
| External Power Supplies | 04/2009 | 278/2009 |
| Household dishwashers | 12/2010 | 1016/2010 |
| Household washing machines | 12/2010 | 1015/2010 |
| Laundry Driers | 10/2012 | 932/2012 |
| Local space heating products | 08/2015 | 1185/2015 ; 1188/2015 |
| Sound and Imaging Equipment | VA 01/2015 | - |
| Ovens, hobs and range hoods | 02/2014 | 66/2014 |
| Refrigerators and freezers | 08/2009 | 643/2009 |
| Residential ventilation | 12/2014 | 1253/2014 |
| Simple Set-Top Boxes | 02/2009 | 107/2009 |
| Complex Set-Top Boxes | VA 07/2010 | - |
| Standby and off-mode losses | 12/2008 | 1275/2008 |
| Networked standby losses of EuPs | 09/2013 | 801/2013 |
| Space and Combination Heaters | 09/2013 | 813/2013 |
| Televisions | 08/2009 | 642/2009 |
| Vacuum cleaners | 07/2013 | 666/2013 |
| Water Heaters | 09/2013 | 814/2013 |

The following table lists instead the different regulations on energy labelling presently in force product groups for the residential sector.

**Table 3: Overview of labelling measures for residential products, 2016. Source: EC**

| **Product group / lot** | **Energy Labelling Measure** | |
|---|---|---|
| | **Publication Date** | **Regulation in force** |
| Air conditioners and comfort fans | 07/2011 | 626/2011 |
| Computers and Servers | not implemented yet | - |
| Domestic Coffee Machines | not implemented yet | - |
| Directional Lighting | 09/2013 | 874/2012 |
| Domestic Lighting | 09/2013 | 874/2012 |
| Household dishwashers | 12/2010 | 1059/2010 |
| Household washing machines | 12/2010 | 1061/2010 |
| Laundry Driers | 05/2012 | 392/2012 |
| Local space heating products | 08/2015 | 1186/2015 |
| Sound and Imaging Equipment | not implemented yet | - |
| Ovens, hobs and range hoods | 02/2014 | 65/2014 |
| Refrigerators and freezers | 12/2010 | 1060/2010 |
| Residential ventilation | 12/2014 | 1254/2014 |
| Space and Combination Heaters | 09/2013 | 811/2013 |
| Televisions | 12/2010 | 1062/2010 |
| Vacuum cleaners | 07/2013 | 665/2013 |
| Water Heaters | 09/2013 | 812/2013 |

## 3.2 Legislation in the tertiary sector

EU energy efficiency measures affecting the tertiary sector are mostly implemented under the same horizontal legislative measures affecting the residential sector (i.e. the Directive on Energy Efficiency, the Directive on Energy Performance of Buildings, the Directive 2010/20/EU on Energy Labelling and the Directive 2009/125/EC on Eco-design). Also in this case EU energy efficiency regulations focusing on specific products commercialised in the tertiary sector are presently mainly implemented through the directives on energy labelling and eco-design. Being generally designed and implemented for specific products and not for specific economy sectors, some of these regulations actually apply also in the residential and the industry sector[43].

The following tables list the products categories installed in the tertiary sector that are presently covered by regulations on eco-design and energy labelling.

**Table 4: Overview of eco-design regulations for products of the tertiary sector, 2016. Source: EC**

| Product group / lot | Eco-Design Regulation | |
|---|---|---|
| | **Publication Date** | **Regulation in force** |
| Circulators in Buildings | 08/2009 | 641/2009 |
| Computers and Servers | 07/2014 | 617/2013 |
| Electric motors | 08/2009; amendment 01/2014 | 640/2009 ; 4/2014 |
| External Power Supplies | 04/2009 | 278/2009 |
| Imaging Equipment | VA 01/2015 | - |
| Local space heating products | i08/2015 | 1185/15 ; 1188/15 |
| Professional wet appliances and driers | not implemented yet | - |
| Refrigerating and freezing equipment | 08/2015 | 2015/1095 |
| Space and Combination Heaters | 09/2013 | 813/2013 |
| Tertiary Lighting | 04/2010 | 245/2009 |
| Standby and off-mode losses | 01/2009 | 1275/2008 |
| Networked standby losses of EuPs | 09/2013 | 801/2013 |
| Ovens, hobs and range hoods | 02/2014 | 66/2014 |
| Simple Set-Top Boxes | 02/2009 | 107/2009 |
| Complex Set-Top Boxes | VA 07/2010 | - |
| Tertiary air-conditioning | 12/2014 | 1253/2014 |
| Ventilation fans | 04/2011 | 327/2011 |
| Water Heaters | 09/2013 | 814/2013 |

[43] It may be worth noticing that the Directives on eco-design and energy labelling do not apply to means of transport for persons and goods.

**Table 5: Overview of energy labelling regulations for products of the tertiary sector, 2016. Source: EC**

| Product group / lot | Labelling Measure | |
|---|---|---|
| | Implementation Date | Regulation in force |
| Circulators in Buildings | not implemented | - |
| Computers and Servers | not implemented | - |
| Electric motors | not implemented | - |
| Imaging Equipment | not implemented | - |
| Local space heating products | 08/2015 | 1186/2015 |
| Refrigerating and freezing equipment | 08/2015 | 1094/2015 |
| Space and Combination Heaters | 09/2013 | 811/2013 |
| Ovens, hobs and range hoods | 02/2014 | 65/2014 |
| Water Heaters | 09/2013 | 812/2013 |

## 3.3 Legislation in the transport sector

The EU energy efficiency legislation regarding transport sector is part of the *EU 2020 Energy Strategy*, having as one of its key targets the cut of 40% in EU greenhouse gas emissions compared to 1990 levels. The transport sector was responsible for the 22.2% of the total $CO_2$ emissions of Europe in 2013[44]. European policy and research activities aim at decarbonizing the transport sector through appropriate regulations for fuels and transport means for persons and goods. These regulations serve clearly also to foster energy efficiency improvements of transport means.

Car energy efficiency has been mostly addressed in the past through voluntary agreements on $CO_2$ emissions limitations with car manufacturers and the mandatory labelling of cars, showing a progressive improvement in $CO_2$ emissions. Euro 5 and 6 standards[45] for light passenger and commercial vehicles were agreed in 2006, and came into force in 2009 and 2014, respectively [6].

The framework Directive on promotion of clean and energy-efficient road transport vehicles[46] requires contracting authorities[47], contracting entities as well as certain operators to take into account lifetime energy and environmental impacts, including energy consumption and emissions of $CO_2$ and of certain pollutants (i.e. emissions of NOx, NMHC and particulate matter), when purchasing road transport vehicles with the objectives of promoting and stimulating the market for clean and energy-efficient vehicles and improving the contribution of the transport sector to the environment, climate and energy policies of the European Union.

Complementing this framework Directive, several Commission Regulations have been introduced such as the 2009 Regulation setting emission performance standards for new passenger cars as part of the EU integrated approach to reduce $CO_2$ emissions from light-duty vehicles[48]. This Regulation establishes $CO_2$ emissions performance requirements for new passenger cars in order to ensure the proper functioning of the

[44] This value includes also emissions from international aviation. Data source: European Environment Agency (EEA).

[45] Regulation 715/2007/EC

[46] Directive 2009/33/EC

[47] Contracting authorities are State, regional or local authorities, bodies governed by public law, associations formed by one or several such authorities or one or several of such bodies governed by public law.

[48] Regulation 443/2009/EC

internal market and to achieve the overall objective of the EU of 120 g $CO_2$/km as average emissions for the new car fleet. This Regulation sets the average $CO_2$ emissions for new passenger cars at 130 g $CO_2$/km, by means of improvement in vehicle motor technology. From 2020 onwards, it is set a target of 95 g $CO_2$/km as average emissions for the new car fleet. The average limit of 130 g CO2/km fully entered into force in 2015, with a gradual introduction of this emission threshold as follows:

- 65% in 2012;
- 75% in 2013;
- 80% in 2014;
- 100% from 2015 onwards.

Member States are responsible for collecting data for each new passenger car registered in their territory. They must provide the Commission with the following information concerning these vehicles:

- their number;
- their average specific emissions;
- their average mass;
- their distribution;
- their footprint.

In 2014, a Commission's Proposal[49] for the amendment of Regulations 2007/715/EC and 2009/595/EC on reduction of pollutant emissions from road vehicles was issued. The focus of this draft proposal is on those areas where market and regulatory failures hinder addressing the overarching challenges situated within the context of the EU's air quality and the Better Regulation Agenda.

Some of the proposal's highlights are:

- Consider methane emissions in the calculation of $CO_2$ emissions, as it is a strong greenhouse gas.
- In order to facilitate the introduction of natural gas vehicles the current total hydrocarbons (THC) emission limit should be increased and the effect of methane emissions should be taken into account and expressed as a $CO_2$ equivalent for regulatory and consumer information purposes.
- Modern diesel vehicles emit high and increasing amounts of $NO_2$ as a share of the total NOx emissions which were not anticipated when Regulation (EC) No 715/2007 was adopted. Most air quality problems affecting urban areas appear to be related to direct $NO_2$ emissions. Therefore, an appropriate emission limit should be introduced.
- The current emission limits for CO and total hydrocarbons (THC) after a cold start at low temperature have been carried over from Euro 3 requirements set out in Directive 98/69/EC of the European Parliament and of the Council, which appear to be outdated in the light of existing vehicle technology and air quality needs. In addition, air quality problems and results of vehicle emission measurements suggest the need to introduce an appropriate limit for NOx/$NO_2$ emissions. Therefore, revised emission limits should be introduced pursuant to Article 14(5) of Regulation (EC) No 715/2007.
- The emission limit set for $NH_3$ in Regulation (EC) No 595/2009 of the European Parliament and of the Council is a requirement designed to limit the slip of ammonia from NOx after treatment technologies which use a urea reagent for the reduction of NOx. The application of the $NH_3$ limit value should therefore only be applied to those technologies and not to positive ignition engines.

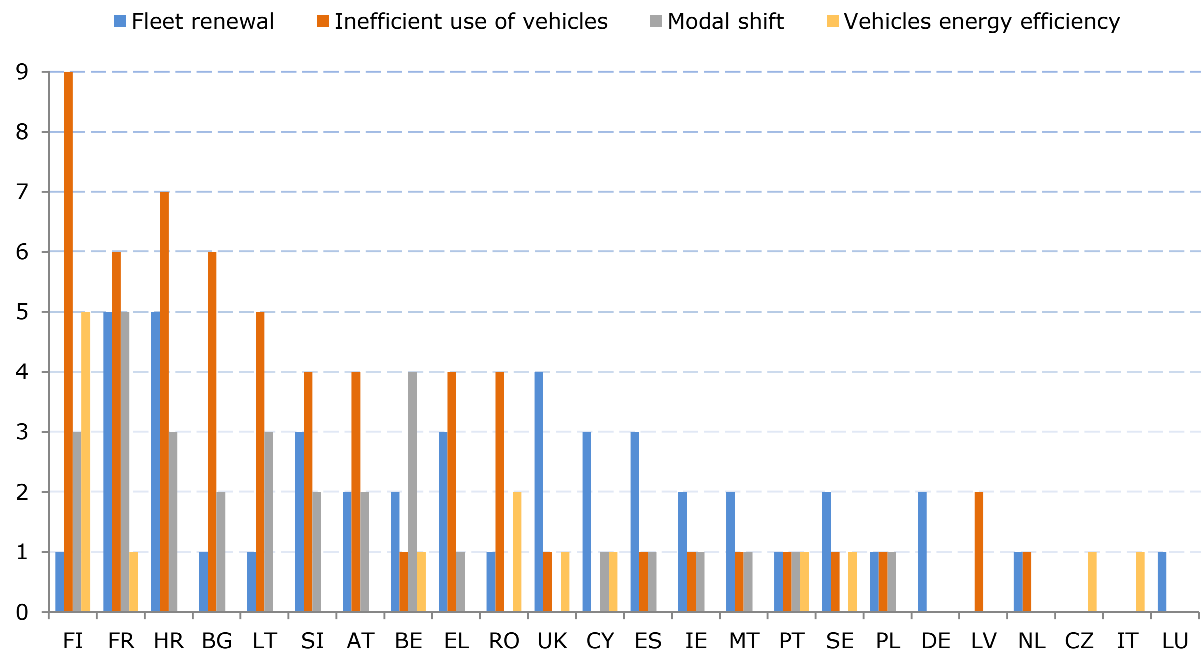
[49] COM/2014/028 final - 2014/0012 (COD)

Tyres are also an important element affecting the energy performances of road transport means. Whilst there is no specific eco-design measure for tyres, there is type-approval legislation on general safety of motor vehicles[50], which sets minimum requirements on tyres' fuel efficiency, wet grip and external rolling noise.

Also, tyres are under a labelling Regulation[51] with respect to fuel efficiency and other essential parameters. Tyre labels help consumers choose a product that is more fuel efficient, has better wet braking and is less noisy. New tyres come with an energy label showing their energy efficiency class, ranging from efficiency class A (most efficient) to G (least efficient).

Within the framework of EED, policy measures have been also implemented with regard to transport sector and have been documented in the National Energy Efficiency Action Plans (NEEAPs) from the different MSs, especially during the third NEEAPs submitted in 2014 and referred as NEEAP3. The following figure shows the number of policy measures per efficiency domains[52] and per MS included into the NEEAP3.

**Figure 28: Number of measures per efficiency domains and per country. Source: MURE Database [6]**




Out of twenty-four countries that have at least one transport measure in the NEEAP3, only four, i.e. Belgium, Finland, France and Portugal, cover all the four domains. Fourteen countries cover three domains (mainly fleet renewal, inefficient use of vehicles and modal shift); one covers two domains and the remaining five countries just one domain with one or two measures per domain.

Member State with higher number of policies is Finland with 19 measures, mainly in the domain of inefficient use of vehicles – 9 measures, followed by France and Croatia with 17 and 15 measures respectively.

[50] Regulation 2009/661/EC

[51] Regulation 2009/1222/EC

[52] Measures related to transport infrastructure are also excluded.

## 3.4 Legislation in the industry sector

The EU main legislation measures directly and indirectly stimulating energy efficiency improvements in the industry sector are represented by the Emissions Trading Directives, the Energy Efficiency Directive, the Eco-design Directive, the Energy Labelling Directive, the Renewable Energy Directive and the Industrial Emissions Directives.

The Energy Efficiency Directive[53], which entered into force on 4 December 2012, addresses the industrial sector, both specifically and within sectors cross-cutting provisions.

Article 8 of EED makes a specific provision for the industry sector; it refers to energy audits and energy management systems.

Article 8(1) and Article 8(4) of the Directive establish the two main obligations for Member States to promote the availability of energy audits and to ensure that large enterprises carry out regular energy audits. Also, it obligates Member States to ensure the availability of efficient high-quality energy audit schemes, which are carried out in an independent manner to all final consumers, including small and medium-sized enterprise (SMEs) of the industry sector.

Energy audits must be carried out by either "qualified" or "accredited" experts. Accreditation is a public authority activity that ensures the continuous control of the technical competence of conformity assessments bodies. Thus, Member States have to put in place certification schemes for the providers of energy audits to make sure that a sufficient number of reliable professionals is available[54].

As per sectors cross-cutting measures with relevance to the industry sector, Article 7 of the EED requires Member States to put in place Energy Efficiency Obligations schemes (EEOs) and/or use alternative policy measures to deliver a targeted amount of energy savings amongst final energy consumers. Therefore, it also involves industry sector.

The EED establishes also that Member States must promote the energy services market, and the industry sector may be involved in or affected by energy service contracts, financial instruments, incentives, grants or loans to support energy efficiency service projects.

The EU ETS directly approaches the industry sector through a 'cap and trade' principle. A limit is set on the total amount of certain greenhouse gases that can be emitted by the factories, power plants and other installations in the system. Within the industry sector the focus is on energy-intensive industry sectors including oil refineries, steel works and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals.

The eco-design and energy labelling Directives also affect the industry sector by regulating the market of some energy-related products used within industrial applications and activities (e.g. electric motors, compressors, cool storage rooms, computers and servers, etc.).

[53] Directive 2012/27/EU

[54] SWD(2013) 447 final

The following tables list the current eco-design and energy labelling regulations affecting ErPs used in the industry sector.

**Table 6: Overview of eco-design regulation for products in the industry sector, 2016. Source: EC**

| Product group / lot | Eco-Design Regulation | |
|---|---|---|
| | Publication Date | Regulation in force |
| Circulators in Buildings | 08/2009 | 641/2009 |
| Computers and Servers | 07/2014 | 617/2013 |
| Electric motors | 08/2009; amended 01/2014 | 640/2009 and 4/2014 |
| External Power Supplies | 04/2009 | 278/2009 |
| Imaging Equipment | VA 01/2015 | - |
| Local room heating products | 08/2015 | 1185/2015 ; 1188/2015 |
| Refrigerating and freezing equipment | 08/2015 | 2015/1095 |
| Space and Combination Heaters | 09/2013 | 813/2013 |
| Tertiary Lighting | 04/2010 | 245/2009 |
| Simple Set-Top Boxes | 02/2009 | 107/2009 |
| Complex Set-Top Boxes | VA 07/2010 | - |
| Distribution and power transformers | 06/2014 | 548/2014 |
| Ventilation fans | 04/2011 | 327/2011 |
| Water heaters | 09/2013 | 814/2013 |
| Electric pumps | not implemented yet | - |
| Central heating products | not implemented yet | - |
| Special motors and VSD | not implemented yet | - |
| Compressors | not implemented yet | - |
| Industrial ovens | not implemented yet | - |
| Machine tools | not implemented yet | - |
| Steam boilers | Study ongoing | - |
| Power cables | Study ongoing | - |
| Enterprise servers | Study ongoing | - |

**Table 7: Overview of energy labelling regulations for products in the industry sector, 2016. Source: EC**

| Product group / lot | Labelling Measure | |
|---|---|---|
| | Publication Date | Regulation in force |
| Computers and Servers | not implemented | - |
| Electric motors | not implemented | - |
| Imaging Equipment | not implemented | - |
| Local space heating products | 08/2015 | 1186/2015 |
| Refrigerating and freezing equipment | 08/2015 | 1094/2015 |
| Space and Combination Heaters | 09/2013 | 811/2013 |
| Water Heaters | 09/2013 | 812/2013 |

The Renewable Energy Directive[55] covers renewable energy production (large scale), as part of the energy supply sector, as well as (small scale) production at the end-users place. For industry, the Directive contains provisions such as calculating the gross final consumption of energy from renewable sources for heating and cooling as the quantity of district heating and cooling produced plus the consumption of other energy from renewable sources [7]. This renewable production decreases the delivery of (fossil) energy through the grid, in the same way as energy savings do [8].

The Industrial Emissions Directive[56] covers instead industrial activities with a major pollution potential, as defined in Annex I to the Directive (energy industries, production and processing of metals, mineral industry, chemical industry, waste management, rearing of animals, etc.). The Directive contains special provisions for the following installations:

- combustion plants (≥ 50 MW);
- waste incineration or co-incineration plants;
- certain installations and activities using organic solvents;
- installations producing titanium dioxide.

The Directive mandates that Member States take the necessary provisions to ensure that any industrial installation which carries out the activities listed in its Annex I meet certain basic obligations such as:

- preventive measures against pollution;
- the best available techniques (BAT) to be applied;
- no significant pollution is caused;
- waste to be reduced, recycled or disposed of in the manner which creates least pollution;
- energy efficiency criteria have to be considered;
- accidents to be prevented and their impact limited;
- sites damages to be remedied when the activities come to an end;

The Directive states that the industrial installations must use the best available technologies to achieve a high general level of protection of the environment as a whole, which are developed on a scale which allows implementation in the relevant industrial sector, under economically and technically feasible conditions. The EC is responsible to adopt BAT conclusions[57] containing the emission levels associated with each BAT. These conclusions will serve as a reference for the drawing up of permit conditions. The permit must provide with the necessary measures to ensure compliance with the operator's basic obligations and environmental quality standards. These measures should include at least [8]:

- emission limit values for polluting substances;
- rules guaranteeing protection of soil, water and air;
- waste monitoring and management measures;
- requirements concerning emission measurement methodology, frequency and evaluation procedure;
- requirements concerning the maintenance and surveillance of soil and groundwater;

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[55] Directive 2009/28/EC

[56] Directive 2010/75/EU

[57] 'BAT conclusions' means a document containing the parts of a BAT reference document laying down the conclusions on best available techniques, their description, information to assess their applicability, the emission levels associated with the best available techniques, associated monitoring, associated consumption levels and, where appropriate, relevant site remediation measures. BAT conclusions are produced based on a BAT reference document resulting from an exchange of information among the Commission, the Member States, concerned industries and NOGs organised according to the Article 13 of the Directive.

- measures relating to exceptional circumstances (leaks, malfunctions, momentary or definitive stoppages, etc.);
- provisions on the minimisation of long-distance or trans-boundary pollution;
- conditions for assessing compliance with the emission limit values.

# 4. Energy Consumption and Energy Efficiency Trends in the Residential Sector

This chapter covers energy efficiency and energy consumption trends in the residential sector, with a focus on electricity and gas consumption. The data are presented and together with some main energy consumption drivers such as economic growth, population growth, weather conditions and household characteristics. Moreover, it is given a specific insight of energy efficiency trends and EU regulations of energy related products (ErP) such as major appliances, heating and cooling appliances, lighting, information and communication technologies and stand-by and off-mode losses of the ErP.

## 4.1 Final energy consumption trends in the residential sector

This subchapter shows the final residential energy consumption trends for the period from 2000 to 2014. Influencing factors in the energy consumption such as economic development and weather conditions are qualitatively analysed. District heating is also covered as it plays a significant role in the supply of low-carbon heating and cooling in Europe.

In 2014, the residential sector represented 24.80% of the final energy consumption in the European Union, being the third consuming sector after transportation (33.22%) and industry sector (25.89%). The overall finding of this chapter is that the final energy consumption in the residential sector started to decrease in the last years. The residential sector has declined especially in 2011 and 2014 where decreases in the consumption above 11% have taken place compared to the previous year (Figure 31).

The following figure shows the final residential energy consumption trend at European level. It can be observed that after reaching a maximum of consumption in 2010 (317 Mtoe) the energy consumption has dropped to 263 Mtoe in 2014, establishing the both values as the maximum and minimum respectively for the 25-years period from 1990 to 2014. During the period 2000-2014, the final residential energy consumption in the EU-28 has dropped by -9.5%, from 291 Mtoe to 263 Mtoe. In 2014, 82% (216 Mtoe) of the final energy consumption in the residential sector has been consumed in EU-15, whereas NMS-13 have accounted for the remainder 18% (48 Mtoe) of the consumption. Both countries groups have undergone a reduction of their residential consumptions during the analysed period.

**Figure 29: Final residential energy consumption in the EU-28, 2000-2014. Source: Eurostat**

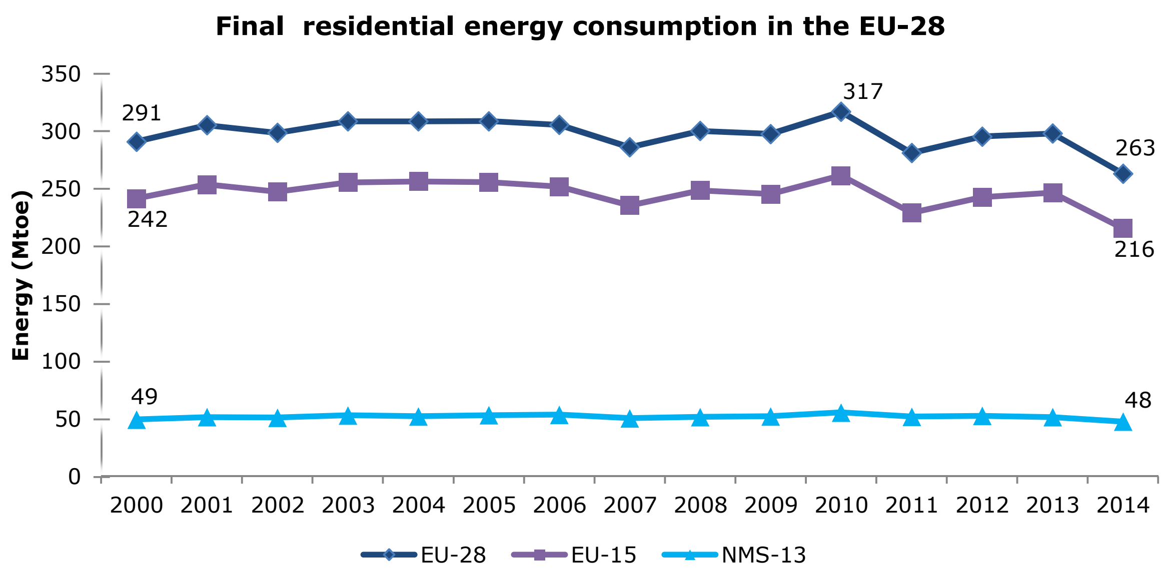


**Figure 30: Final residential energy consumption in the EU-28 (detailed), 2000-2014. Source: Eurostat**

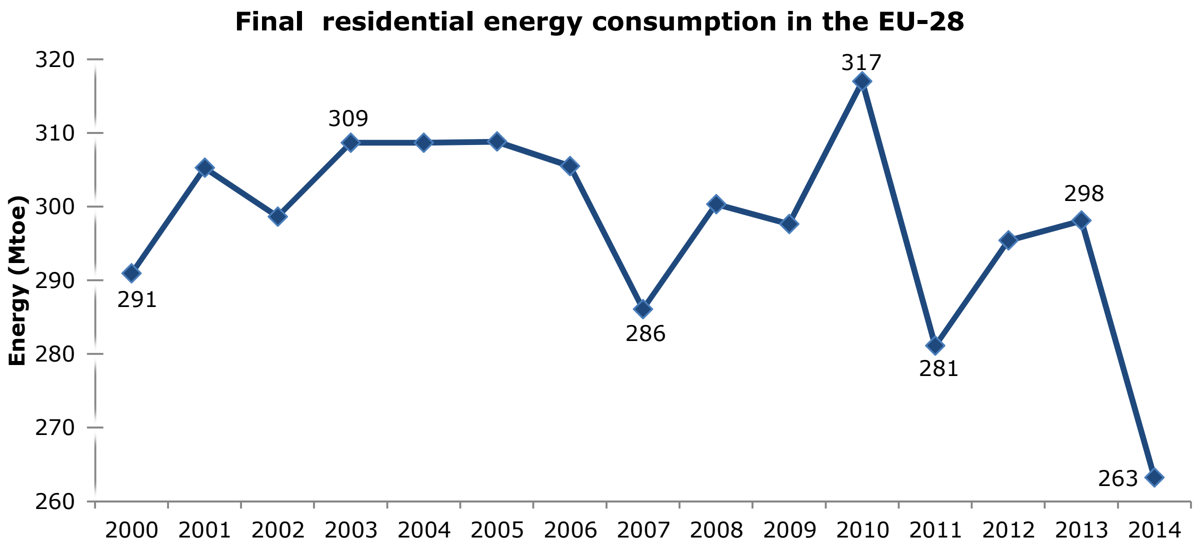
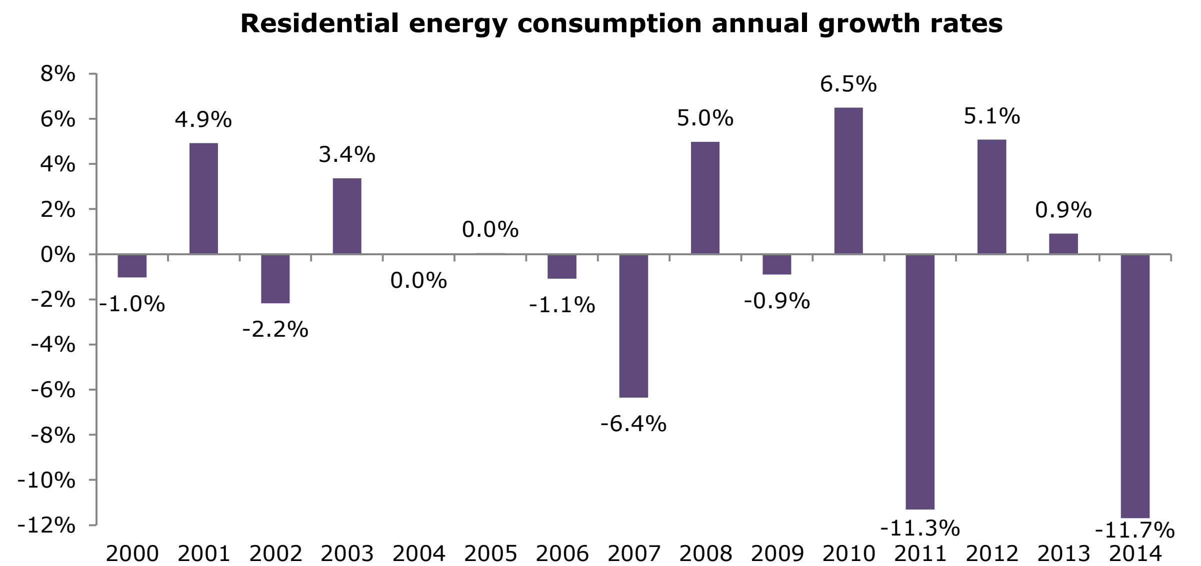



Figure 30 and Figure 31 complement the previous figure by showing a visualisation with axis-expanded and the growth rates respect to the previous year. It can be observed that from 2003 to 2006 the consumption remained quasi-constant with the highest change of -1.1% between 2005 and 2006. Since 2007 onwards, the final residential energy consumption has registered a continuous fluctuation. To be noted that when consumption decreases, it does so at a higher rate compared to when the energy consumption grows. In 2014, there has been a significant drop in the residential consumption by -11.7% which represents, as already mentioned, the lowest value of final energy consumption during the 1990-2014 period.

**Figure 31: Final residential energy consumption annual growth rates in the EU-28, 2000-2014. Source: Eurostat**




Per capita final energy consumption in the residential sector has lowered by 79 koe at European level from 2000 to 2014, representing a drop of 13.1%. The trend of this indicator mainly follows that of the final residential energy consumption as the population growth rates changes have been much less sharp than the energy consumption changes. Therefore, despite the fact that the EU-28 population has been continuously growing, its influence on the final residential energy consumption changes is quite limited.

**Figure 32: Final residential energy consumption per capita in the EU-28, 2000-2014. Source: Eurostat**

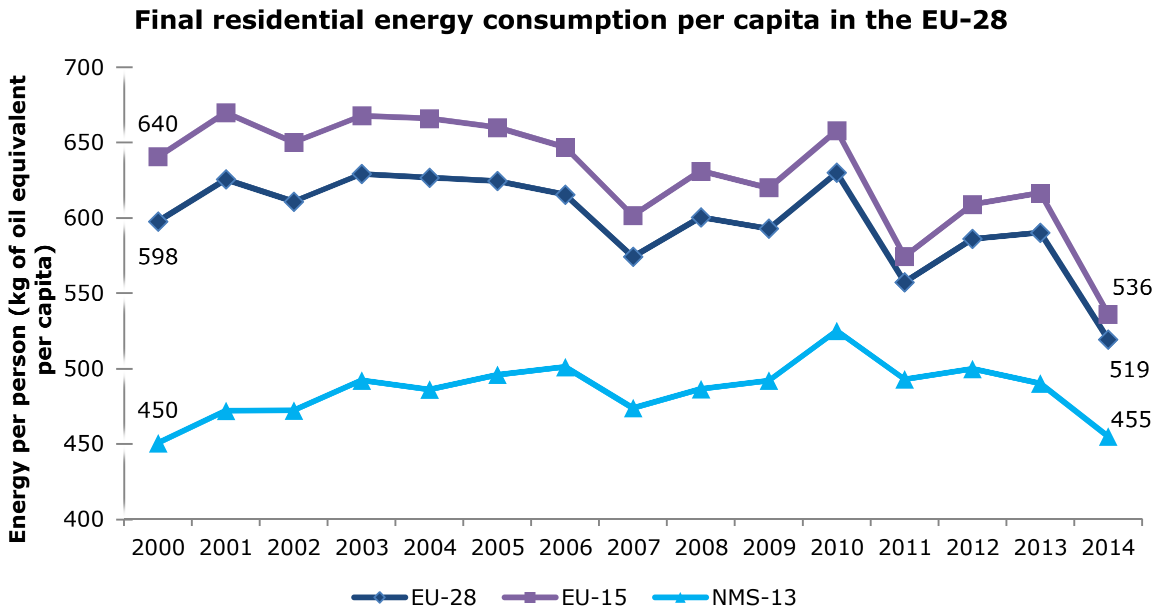
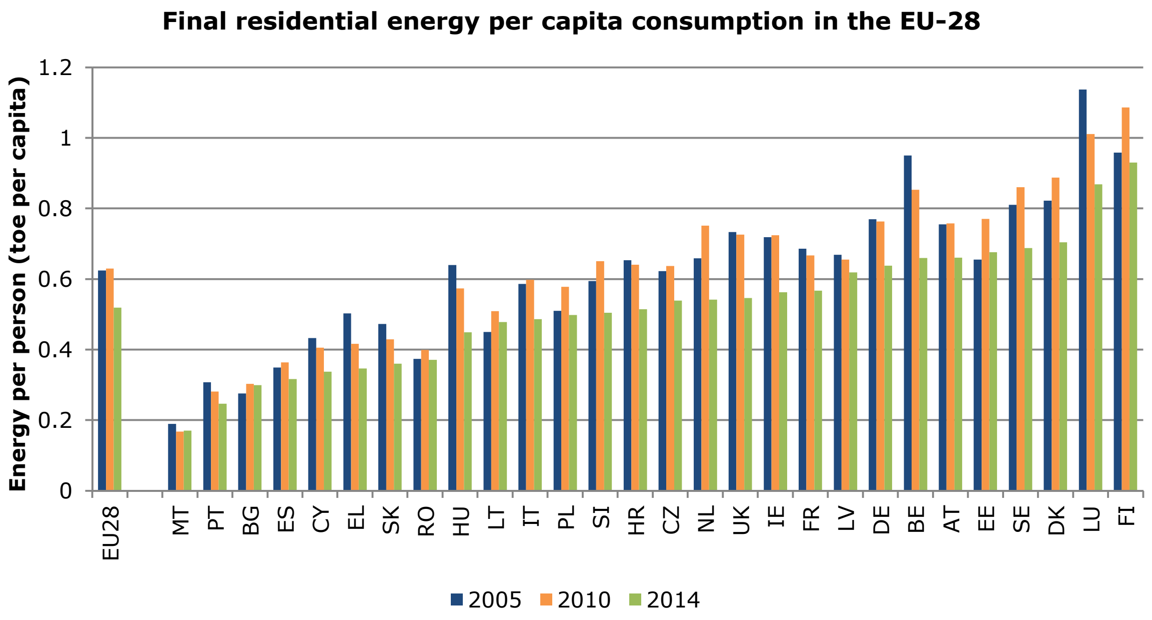



**Figure 33: Final residential energy consumption per capita by EU-28 Member State, comparison 2005, 2010 and 2014. Source: Eurostat**




When analysing the final residential energy per capita by Member State (Figure 33), it is observed that in 2014 the countries with highest consumption are Finland with 0.93 toe/cap, followed by Luxembourg (0.87 toe/cap) and Denmark (0.70 toe/cap). In contrast, Malta, Portugal and Bulgaria have the lowest rate with 0.17, 0.25 and 0.30 toe/cap respectively. The average EU-28 value has dropped by -16.8% in the period between 2005 and 2014 (from 0.624 toe/cap to 0.519 toe/cap).

Half of the Member States, i.e. fourteen countries, have registered a per capita final energy consumption below the average of EU-28 (< 0.519 toe/cap) in 2014. Out of these countries, seven have mainly or solely Mediterranean climate. These countries are: Malta, Portugal, Spain, Cyprus, Greece, Italy, and Croatia. This result may indicate that climate is an important driver of residential energy consumption as mild winters lead generally to lower energy consumption. To be noted that the remaining 7 countries belong to the group of NMS-13. Rather than by energy efficiency policies in force, this might be caused by factors such as cultural habits, economic development or availability of energy resources in comparison to other EU-28 countries.

**Figure 34: Share of fuel types to final residential energy consumption in the EU-28, 2000 and 2014. Source: Eurostat**

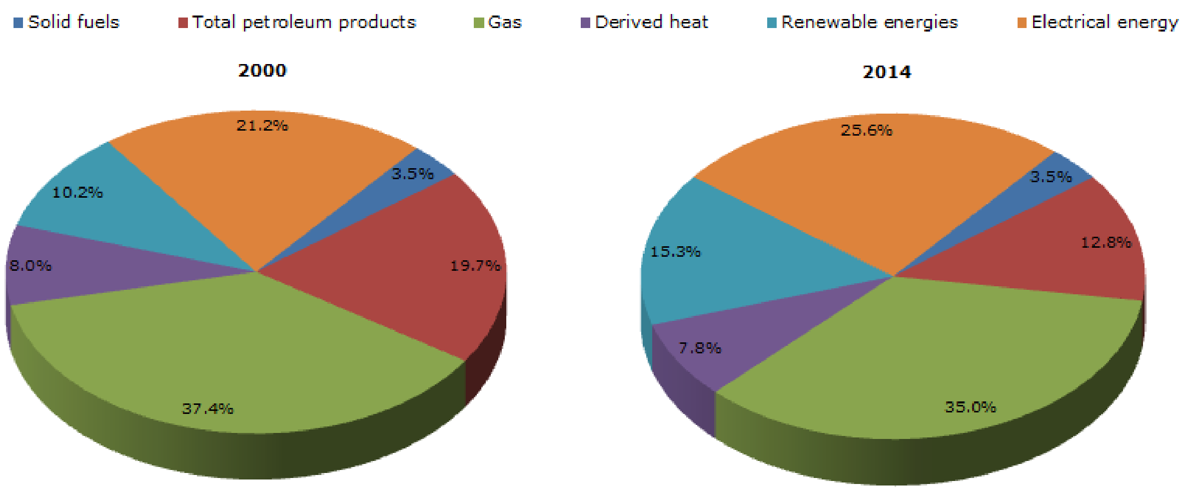


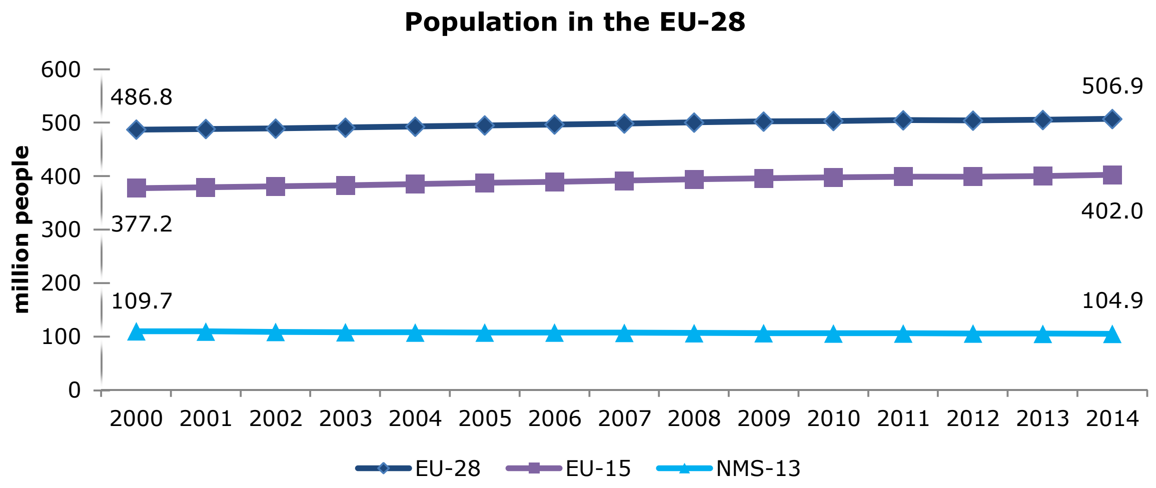

Figure 34 shows the share of each fuel type to final residential energy consumption. In 2014, the gas has accounted 35.0% of the consumption followed by electrical energy (25.6%) and renewable energies (15.3%). The share of electricity includes electricity generated from renewable energy sources which are integrated into the electrical network i.e. wind power, photovoltaic power, hydro power and tide, wave and ocean energy. Therefore, the share of renewables mainly focusses on production of heat from renewable resources.

As gas and electricity are the main energy sources for the residential sector, their consumption trends have been analysed independently later in this chapter.

## Factors influencing residential energy consumption

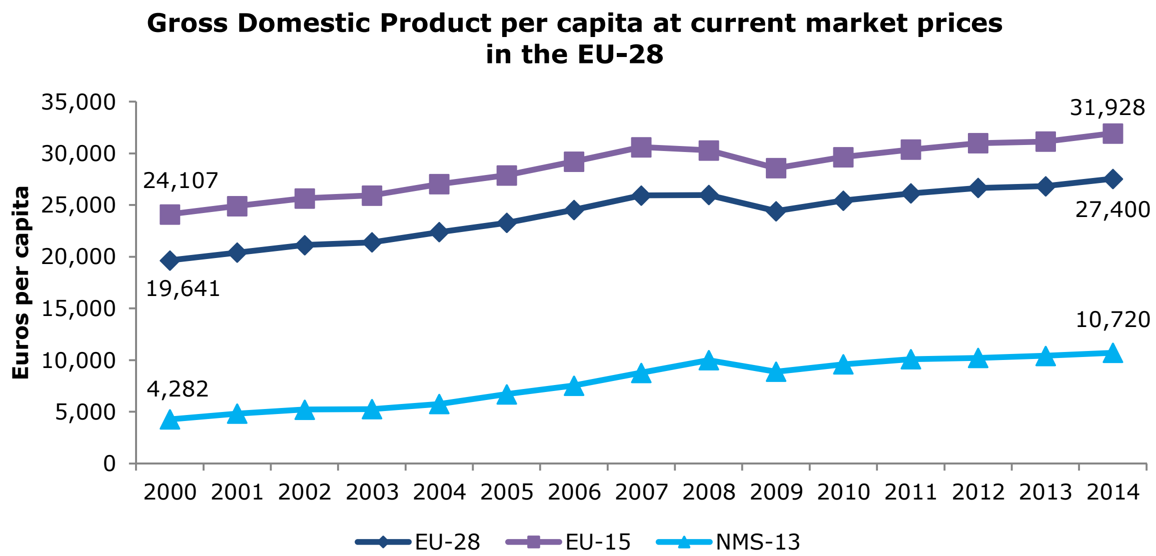
When analysing energy consumption, it is important to consider influencing factors such as population growth, economic development and weather conditions. No quantitative analysis aiming to assess the influence of these factors is presented in this report. Nevertheless, possible explanations for the registered consumption patterns are proposed by simply comparing energy consumption trends with the trends registered for the following parameters: population, GDP per capita, weather conditions (actual heating degree days), number of dwellings per country, average persons per household. The influence of these factors can in principle help better understand the relation between energy consumption and efficiency trends in the residential sector.

**Figure 35: Population in the EU-28, 2000-2014. Source: Eurostat**




Between 2000 and 2014 the population in the EU-28 grew by 4.12%. In the same period the residential final energy consumption dropped by -10.9%. The population in the NMS-13 decreased by 4.4% between 2000 and 2014. In the EU-15, on the other hand, the population grew by 6.59% in the same period. Therefore, the decrease in the total residential energy consumption observed in the NMS-13 turns into an increase in the per capita energy consumption due to the higher population decrease for the period 2000-2014, as illustrated by correlating Figure 29, Figure 32 and Figure 34.

**Figure 36: Gross Domestic Product per capita at current market prices in the EU-28. Source: Eurostat**




Another factor that can influence energy consumption is the economic development and economic situation of the countries. GDP per capita[58] in the EU-28 has been increasing continuously between 2000 and 2014 with a drop in GDP in 2009 due to the economic and financial crisis worldwide. Between 2009 and 2010 the GDP per capita increased again by 4.18% in the EU-28 (Figure 36). The GDP per capita across countries in the EU-28 for the year 2014 results very largely dispersed across the Member States can be

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[58] All GDP numbers are given in current prices as of the year 2014 (source: Eurostat)

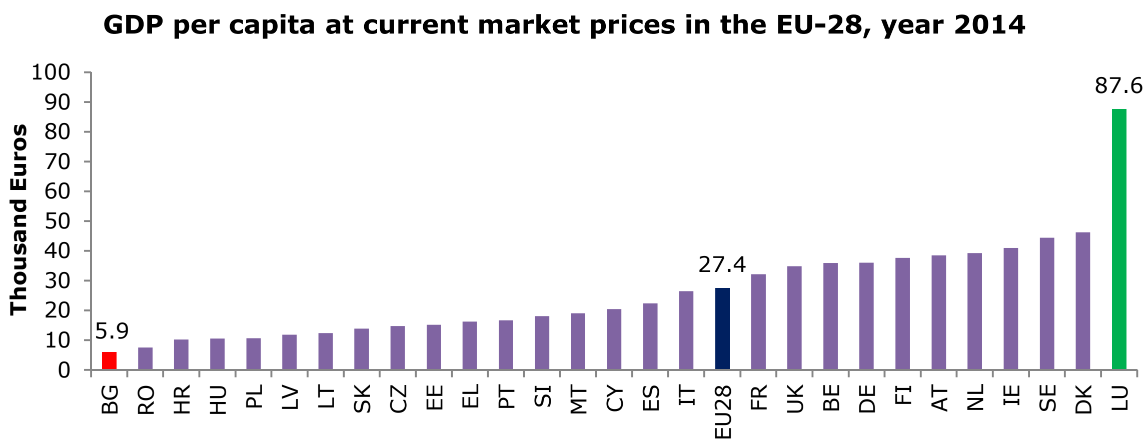
identified as illustrated in Figure 37. The GDP per capita in Bulgaria was EUR 5,900 in 2014 whereas GDP in Luxembourg was EUR 87,600. The average GDP per capita in the EU-28 was EUR 27,400 in the year 2014. Compared to an increase of 32% in GDP per capita between 2000 and 2014, final residential energy consumption per capita fell by 14.5% in the same period. Given the large dispersion in GDP per capita in the EU-28 it is of interest to compare these data with average per capita energy consumption. As showed in Figure 33, Finland, Luxembourg and Denmark which are the countries with highest consumption per capita also have above average GDP per capita. Higher GDP levels may indeed lead to buy more energy using equipment at home resulting hence in higher energy consumption.

The growth in GDP per capita can be attributed to important economic development during these years, despite the population increase observed. A comparison between the economic growth and energy consumption growth rate indicated that the observed significant economic growth has not been accompanied by a same increase in energy consumption.

It is clear that economic development is positively correlated with total final energy consumption. However, especially in the residential sector the economic growth in the EU can be accompanied by a more efficient usage of energy as economic growth can also lead to more energy efficient equipment resulting in lower energy consumption levels.

In the household sector an increase in efficient use can be due to more efficient appliances and equipment, and more efficient systems and better insulated buildings in general. The market penetration rates and energy consumption trends are introduced later in this chapter for the so-called 'Energy-related Products'.

**Figure 37: GDP per capita at current market prices in the EU-28, year 2014. Source: Eurostat**



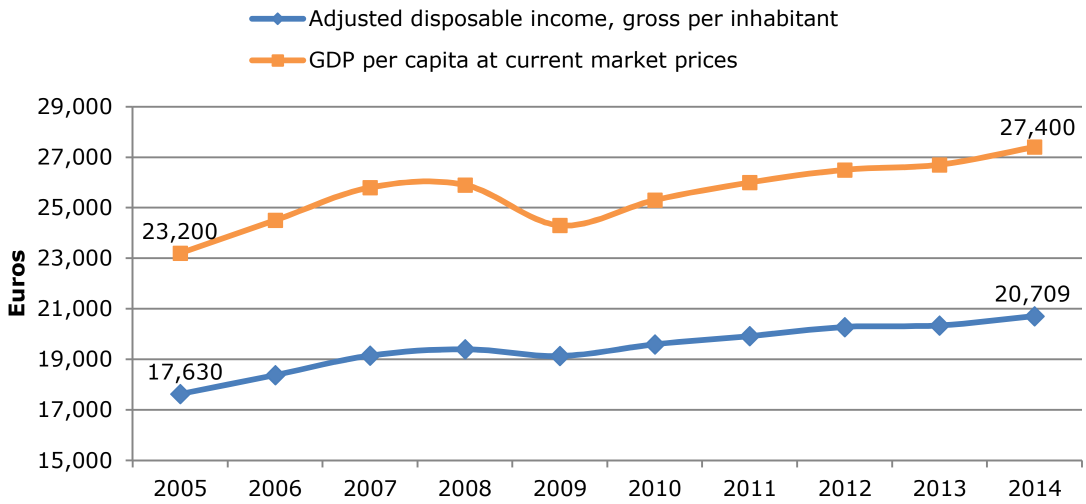

Although Gross Domestic Product is largely and traditionally used in energy statistics for obtaining key indicators such as energy intensity, the disposable income of households or adjusted gross disposable income can represent a more interesting economic indicator when focussing on residential energy consumption.

Disposable income of households may be defined as the net amount they have earned, or received as social transfers, during the accounting period excluding exceptional flows linked to capital transfers or changes in the volume/value of their assets minus current transfers in cash (taxes on income and wealth, etc.). It is mainly composed of wages received, revenues of the self-employed and net property income such as interest received on deposits minus interest paid on loans and dividends.

Adjusted gross disposable income also includes social transfers in kind that account for the flows of individual services which are provided free of charge by the government.

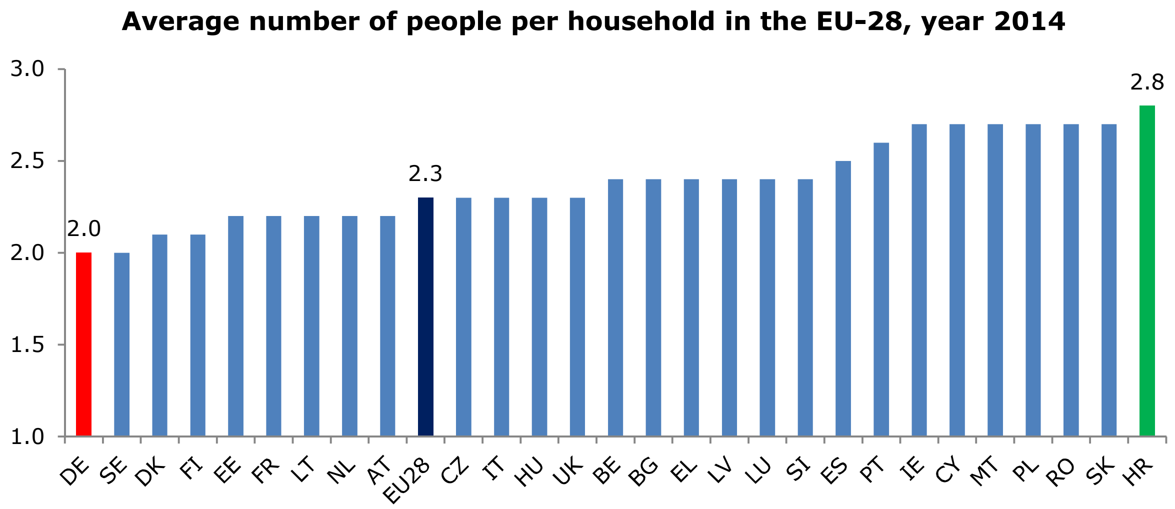
These services mainly consist of education, health and social services but also housing, cultural and recreational services. They exclude collective services that are provided simultaneously to all members of the community, such as security and defence, legislation and regulation. Thus, adjusted disposable income improves the comparison of income levels across countries by taking into account the different degrees of involvement of governments in the provision of free services to households [9]. Figure 38 shows the trend-line comparison of both adjusted disposable income per capita and GDP per capita for the 10-years period between 2005 and 2014. It can be observed that there is a notable difference between both variables; in 2014 the difference reaches EUR 6,691. Thus, although largely used, the GDP associated with the residential sector may turn into an unfavourable indicator for end-users in so far as it does not reflect the real purchasing power of the inhabitants.

**Figure 38: Adjusted disposable income per capita and GDP per capita at current market prices in the EU-28, 2005-2014. Source: Eurostat**



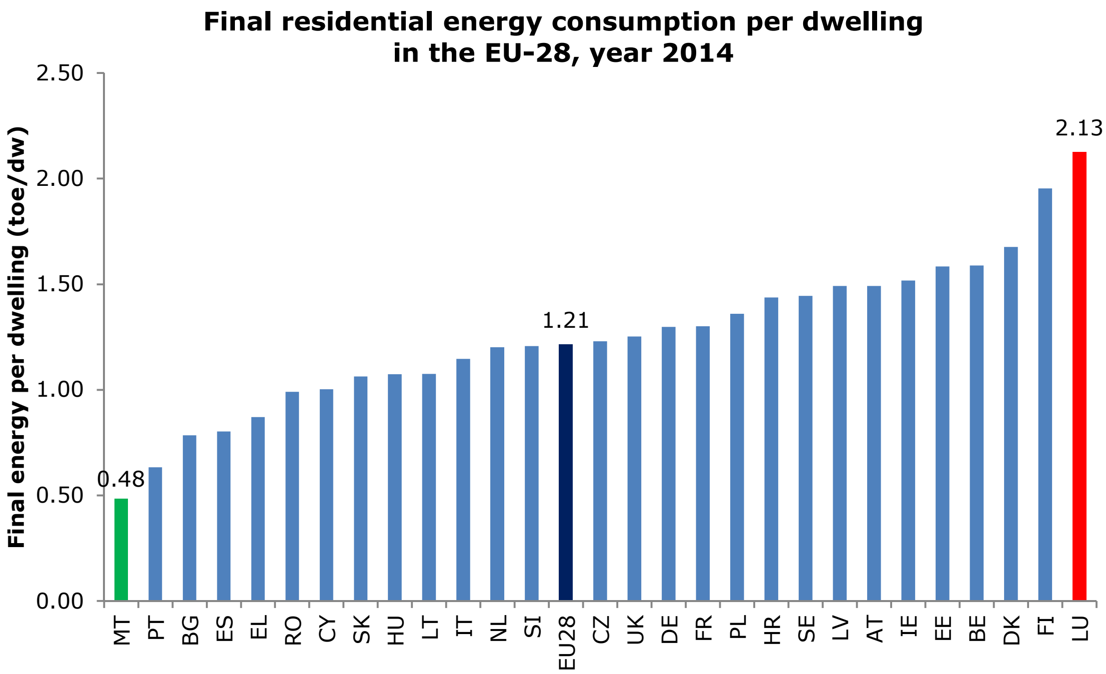

Per capita consumption is also influenced by the number of people living together in one household. Most of the energy-using equipment is indeed shared by the people living together in one household (e.g. heating and cooling equipment, major domestic appliances and electronic equipment). The average number of persons per household in the EU-28 was 2.3 in the year 2014. Germany and Sweden have the lowest average number of persons per household (2.0) and Croatia the highest (2.8), as showed by Figure 39. Luxembourg has the highest GDP per capita and also an above EU-28 average household size. The overall development in Europe is an increase in population accompanied by an increase in the number of smaller households (in terms of persons per household) which leads to an increase of energy consumption per household.

**Figure 39: Average number of people per household in the EU-28 Member States, 2014. Source: Eurostat**



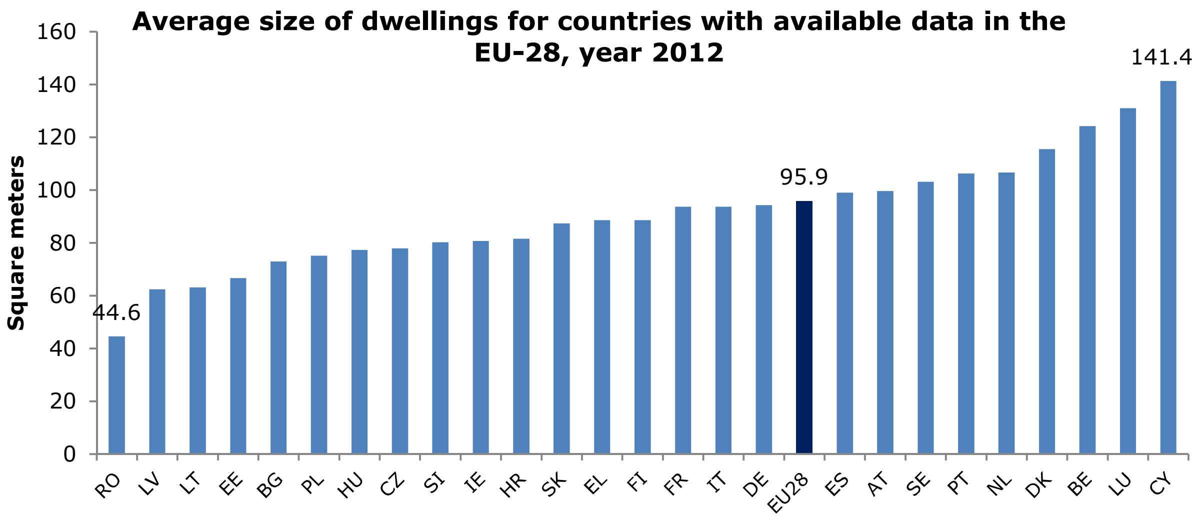

The average final residential energy consumption per dwelling in the EU-28 in the year 2014 reached 1.21 toe. Luxembourg accounted the highest consumption (2.13 toe) and Malta (0.48 toe) the lowest.

**Figure 40: Final residential energy consumption per dwelling in the EU-28, year 2014. Source: JRC calculation based on Eurostat data**




Besides the number of people per household the actual size in square meters of household dwellings is another interesting indicator of the households' energy consumption. Large dwellings generally have a higher heating and cooling demand and higher energy consumption by lighting equipment. Romania is one of the Member States with the largest average number of persons per household (2.7) but has the smallest dwellings average size. Cyprus, Luxembourg and Belgium are the Member States with the largest average size (see Figure 41).

**Figure 41: Average size of dwellings for countries with available data in the EU-28, year 2012. Source: Eurostat**




Weather and climate are environmental conditions that affect energy consumption as for instance severity of winter or summer seasons can lead to occasional consumption peaks. The parameters which are related to the heating and cooling needs are the so-called heating degree day (HDD) and cooling degree day[59] (CDD).

The final residential energy consumption per dwelling has been decreasing during the 10-years period from 2005 to 2014 in the EU-28. In 2005 the residential consumption per dwelling was 1.58 toe. In 2014, the consumption is 1.21 toe per dwelling, meaning a decrease of 23.4%. This may indicate an existing correlation between the energy consumption per dwelling and climatic conditions (heating degree days) as shown in the following figure. The final energy consumption per dwelling follows the HDDs with exception of year 2009 and 2013. Those differences might be explained by the influence or other factors, notably in relation to income levels, building design, energy systems and behavioural aspects. For instance, in 2009 the society crisis concern and the economic repercussion may explain the negative correlation between both variables (final energy consumption and HDD) as GDP per capita and disposable income fell that year (Figure 38).

[59] A degree-day is defined as the difference in temperature between the outdoor mean temperature over a 24-hour period and a given base temperature. Per definition, the base temperature is 18ºC. Thus, HDD and CDD are the number of degrees that a day's average temperature is below/above 18ºC which is the outside temperature below which buildings need to be heated or cooled [Source: EEA].

**Figure 42: Final residential energy consumption per dwelling and heating degree days in the EU-28, 2005-2014. Source: Eurostat[60]**

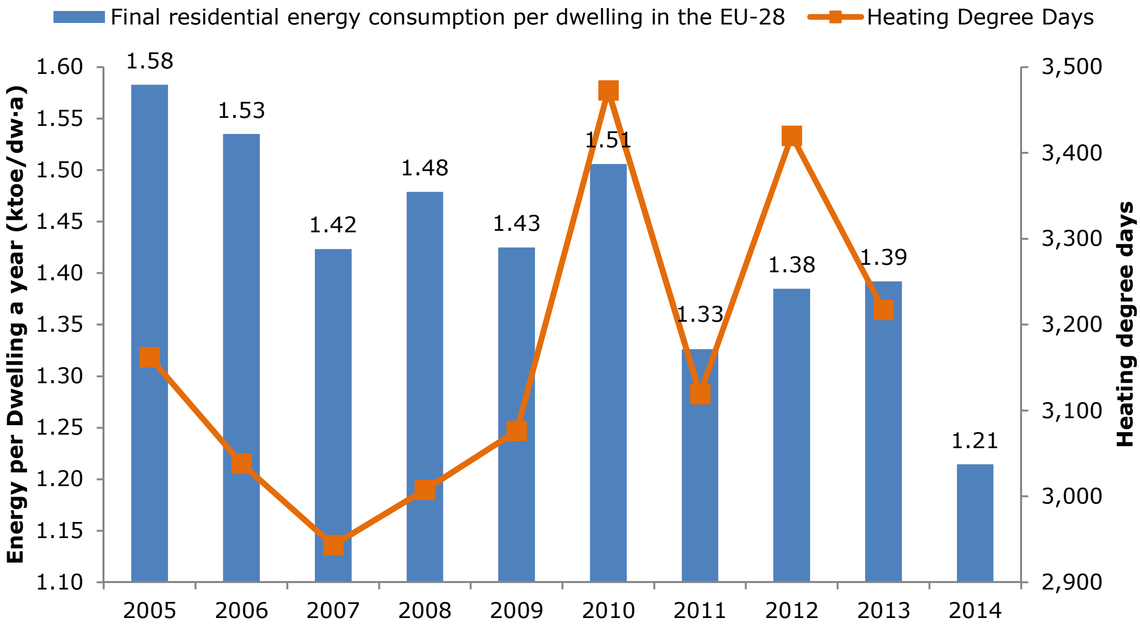
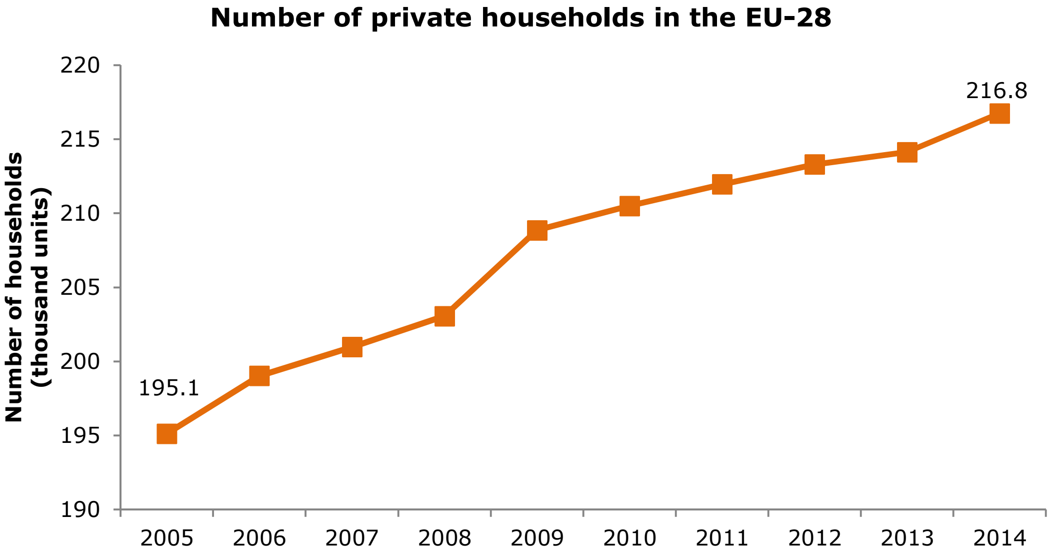



**Figure 43: Number of private households (in thousands) in the EU-28, 2005-2014. Source: Eurostat**



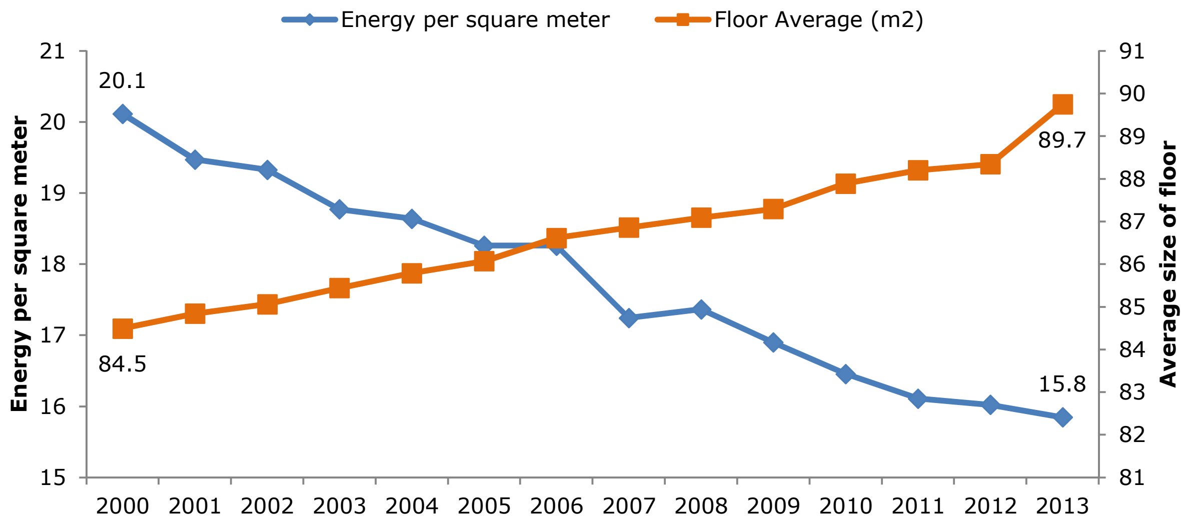

Although the number of private households in the EU-28 has been continuously growing and the size of houses in terms of persons per household has slightly decreased, the final residential energy consumption follows a decreasing trend.

Between 2000 and 2013 the average size of dwelling did, however, not considerably change (increase by 5.2 sqm in the whole period) - Figure 44. The decrease in consumption per dwelling during the same period can thus not be explained by smaller households, and it may be result of higher share of more efficient equipment and

[60] Final residential energy consumption per dwelling has been calculated by the report authors as the ratio between the final residential energy consumption data and the data related to the number of dwelling in the EU-28 as made available by Eurostat. The HDD value was not available for year 2014.

appliances, and other improvements in building elements, for example better building's envelopes.

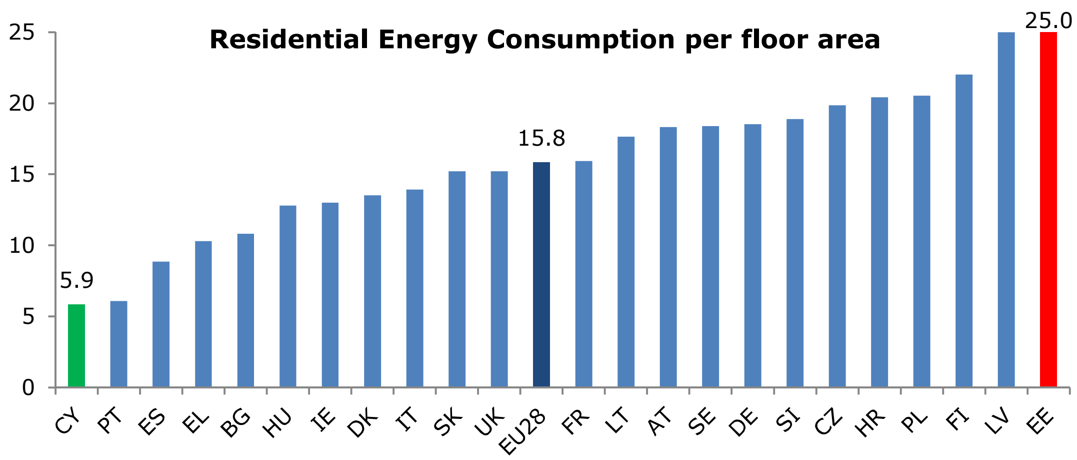
**Figure 44: Average energy per unit of area a year and floor size in the EU-28, 2000-2013. Source: Odyssee**




The average energy per unit of area at EU-28 level was 15.8 koe/m$^2$ in 2013. This represents a drop by 21.4% which sets the lowest value along the analysed period (2000-2013). It can be observed that the increase of average floor area helps reduce this indicator as it has grown during the same period. The influence of the weather conditions can be also appreciate if the heating degree days are compared with the residential energy consumption as already indicated in previous figures.

The residential energy consumption per unit of area across the EU-28 Member States for the year 2013 is illustrated in Figure 45. To be noted that the average EU-28 level is very close to the median. In 2013, the Member States with the highest per area residential energy consumption were Estonia and Latvia (25.0 koe/m$^2$), followed by Finland (22.0 koe/m$^2$) and Poland (20.5 koe/m$^2$). On the other hand, the Member States with the lowest values were Cyprus (5.9 koe/m$^2$), Portugal (6.1 koe/m$^2$) and Spain (8.8 koe/m$^2$).

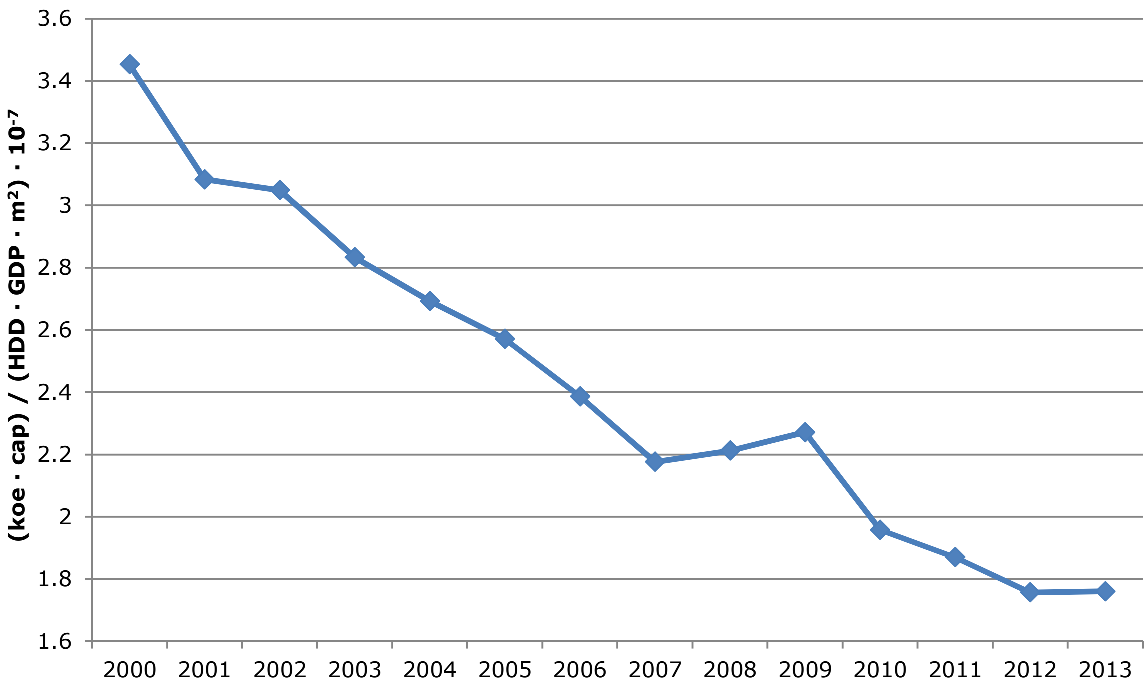
**Figure 45: Residential energy consumption per household floor size in the EU-28 Member States, 2013. Source: Odyssee[61]**




[61] Excludes BE, LU, MT, NL and RO due to incomplete data.

The following figure establishes a correlation between the residential energy consumption and the mentioned influencing factor (i.e. economic growth, climatic conditions and living conditions). The correlation is directly proportional to the per capita energy consumption and inversely proportional to HDD, GDP per capita and per capita household floor area. The correlation shows a decreasing trend (by -49%) during the 14-years period comprised from 2000 to 2013. The trend is mainly bound to the growing trends of income levels (GDP) and the average size of households in terms of square meter per person, together with the decreasing trend in the residential energy consumption. The alterations in the trend may be explained by the influence of these factors. For instance, in 2007 a mild winter led to lower energy consumption and the rise of GDP/cap that year helped lower this indicator. Opposite occurred in 2009, despite the fact of not being a severe winter and thus the correlation's value should have decreased, the GDP reduction due to the impact of the financial and economic crisis made the value rise by 2.2% in comparison to the previous year. In the following year (2010), the GDP recovery and the high number of HDD made the value return to its overall decreasing trend. To be noted that, although the energy consumption and the HDD are positively correlated, the impact produced by the HDD is higher due to the larger range of their values.

**Figure 46: Residential energy per capita, normalized by HDD, GDP per capita and $m^2$ per capita in the EU-28, 2000-2013. Source: Odyssee, Eurostat**



## 4.2 Electricity consumption trends in the residential sector

Electricity accounted for 25.6% of the final residential energy consumption in the EU-28 in 2014. This is the second highest share after gas consumption share (35.0%). The final residential electricity consumption in the EU-28 has grown by 9.4% in the 15-year period between 2000 and 2014. The electricity consumption reached 785 TWh in 2014, 87.6% of which was consumed in EU-15 (688 TWh) and the remainder 12.4% has been accounted by NMS-13 (97 TWh). EU-15 and NMS-13 have increased their final electricity consumption by 8.26% and 18.39% respectively.

The highest consumption during the analysed period occurred in 2010 when it grew up to 850 TWh. Between 2000 and 2010, the final electricity consumption in the residential sector was continuously increasing, alike between 2011 and 2013. After the consumption peak in 2010, the consumption drop by 4.86% in 2011; in 2014 the value dropped by 5.27% in comparison to the previous year as illustrated in Figure 47 and Figure 48.

**Figure 47: Final residential electricity consumption in the EU-28, 2000-2014. Source: Eurostat**

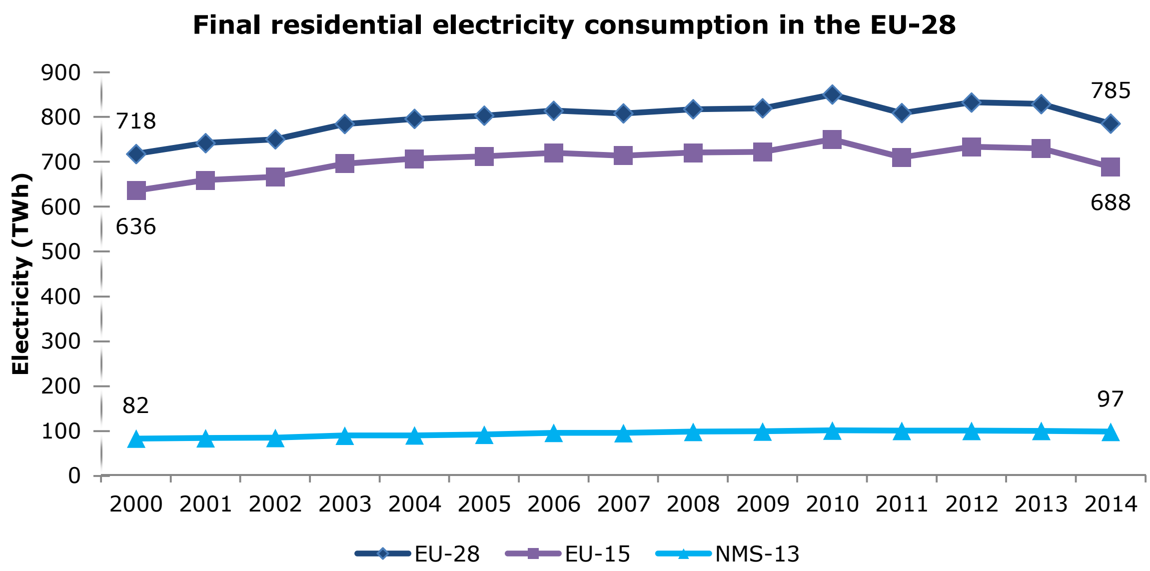
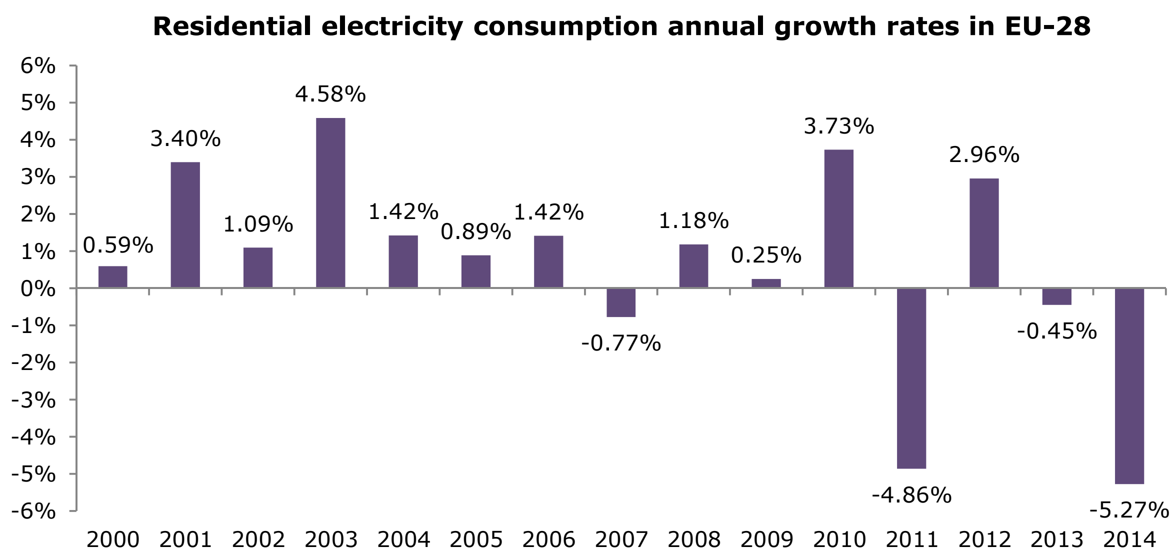
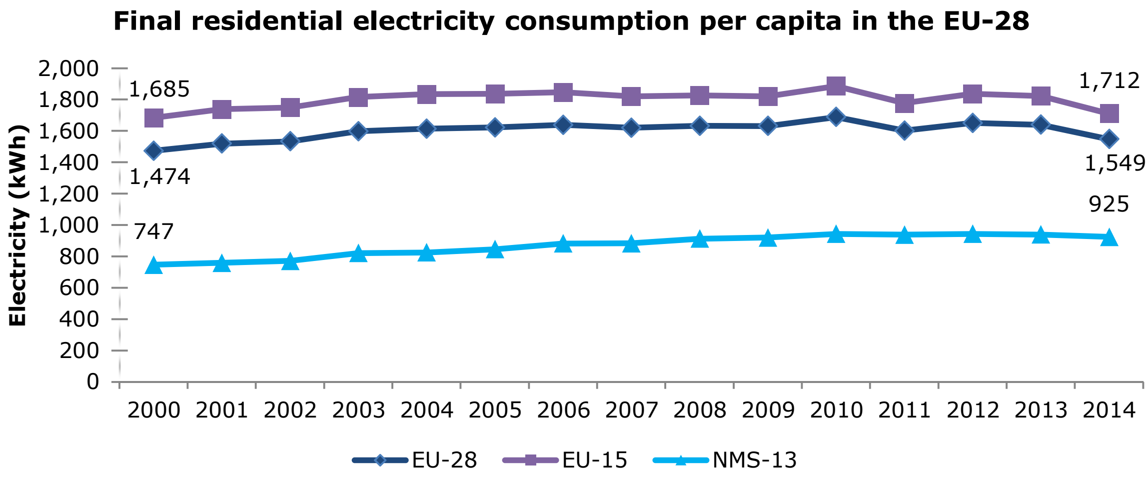



**Figure 48: Final residential electrical energy consumption annual growth rates in the EU-28, 2000-2014. Source: Eurostat**



The final residential electricity consumption per capita in the EU-28 has grown by 5.1% between 2000 and 2014. The average per capita electricity consumption in the residential sector was 1,549 kWh in 2014. The average per capita consumption was 1.85 times lower in NMS-13 compared to EU-15 in 2014. The consumption per capita in EU-15 has also grown by 1.57% in the same period (Figure 49). To be noted that the NMS-13 increase in its final residential energy consumption (18.4%) has been accompanied by a population's decrease by -4.4% in the same period (Figure 35).

**Figure 49: Final residential electricity consumption per capita in the EU-28, 2000-2014. Source: Eurostat**




Concerning final residential electricity consumption growth rates across the EU-28 Member States for period 2000-2014, it can be observed that eleven MS registered growth rates below the European average (9.42%).

The Member State with lowest growth rates has been Belgium with -20.20%, followed by Sweden (-12.37%) and Slovakia (-9.26%). The Member States with highest final residential electricity consumption growth rate are Spain (62.11%), Romania (55.65%) and Lithuania (50.32%). Figure 50 shows the growth rates for three different periods. It can be clearly noticed that there is a dramatic change in the consumption pattern after the financial and economic crisis which peaked in 2008. For instance, Spain drastically changed its consumption pattern from a growing trend of 56.39% for the period 2000-2007 to a growing trend of 3.66% for the period 2007-2014. Ten countries have undergone a positive growth rate in the period 2007-2014. The highest growth rate took place in Romania (14.64%).

**Figure 50: Final residential electricity consumption growth rates in the EU-28 by Member State; 2000-2014, 2000-2007 and 2007-2014. Source: Eurostat**

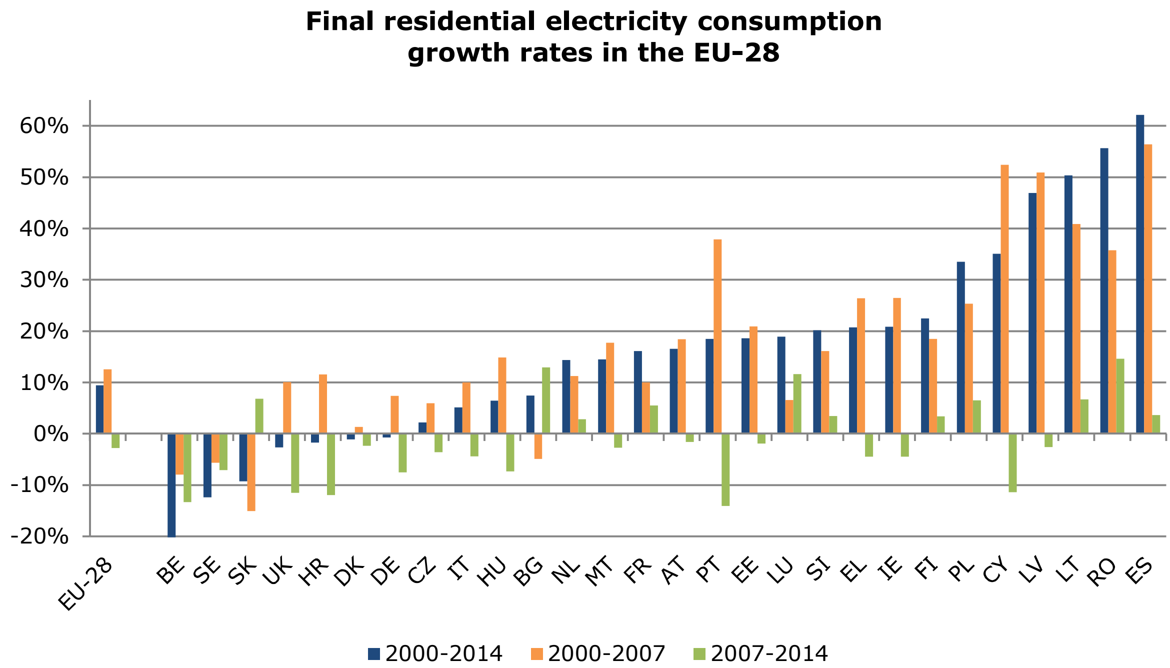
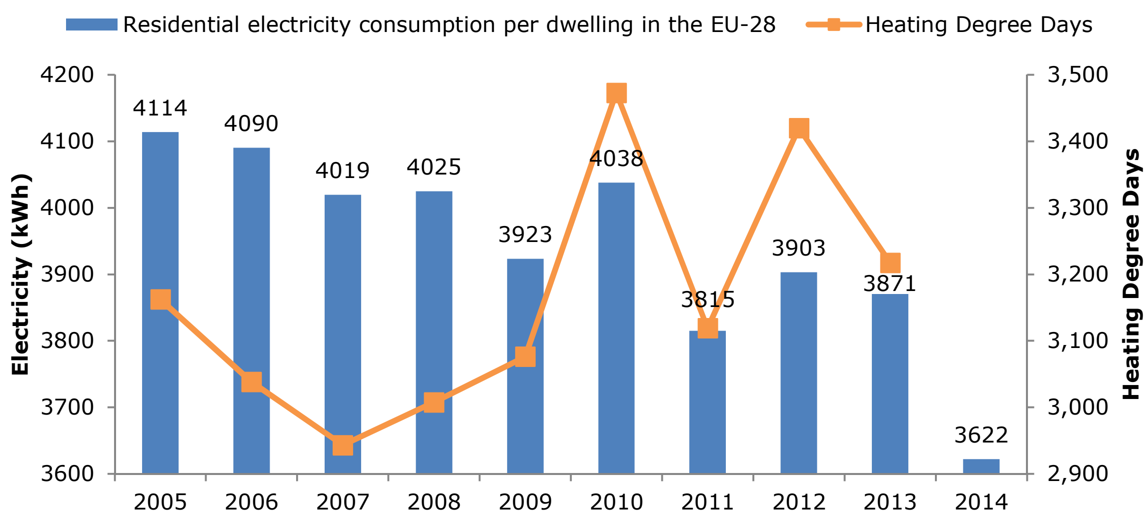



**Figure 51: Residential electricity consumption per dwelling in the EU-28, 2005-2014. Source: Eurostat[60]**




The residential electricity consumption per household was 3,622 kWh in 2014, the lowest value of the whole period. During the last 10 years, this value has been reduced by -11.96% (Figure 51). The lowering trend is observed along the whole 10-years period with the exception of the years 2008, 2010 and 2012 when the consumption of electrical energy per dwelling grew in comparison to the previous year. It is observed a positive correlation between the consumption per dwelling and the heating degree days with exception of year 2009 which can be explained by the income levels as GDP had a significant drop that year. In 2014, Romania was the country with lowest electricity consumption per dwelling with 1,594 kWh followed by Poland (2,016 kWh/dw) and Lithuania (2,029 kWh/dw). In contrast, Finland (8,232 kWh/dw), Sweden (8,020 kWh/dw) and France (5,203 kWh/dw) were the Member States with highest residential electricity consumption per household. Twelve of the EU-28 MS have a below average residential electrical energy consumption per dwelling. Only six Member States have increased their consumption in the 10-years period comprised between 2005 and 2014, these are: Bulgaria, Estonia, Latvia, Lithuania, Poland and Romania; to be noted that all of them are NMS-13 as illustrated in Figure 52.

**Figure 52: Residential electricity consumption trends per household by Member State in the EU-28; 2005, 2010 and 2014. Source: Eurostat**

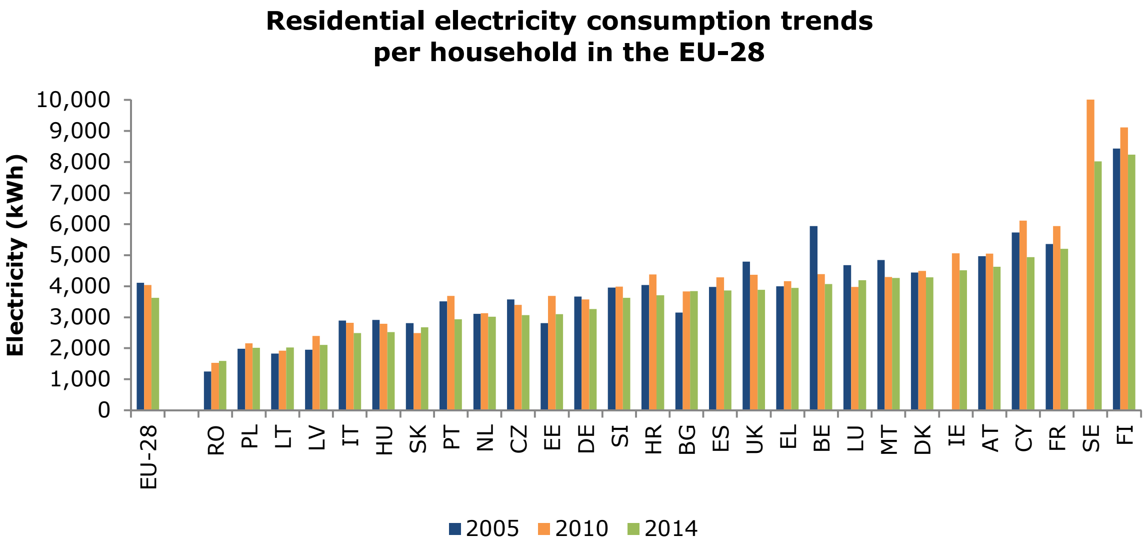
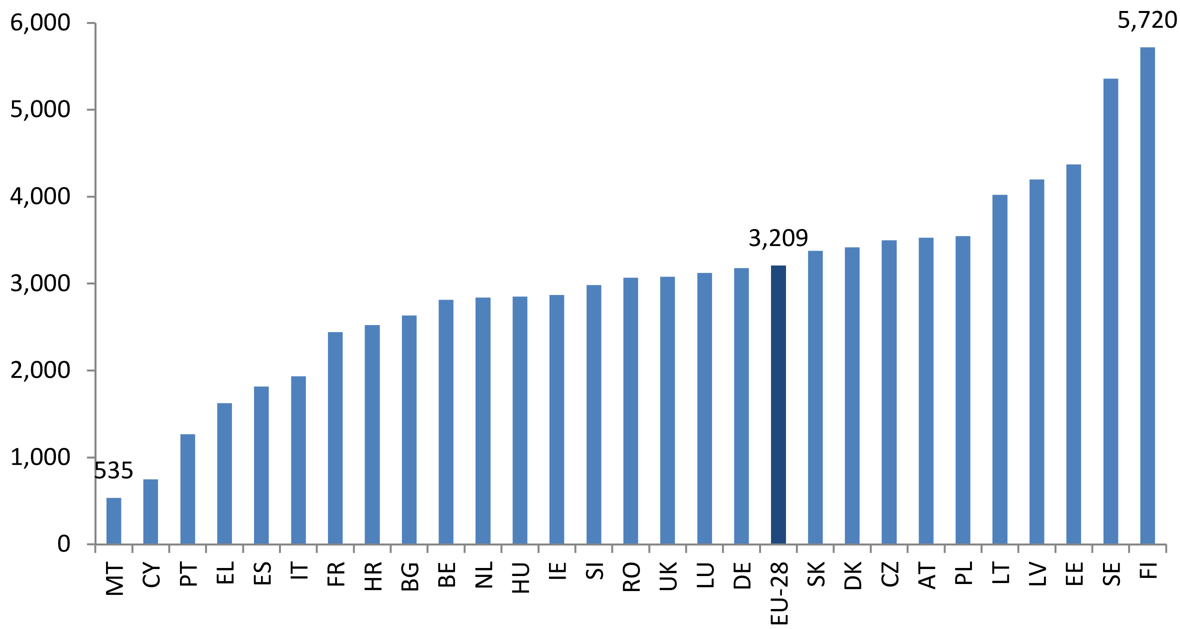



**Figure 53: Mean Heating Degree days (1980-2015) in the EU-28 by Member State. Source: Eurostat**




As previously mentioned, weather conditions have an influence on energy consumption. Figure 53 shows the mean heating degree days in the EU-28 by Member State between 1980 and 2015. The EU-28 Member States with the highest value of mean heating degree days are Finland, Sweden and Estonia. In Figure 54, it can be observed that Finland is the country the highest electricity consumption for thermal uses (5,521 kWh/hh) and highest mean value of heating degree days. Other countries with above average EU-28 mean heating degree days such as Sweden, Estonia, Latvia or Lithuania do not show a same correlation; probably due to heating powered by other energy sources (e.g. biomass, gas or district heating). It highlights that the second MS with the highest electricity consumption for thermal uses (France) consumes less than half of the energy consumption (2,246 kWh per household) than Finland which is the first. The MSs with lowest electricity consumption for thermal uses are Romania, Poland and Lithuania.

**Figure 54: Electricity consumption for thermal uses per electrified household in the EU-28, 2005, 2010 and 2014. Source: Enerdata**

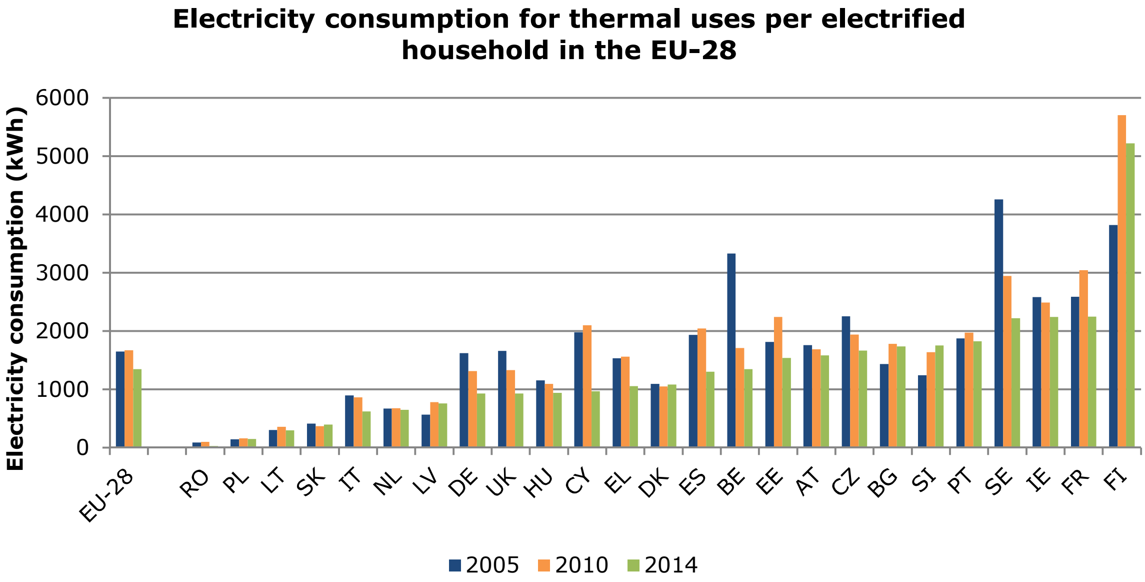
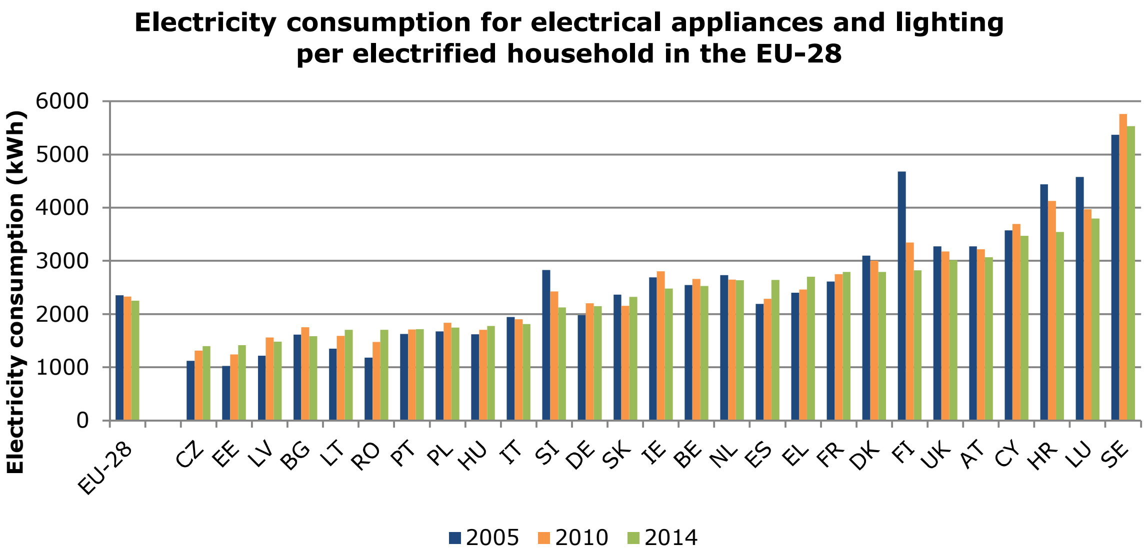



**Figure 55: Electricity consumption for electrical appliances and lighting per electrified household in the EU-28, 2005, 2010 and 2014[62]. Source: Enerdata**

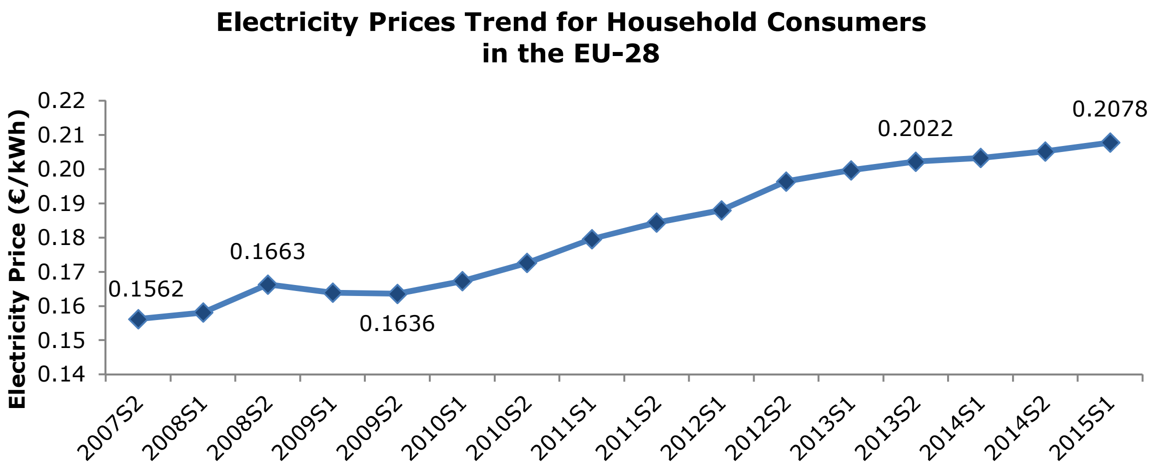



Other significant contributors to the electricity consumption at that residential level are electrical appliances and lighting systems. Figure 55 shows their electrical energy consumption for the EU-28 Member States for three different years. The EU-28 electricity consumption for electrical appliances and lighting has dropped by 4.3% for the 10-years period between 2005 and 2014. The EU-28 Member States with the highest electrical energy consumption for these end-uses is Sweden which accounted 5,533 kWh

[62] Space heating systems, air conditioning, water heaters or cooking appliances are not included.

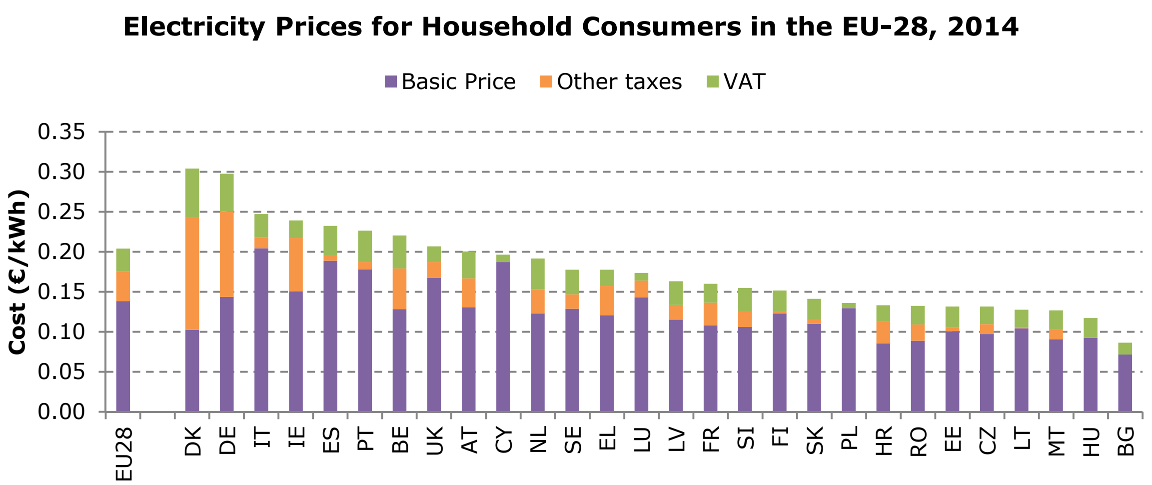
per household in 2014, followed by Luxembourg and Croatia, while Czech Republic had the lowest energy consumption per household, 1,398 kWh. The case of Sweden and Luxembourg might be explained by their above average GDP values, Luxembourg is first and Sweden is third among the EU-28 countries, as higher GDP levels may lead to purchase more energy using products at home producing higher electrical energy consumption. In contrast, the case of Croatia might be the result of having the highest average number of people per household (2.8). Nevertheless, these conclusions should be taken with caution and further and thorough studies would be needed to understand the differences among countries.

**Figure 56: Electricity prices for household consumers in the EU-28 by semesters, band DC - all taxes and levies included, 2007S2-2015S1. Source: Eurostat**




Electricity expenses as part of residential utilities are a cost to consider. In 2014, the average EU-28 expenses per dwelling for electricity were EUR 739.79[63]. The electricity price for household consumers has continuously grown during the last years. In the second semester of 2007 the average EU-28 electricity price was EUR 0.1562/kWh and in the first semester of 2015 the price has reached EUR 0.2078/kWh, this trend represents an increase of 33% as illustrated in the figure above.

**Figure 57: Electricity prices for household consumers in the EU-28, band DC, 2014. Source: Eurostat**




[63] This value has been calculated from the average electricity price for household consumers (band DC) multiplied by residential electricity consumption per dwelling reported in Figure 51.

Looking at the electricity prices across the EU-28 Member States for the year 2014, Denmark has the highest electricity price (EUR 0.304/kWh) followed by Germany (EUR 0.298/kWh) and Italy (EUR 0.239/kWh). The lowest electricity prices are found in Bulgaria (EUR 0.086/kWh), Hungary (EUR 0.117/kWh) and Malta (EUR 0.136/kWh). To be noted that Denmark has the highest electricity price and 66.3% of the price are taxes and levies. This value is more than two times higher than the EU-28 average percentage of taxes and levies for the year 2014 (32.2%).

The following table shows and overview of the final residential electricity consumption across the EU-28 Member States. It provides with electricity consumption at residential sector for years 2000, 2007 and 2014, as well as the growth rates thereof. The data have been already introduced and analysed along the chapter.

**Table 8: Overview of final residential electricity consumption in the EU-28 Member States, 2000-2014. Source: Eurostat**

| | Residential Electricity Consumption (GWh) | | | Growth Rates (%) | | |
|---|---|---|---|---|---|---|
| | 2000 | 2007 | 2014 | 2000-2014 | 2000-2007 | 2007-2014 |
| **EU-28** | 717,561 | 807,789 | 785,157 | 9.4% | 12.6% | -2.8% |
| **BE** | 23,738 | 21,856 | 18,942 | -20.2% | -7.9% | -13.3% |
| **BG** | 9,858 | 9,376 | 10,590 | 7.4% | -4.9% | 12.9% |
| **CZ** | 13,822 | 14,646 | 14,125 | 2.2% | 6.0% | -3.6% |
| **DK** | 10,215 | 10,349 | 10,104 | -1.1% | 1.3% | -2.4% |
| **DE** | 130,500 | 140,100 | 129,600 | -0.7% | 7.4% | -7.5% |
| **EE** | 1,466 | 1,773 | 1,739 | 18.6% | 20.9% | -1.9% |
| **IE** | 6,375 | 8,063 | 7,704 | 20.8% | 26.5% | -4.5% |
| **EL** | 14,207 | 17,957 | 17,151 | 20.7% | 26.4% | -4.5% |
| **ES** | 43,619 | 68,214 | 70,710 | 62.1% | 56.4% | 3.7% |
| **FR** | 128,720 | 141,589 | 149,426 | 16.1% | 10.0% | 5.5% |
| **HR** | 5,729 | 6,392 | 5,629 | -1.7% | 11.6% | -11.9% |
| **IT** | 61,112 | 67,220 | 64,255 | 5.1% | 10.0% | -4.4% |
| **CY** | 1,055 | 1,608 | 1,425 | 35.1% | 52.4% | -11.4% |
| **LV** | 1,189 | 1,794 | 1,747 | 46.9% | 50.9% | -2.6% |
| **LT** | 1,767 | 2,489 | 2,656 | 50.3% | 40.9% | 6.7% |
| **LU** | 792 | 844 | 942 | 18.9% | 6.6% | 11.6% |
| **HU** | 9,792 | 11,250 | 10,423 | 6.4% | 14.9% | -7.4% |
| **MT** | 559 | 658 | 640 | 14.5% | 17.7% | -2.7% |
| **NL** | 20,019 | 22,268 | 22,896 | 14.4% | 11.2% | 2.8% |
| **AT** | 14,962 | 17,723 | 17,439 | 16.6% | 18.5% | -1.6% |
| **PL** | 21,034 | 26,369 | 28,083 | 33.5% | 25.4% | 6.5% |
| **PT** | 10,056 | 13,863 | 11,915 | 18.5% | 37.9% | -14.1% |
| **RO** | 7,652 | 10,389 | 11,910 | 55.6% | 35.8% | 14.6% |
| **SI** | 2,601 | 3,021 | 3,125 | 20.1% | 16.1% | 3.4% |
| **SK** | 5,419 | 4,602 | 4,917 | -9.3% | -15.1% | 6.8% |
| **FI** | 17,441 | 20,662 | 21,362 | 22.5% | 18.5% | 3.4% |
| **SE** | 42,020 | 39,638 | 36,821 | -12.4% | -5.7% | -7.1% |
| **UK** | 111,842 | 123,076 | 108,881 | -2.6% | 10.0% | -11.5% |

## 4.3 Gas consumption trends in the residential sector

Gas consumption accounted for 35.0% of the final residential energy consumption in the EU-28 in 2014, confirming gas as the main source of final energy. The final residential gas consumption in the EU-28 has dropped by 15.3% in the 15-years period between 2000 and 2014. The gas consumption reached 92 Mtoe in 2014, out of which 87.9% was consumed in EU-15 (81 Mtoe) and 12.1% (11 Mtoe) in the NMS-13. EU-15 and NMS-13 have both decreased their final gas consumption by 15.7% and 11.9% respectively.

The highest consumption during the period between 2000 and 2014 occurred in 2010 when the gas consumption reached 121.8 Mtoe which is also the highest rise in comparison to previous year of the period, an increase by 10% in comparison to 2009. In contrast, the highest drops occurred in 2011 and 2014 when gas consumption decreased by more than 16% compared to previous years (see Figure 58). In 2014, it has been experienced the highest drop in the consumption of the whole period, a decrease by 17%.

**Figure 58: Final residential gas consumption trends in the EU-28, 2000-2014. Source: Eurostat**

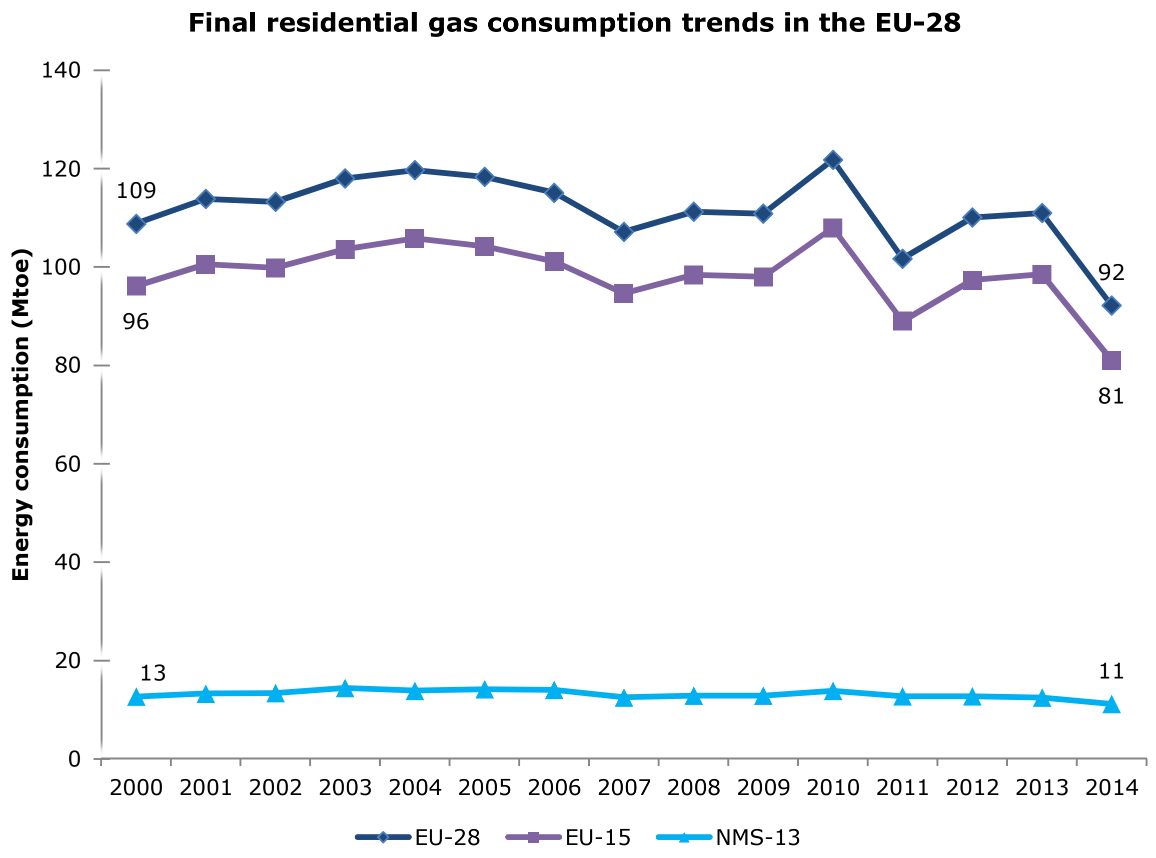
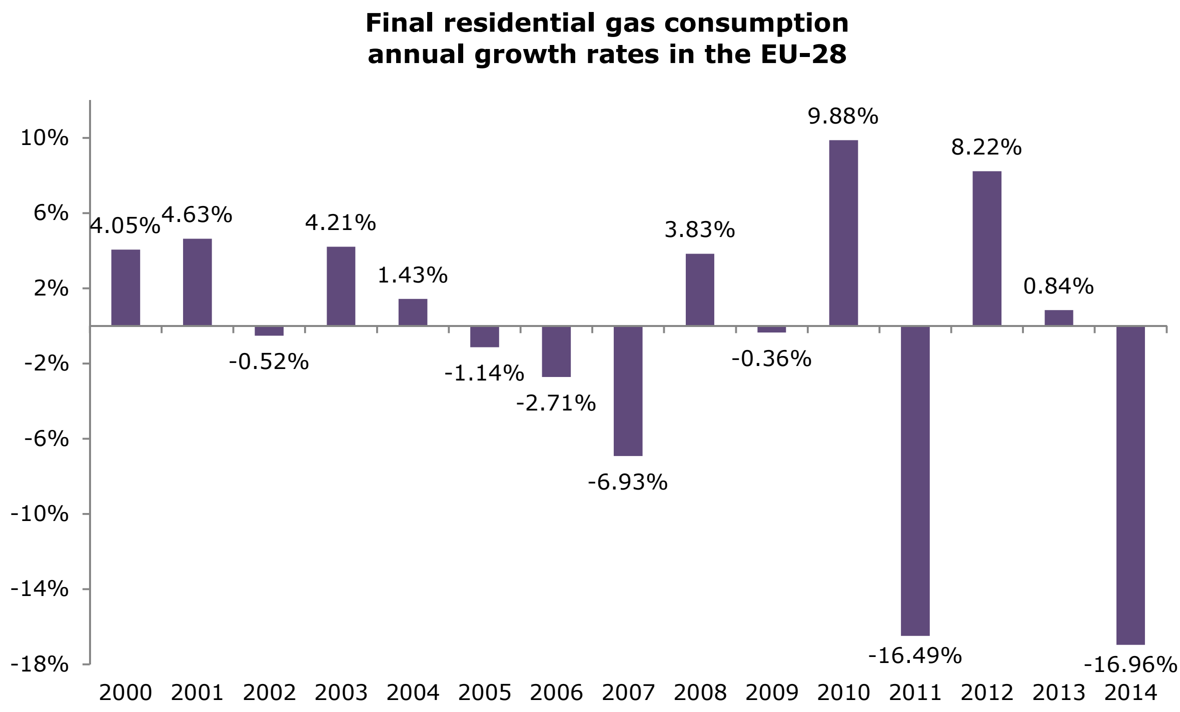
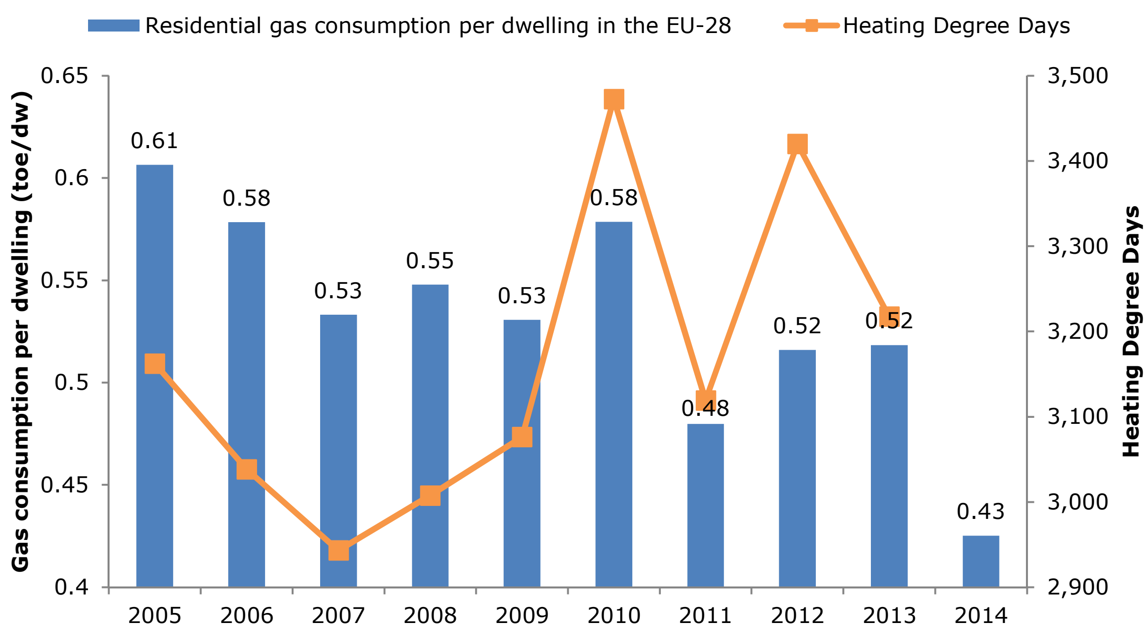


**Figure 59: Final residential gas consumption annual growth rates in the EU-28, 2000-2014. Source: Eurostat**




The final residential gas consumption per dwelling in the EU-28 has reached 0.43 to in 2014, which represents a drop by 29.9% in comparison to year 2005 level. Between 2005 and 2009 there was a decreasing trend which was interrupted in 2010 by a rise of 9%. In 2011, the final residential gas consumption per dwelling again down to 0.48 toe per dwelling and grew during 2013. In 2014, it has dropped again by 18% in comparison to year 2013, setting the lowest value of the analysed 10-years period as illustrated in Figure 60.

**Figure 60: Final residential gas consumption per dwelling and heating degree days in the EU-28, 2005-2014. Source: Eurostat[60]**



Looking at the residential gas consumption per household across the EU-28 Member States, it can be observed that during 2014 seventeen MSs have had below average EU-28 gas consumption which is 0.43 toe/dw (4945.3 kWh/dw), see Figure 61. The MS with the highest residential gas consumption per dwelling has been Luxembourg (1.00 toe/dw) followed by the Netherlands (0.84 toe/dw) and the United Kingdom (0.77 toe/dw). In contrast the lowest gas consumption per dwelling occurred in Sweden (0.007 toe/dw), Finland (0.011 toe/dw) and Bulgaria (0.016 toe/dw). The low values of gas consumption achieved by Sweden and Finland despite their high value of mean heating degree days might be explained by the use of other energy sources such as electricity, biomass or district heating plants when focussing on heating purposes (see Figure 68 and Figure 54). It is notable that all the countries have decreased their consumption in comparison to year 2005.

**Figure 61: Residential gas consumption trends per household in the EU-28 Member States, 2005, 2010 and 2014. Source: Eurostat**

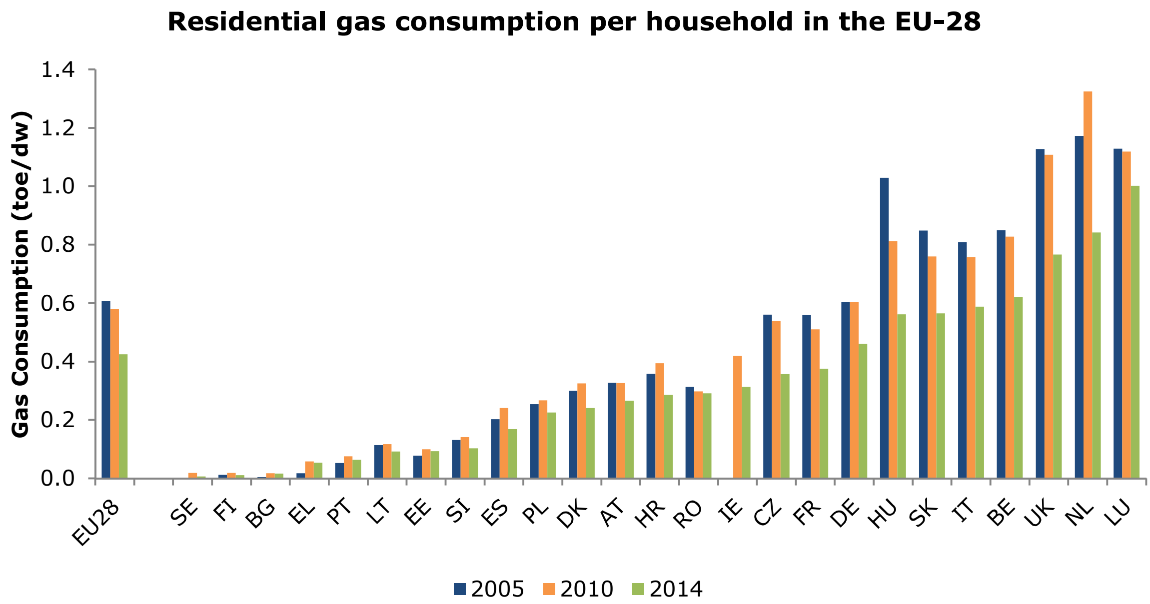
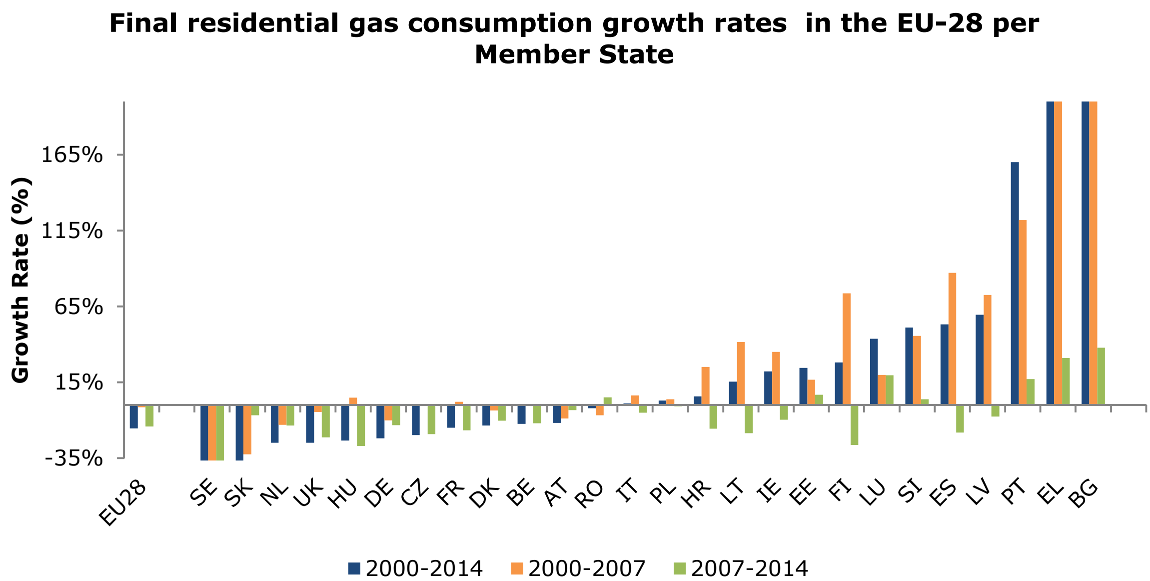
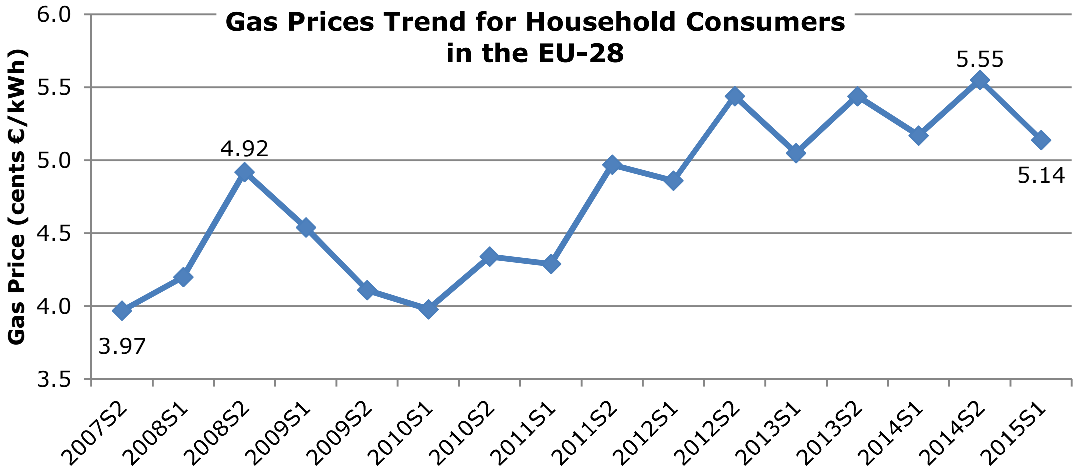



**Figure 62: Final residential gas consumption growth rates in the EU-28 per Member State; 2000-2014, 2000-2007 and 2007-2014. Source: Eurostat**



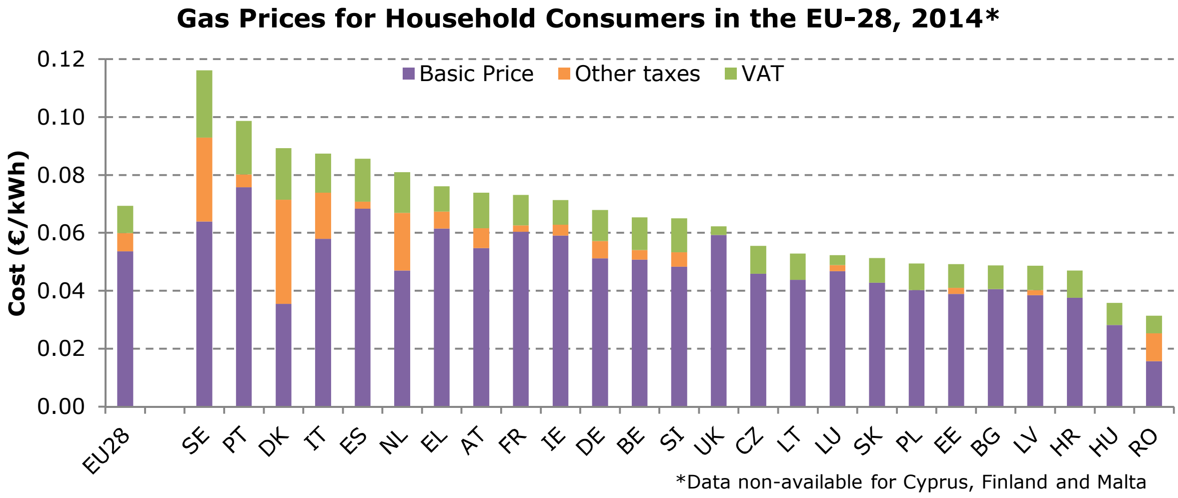
As already mentioned, the final residential gas consumption has decreased by 15.29% in the period between 2000 and 2014. The MS with the highest final residential gas consumption growth rate has been Bulgaria with a 22,500% increase, followed by Greece (4,626%) and Portugal with 160%; whereas the highest reduction rates have occurred in Sweden (-69%), Slovakia (-37%), the Netherlands and the United Kingdom (-25%). Generally, it can be observed a significant change in the consumption trend from 2007 onwards as illustrated in Figure 62. To be noted the cases of Bulgaria, Greece and Portugal, where the growth rates sharply changed between the periods 2000-2007 and 2007-2014.

**Figure 63: Gas prices for household consumers in the EU-28 by semesters, band D2 - all taxes and levies included, 2007S2-2015S1. Source: Eurostat**




Being gas the energy source with the highest share at residential level, it is expected to have a representative cost in the yearly energy bills. In 2014, the average EU-28 expenses per dwelling for gas were EUR 264.33[64]. Despite its considerable fluctuations the average EU-28 gas price for households has undergone a rise of 29.5% between the second semester of 2007 and the first semester of 2015 when prices were EUR 0.0397/kWh and EUR 0.0514/kWh respectively (Figure 63).

**Figure 64: Gas prices for household consumers in the EU-28, band D2, 2014. Source: Eurostat**




[64] This value has been calculated from the average gas price for household consumers (band D2) multiplied by residential gas consumption per dwelling reported in Figure 60.

Looking at the gas prices across the EU-28 Member States for the year 2014, Sweden has the highest gas price (EUR 0.116/kWh) followed by Portugal (EUR 0.099/kWh) and Denmark (EUR 0.089/kWh). In contrast, the lowest gas prices are found in Romania (EUR 0.031/kWh), Hungary (EUR 0.036/kWh) and Croatia (EUR 0.047/kWh). As for electricity prices, Denmark has the highest gas taxes and levies percentage (60.3%). The EU-28 average percentage of taxes and levies is 22.7% for the year 2014 as illustrated in the figure below.

The following table shows and overview of the final residential gas consumption across the EU-28 Member States. It provides with gas consumption at residential sector for years 2000, 2007 and 2014, as well as the growth rates thereof. The data have been already introduced and analysed along the chapter.

**Table 9: Overview of final residential gas consumption in the EU-28 Member States, 2000-2014. Source: Eurostat**

| | Residential Gas Consumption (ktoe) | | | Growth rates (%) | | |
|---|---|---|---|---|---|---|
| | 2000 | 2007 | 2014 | 2000-2014 | 2000-2007 | 2007-2014 |
| **EU28** | 108,804.8 | 107,147.5 | 92,166.6 | -15.3% | -1.5% | -14.0% |
| **BE** | 3,292.6 | 3,278.8 | 2,887.4 | -12.3% | -0.4% | -11.9% |
| **BG** | 0.2 | 32.8 | 45.2 | 22,500.0% | 16,300.0% | 37.8% |
| **CZ** | 2,049.3 | 2,036.1 | 1,645.0 | -19.7% | -0.6% | -19.2% |
| **DK** | 658.5 | 634.7 | 569.7 | -13.5% | -3.6% | -10.2% |
| **DE** | 23,441.0 | 21,071.6 | 18,298.1 | -21.9% | -10.1% | -13.2% |
| **EE** | 41.9 | 48.9 | 52.2 | 24.6% | 16.7% | 6.7% |
| **IE** | 437.8 | 591.7 | 534.6 | 22.1% | 35.2% | -9.7% |
| **EL** | 4.9 | 176.6 | 231.6 | 4,626.5% | 3,504.1% | 31.1% |
| **ES** | 2,019.9 | 3,779.0 | 3,094.3 | 53.2% | 87.1% | -18.1% |
| **FR** | 12,661.4 | 12,940.5 | 10,779.7 | -14.9% | 2.2% | -16.7% |
| **HR** | 410.2 | 513.5 | 433.6 | 5.7% | 25.2% | -15.6% |
| **IT** | 14,974.8 | 15,942.1 | 15,150.8 | 1.2% | 6.5% | -5.0% |
| **LV** | 63.5 | 109.6 | 101.3 | 59.5% | 72.6% | -7.6% |
| **LT** | 104.0 | 147.2 | 120.0 | 15.4% | 41.5% | -18.5% |
| **LU** | 156.6 | 187.8 | 224.9 | 43.6% | 19.9% | 19.8% |
| **HU** | 3,025.3 | 3,174.4 | 2,320.7 | -23.3% | 4.9% | -26.9% |
| **NL** | 8,508.6 | 7,393.9 | 6,394.0 | -24.9% | -13.1% | -13.5% |
| **AT** | 1,134.3 | 1,035.2 | 1,000.7 | -11.8% | -8.7% | -3.3% |
| **PL** | 3,051.7 | 3,169.6 | 3,144.0 | 3.0% | 3.9% | -0.8% |
| **PT** | 99.2 | 220.2 | 258.1 | 160.2% | 122.0% | 17.2% |
| **RO** | 2,216.9 | 2,067.4 | 2,173.3 | -2.0% | -6.7% | 5.1% |
| **SI** | 58.6 | 85.3 | 88.6 | 51.2% | 45.6% | 3.9% |
| **SK** | 1,642.2 | 1,110.3 | 1,037.1 | -36.8% | -32.4% | -6.6% |
| **FI** | 22.4 | 38.9 | 28.7 | 28.1% | 73.7% | -26.2% |
| **SE** | 102.9 | 54.5 | 31.9 | -69.0% | -47.0% | -41.5% |
| **UK** | 28,625.8 | 27,307.1 | 21,521.2 | -24.8% | -4.6% | -21.2% |

CY, MT – No available data.

## 4.4 District heating production trends in EU

In 2015, above 72% of the EU-28's population lives in urban areas, according to latest available Eurostat statistics [10], indicating that a major part of the EU's buildings are in high heat density areas. This condition is in itself a strong argument for utilising district heating in Europe [11].

In a District Heating (DH) network one or more central sources provide hot water which is conveyed to the users who can be domestic consumers, commercial buildings and appropriate industries by means of insulated water pipes. Similar distribution systems exist for District Cooling (DC).

If the heat comes from the reject or waste heat from a power generating unit this is referred to as Combined Heat and Power, CHP for short, or Cogeneration. The combination of CHP and DH is referred to as CHP-DH [12].

The European Union does not have a specific energy policy or directive concerning district heating. However, the specific directives for combined heat and power, industrial emissions, emissions trading, energy performance in buildings, renewable energy, waste management, energy taxation and energy efficiency either affect or include provisions concerning district heating.

The latest projection within the EU energy policy context concerning future heat deliveries from district heating systems and industrial CHP plants are included in the *Energy Roadmap 2050*[65] communication. District heating is addressed for instance in the Article 14 of EED establishing that Member States must carry out comprehensive assessment of the potential for the application of efficient district heating and cooling.

Conclusions from preliminary studies on Heat Roadmap Europe (HRE) [13], [14] and other JRC scientific and policy reports [12]; indicate the following potential contributions of DH and CHP-DH to EU energy goals:

- More district heating in Europe will reduce the energy system costs considerably since local heat recycling and renewable energy use will reduce expensive energy imports, while also increasing the efficiency of both the electricity and heat sectors.
- The associated reduction in primary energy supply from fossil fuels will also considerably reduce emissions of carbon dioxide. The reduced energy imports will also increase security of supply and energy independence.
- District heating can increase energy demand flexibility.
- Cost savings for the energy consumer due to low marginal cost of the waste heat.
- Beneficial use of local energy resources or sources that cannot be used on an individual basis (notably waste, biomass and geothermal resources in district heating and cooling systems).
- CHP-DH addresses the domestic heat sector which is the largest and most difficult sector to decarbonise in many EU countries: Moreover, CHP-DH offers the potential to decarbonise the heat sector whilst at the same time securing local heat and electricity supplies.
- CHP-DH can pave the way for a robust infrastructure supporting the integration of wind power, solar energy and low energy buildings and capable of dealing with energy supply intermittency and peak heat demands.
- The installation of the technology is labour intensive and is likely to produce new jobs and employment of indigenous products.
- Improved safety due to the absence of fuels in dwellings.

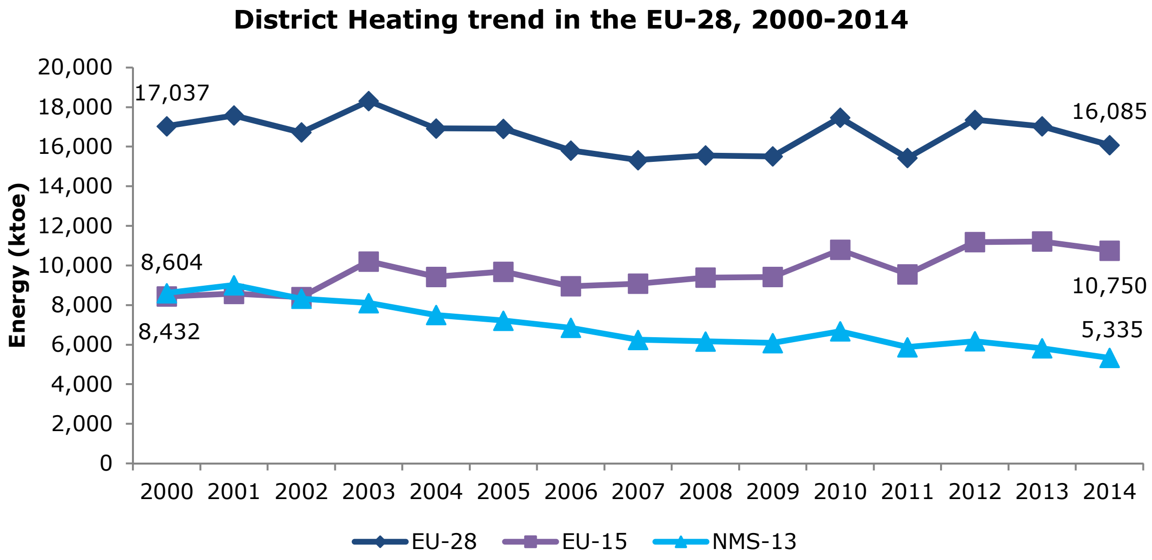
District Heating plants contribution to energy supply of the EU can be analysed from Eurostat data. Figure 65 shows the trends of the energy supply of this sort of systems

[65] COM(2011) 885 final

for EU-28, EU-15 and NMS-13. It can be observed that the EU-28 total output of district heating plants has fallen between 2000 and 2014 by 5.6%. Whilst NMS-13 have undergone a drop of 38%, EU-15 has grown by 27.5% in the amount of the energy consumption produced by District Heating plants in the same time period. In 2014, EU-28 district heating plants supplied 16 Mtoe, 10.7 Mtoe of which produced in the EU-15 and the NMS-13 have accounted the remainder 5.3 Mtoe as illustrated in Figure 65.

These opposite trends between the two groups of countries might be explained by the use of more efficient technologies in CHP-DH plants in the NMS-13; the higher efficiency in the power plants, the lower residual heat to deliver as derived heat. The promotion of district heating as a competitive and reliable solution in the EU-15 might explain the growth trend[66].

**Figure 65: District heating plants supply (output production) trends in the EU28, 2000-2014. Source: Eurostat**




Germany is the country with the highest district heating supply across the EU-28 (its district heating energy supply amounted to 2,864 ktoe in 2014) and is followed by Poland (2,403 ktoe) and the United Kingdom (1,625 ktoe).

[66] The European Commission is seriously committed to promote the use of these energy sources and technologies, as proved by the Renewable Energy Directive (Binding National Targets, National Renewable Energy Action Plans) and the Energy Efficiency Directive (Art. 14, necessity to exploit renewable energy sources heating and cooling potential and develop heating markets at local and regional levels). Source: heatroadmap.eu

**Figure 66: District heating plants supply (output production) in the EU28[67] breakdown per Member States; 2000, 2007, and 2014. Source: Eurostat**

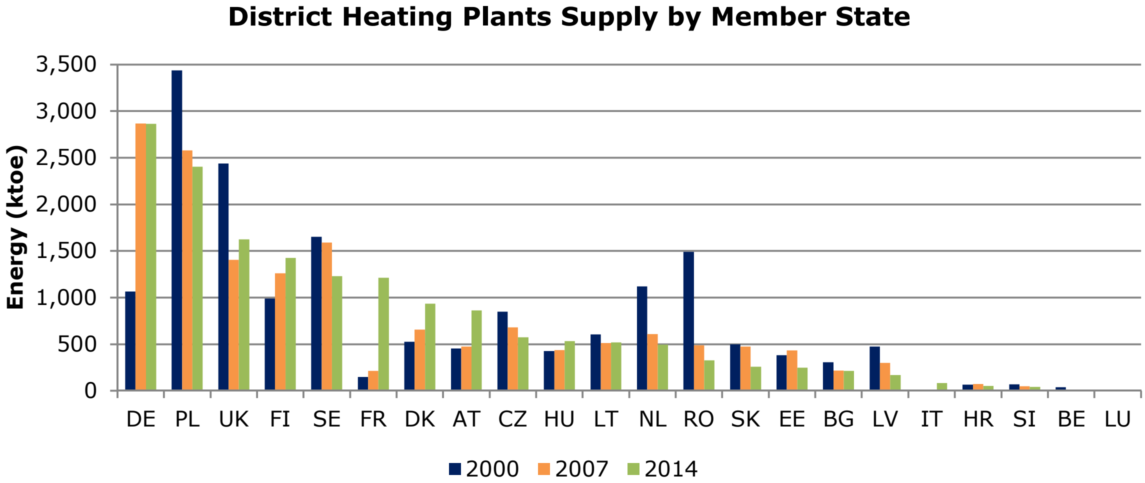
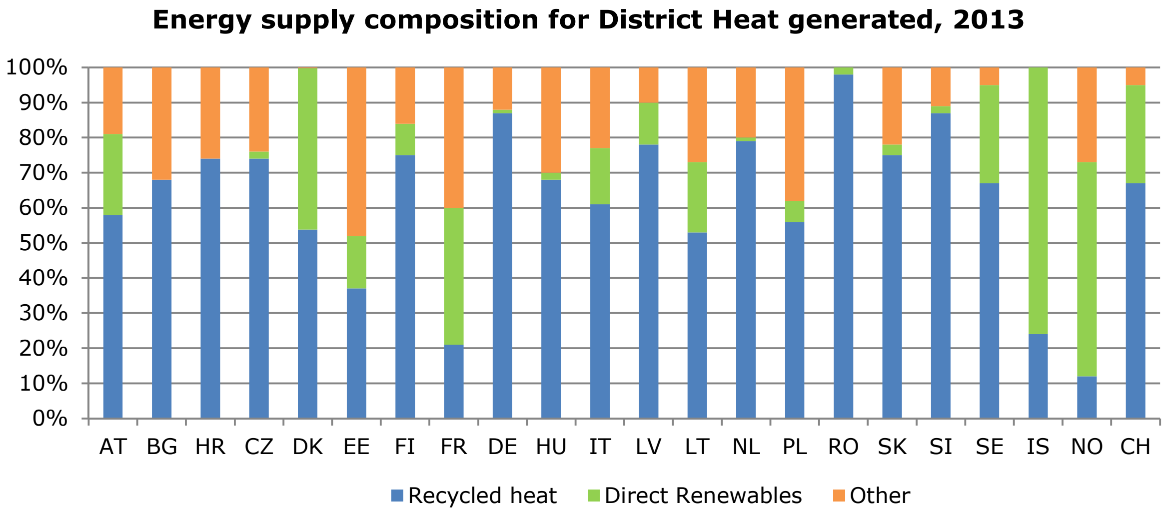



**Figure 67: Energy supply composition[68] for District Hear generated in the EU28 and EEA-EFTA countries, 2013. Data source: Euroheat & Power**




In 2013, the district heating supply data across the EU28 and EEA-EFTA countries[69] (Figure 67) shows that seventeen countries had recycled heat as main energy supply source. The first is Romania (98%) which is followed by Slovenia and Germany (87%), and the Netherlands (79%). Three countries had direct renewables as main energy supply source. These are: Iceland (76%), Norway (61%) and Denmark (46%). The remaining two countries used other energy supply source for their district heating

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[67] Member States that not appear in the figure (i.e. Ireland, Greece, Spain, Cyprus, Malta, and Portugal) either have no DH networks, or produce negligible amounts of energy through DH.

[68] 'Recycled heat' includes surplus heat from electricity production (CHP), waste-to-energy cogeneration plants and industrial processes independently of the fuel used (renewables or fossil) for the primary process. Two-thirds of the energy delivered by heat pumps is also considered as recycled heat.

'Direct renewables' covers the use of renewable energy in heat-only boilers and installations other than CHP.

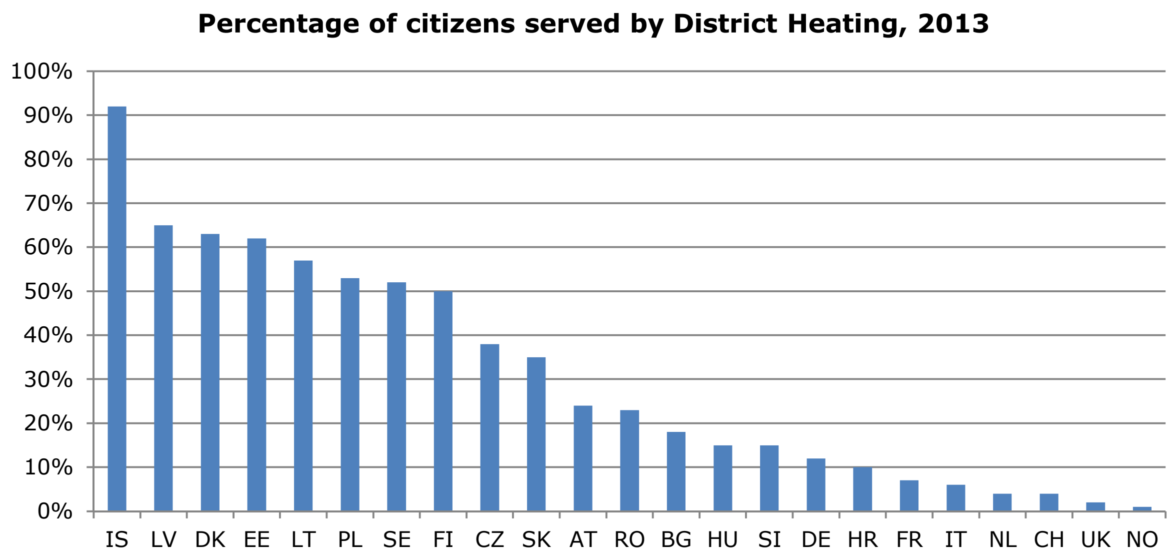
'Other' covers heat-only boilers, electricity and one-third of the heat originating from heat pumps.

[69] Data are available for 22 countries.

production. These are: Estonia (48%) and France (40%). To be noted that only two countries (Romania and Iceland) have their composition based on two energy sources.

Figure 68 shows for the same year the percentage of citizens served by District Heating in the EU28 and EEA-EFTA countries. Eight of the countries reached half or more of their populations with district heating systems. These countries are: Iceland (92%), Latvia (65%), Denmark (63%), Estonia (62%), Latvia (57%), Poland (53%), Sweden (52%), and Finland (50%). In contrast, district heating systems are serving below 5% of countries' population in the Netherlands and Switzerland (4%), United Kingdom (2%), and Norway (1%).

**Figure 68: Percentage of citizens served by District Heating in the EU28 and EEA-EFTA countries, 2013. Data source: Euroheat & Power**




## 4.5 Energy efficiency trends of energy-related products in the residential sector

The Eco-Design Directive, 2009/125/EC, defines an Energy-related products (ErP) as any good that has an impact on energy consumption during use which is placed on the market and/or put into service, and includes parts intended to be incorporated into energy-related products which are placed on the market and/or put into service as individual parts for end-users and of which the environmental performance can be assessed independently.

Household energy-related products so far addressed by the above mentioned directive include: domestic appliances (e.g. refrigerators, washing machines, tumble driers, all range of heating and cooling appliances, etc.), lighting systems, ICT equipment, and electrical and electronic household and office equipment in general.

The present subchapter analysed present energy efficiency trends of major domestic appliances, which comprise refrigerators and freezers (cold appliances), washing machines, tumble driers and dishwashers; cooking appliances such as ovens, hobs and range hoods; vacuum cleaners; space heating and boilers; residential room air conditioners; electric water heaters; and lighting lamps.

### 4.5.1 Major appliances

Energy efficiency policies in the major appliances sector turned out to be very successful. The success is due to a combination of EU legislation (energy labelling, and minimum energy performance standards), national programmes (e.g. tax levies in Italy, scrapping bonus for cold appliances in Austria, price rebate schemes in Spain, supplier obligations and White Certificate scheme in France, Italy and United Kingdom[70]) as well as the initial voluntary agreements of manufacturers (Conseil Européen de la Construction d'Electro-Domestiques (CECED) – European Committee of Domestic Equipment Manufacturers)[71].

Within the framework of the Eco-design Directive several Regulations have been implemented, the last ones concerning eco-design requirements for ovens, hobs and range hoods entered into force in February 2014.

The success of the energy label for major domestic appliances is confirmed by the fact that the sales of models in top energy label classes have increased steadily in the recent years: the market share of A+ or higher class appliances jumped from 51% in 2011 to 92% in 2014 as shown in Figure 69. This reflects the willingness of the industry to offer more and more energy efficient appliances and of consumers to buy them [15].

Notably, the market share of washing machines in the A+++ class, has increased by 29% between 2011 (14%) and 2014 (43%).

Dishwasher's category has also undergone a visible strong progress. While in 2011, the A class had the highest share, 2014 classes with the highest market share were A+ and A++.

98% and 96% market shares have been respectively achieved by cooling and freezers appliances under A+ or higher energy efficiency classes.

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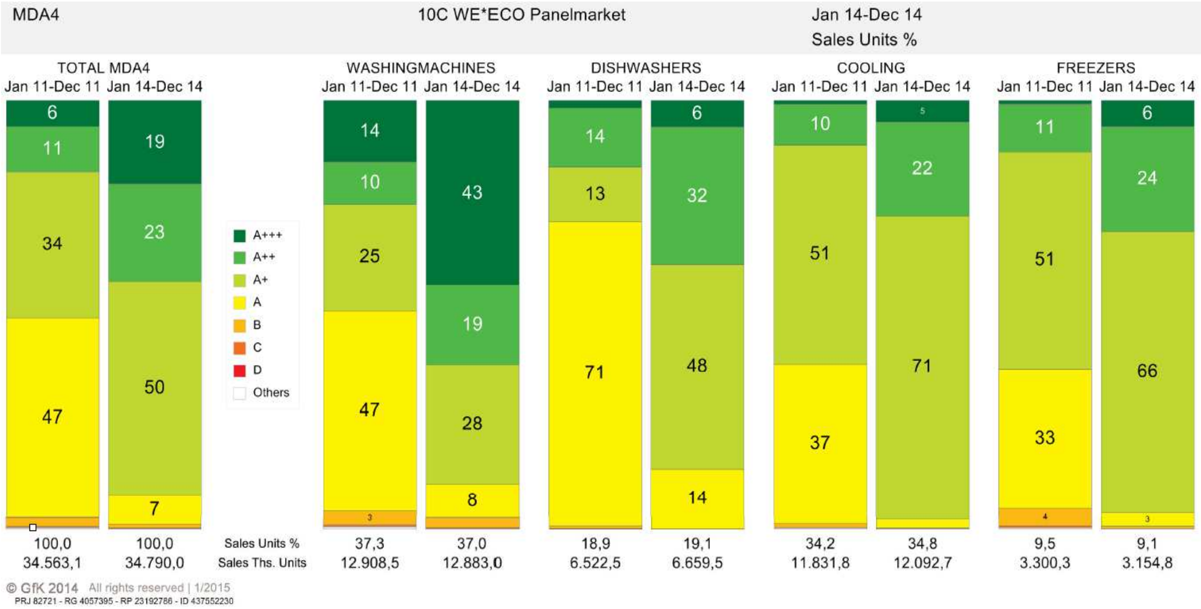
[70] The list of national programmes reported here does not pretend to be exhaustive of all the measures implemented by Member States.

[71] At this moment no voluntary agreements are in force for major appliances. Regulations in force for this sort of energy-related products can be found in chapter 2.

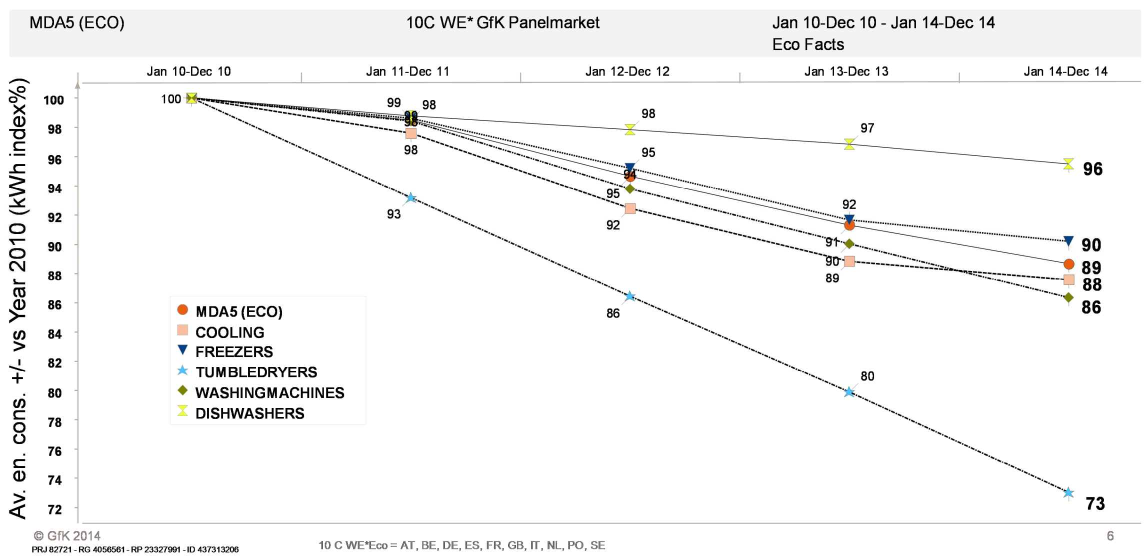
**Figure 69: Market distribution by energy label classes and by products groups (comparison 2011 and 2014)[72]. Source: GfK Retail and Technology Panel [15]**




Besides energy label classes, the actual average energy consumption of the appliances is also an interesting parameter to analyse. Figure 70 shows the reduction percentage rate of the average energy consumption of new products for five major domestic appliances over a five-years period. Over the 2010-2014 period, new appliances became significantly more efficient, hence the average energy consumption was reduced; on average, energy consumption reduction was 11% in 2014 compared to 2010. It can be observed that the highest reduction rate (27%) was made by the tumble drier category with an average energy consumption reduction of 6-7% per year, followed by average energy consumption reduction rates of 14% in washing machines, 12% in cooling appliances, 10% in freezers and 4% in dishwashers.

These values take into account changes in average size or capacity of appliances.

**Figure 70: Average energy consumption trends by product groups in Western EU (2010-2014). Source: GfK Retail and Technology Panel [15]**

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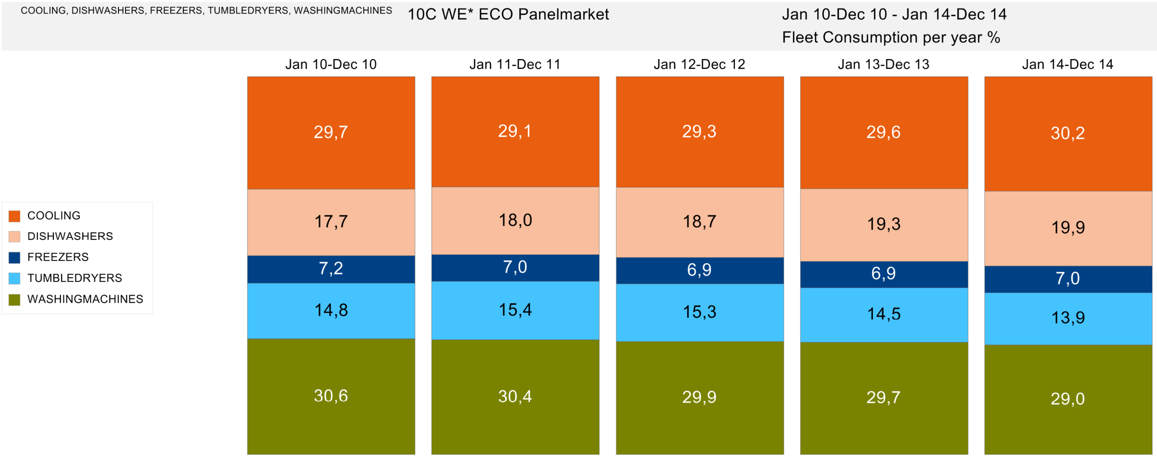
72 Countries covered: AT, BE, DE, ES, FR, UK, IT, NL, PT, SE

**Figure 71: Share of fleet energy consumption [73] by product groups (2010-2014). Source: GfK Retail and Technology Panel [15]**




| | Jan 10-Dec 10 | Jan 11-Dec 11 | Jan 12-Dec 12 | Jan 13-Dec 13 | Jan 14-Dec 14 |
|---|---|---|---|---|---|
| Fleet Consumption per year in mio Absolute | 10.016 | 9.963 | 9.178 | 8.634 | 8.717 |
| Fleet Consumption per year in mio Growth Rate PY | 4,7 | -0,5 | -7,9 | -5,9 | 1,0 |
| Sales Ths. Units Absolute | 37.523 | 38.008 | 37.265 | 36.815 | 38.337 |
| Sales Ths. Units Growth Rate PY | 3,8 | 1,3 | -2,0 | -1,2 | 4,1 |

In order to assess the actual impact of the energy consumption of domestic appliances, it is necessary to account not only the average consumption per appliance, but also the number of appliances sold/in use.

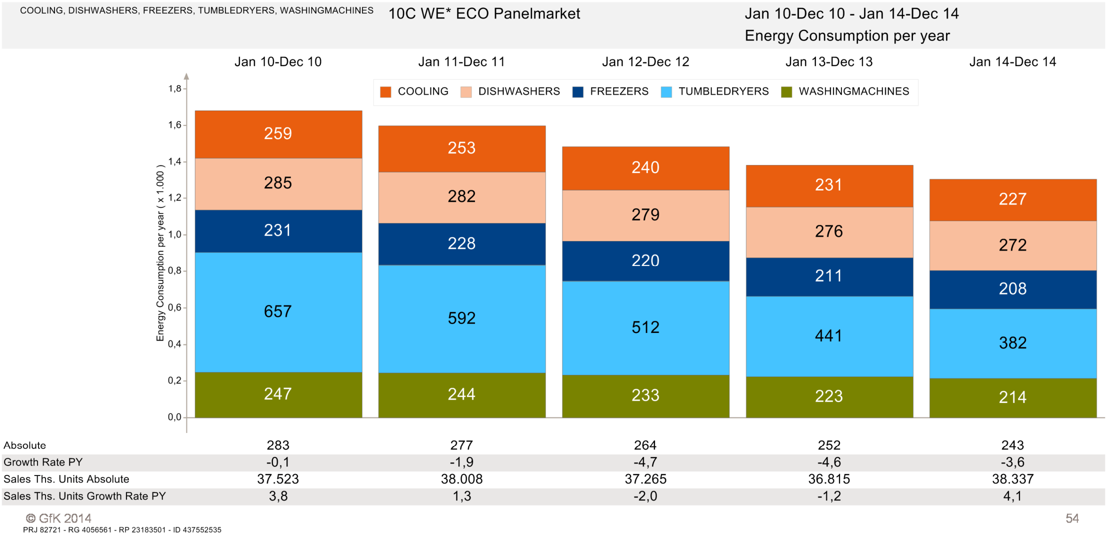
"Must-have" appliances, such as washing machines and refrigerators are now regularly purchased by nearly all EU families, while "nice-to-have" appliances like tumble driers and dishwashers consume less overall energy consumption, simply because fewer appliances are sold due to either lower household penetration or longer lifetimes.

As shown in Figure 71, the shares of fleet consumption by product family have slightly changed over the period 2010-2014. Cooling and washing machines categories account nearly 30% each of the total fleet energy consumption – the "must-have" appliances with highest household penetration.

Figure 71 is complemented with Figure 72 which shows the average energy consumption per product type and where the data displays that the energy intensiveness of tumble driers and dishwashers stands out. Through innovative heat pump technology, especially in the area of tumble driers, significant energy efficiency potential was exploited and average energy consumption was reduced dramatically since 2010. This could also be a success of the energy label, as only heat pump driers can get an A+ (or higher) label [15]. Figure 72 shows a decrease of 9.9% in the average energy consumption of all appliances categories as a whole over the five-year period between 2010 and 2014.

[73] Sum of energy consumption of all sold appliances. The histogram below the graph is measured in millions. Countries covered: AT, BE, DE, ES, FR, UK, IT, NL, PT, SE

**Figure 72: Consumption of an average product sold in 10 EU-28 MSs[72] (declared kWh/year), 2010-2014. Source: GfK Retail and Technology Panel [15]**




### 4.5.1.1 Cold appliances (refrigerators and freezers)

The market of cold appliances is characterised by a high level of substitution of old appliances rather than by an increase of the existing stock. New cold appliances on the market became much more efficient in terms of energy consumption during the last years due to increasing awareness about energy consumption and the energy labelling scheme of the EU [16].

Over the last years, the refrigerator stock reached the saturation level with penetration rates of around 100% in almost all EU-28 countries. At the same time, the freezer market registered a significant decreasing tendency, due to the increased use of combined refrigerators/freezers [16].

Commission Regulation (EC) No 643/2009 implemented the Eco-design Directive 2005/32/EC introduced new minimum energy performance standards for household refrigerating appliances. Minimum efficiency requirements for cold appliances have been in force since 1996.[74] These minimum efficiency requirements have been exceeded by far also thanks to a self-commitment in banning the least efficient appliances from the market by manufacturers associations (CECED). The industry decided not to introduce a new voluntary agreement after that new Regulation. The following minimum requirements based on an Energy Efficiency Index (EEI) measuring the energy performances of refrigerating appliances have been established by the above mentioned regulation:

For compression-type refrigerating appliances

- From 1 July 2010: EEI < 55
- From 1 July 2012: EEI < 44
- From 1 July 2014: EEI < 42

For absorption-type and other-type refrigerating appliances

- From 1 July 2010: EEI < 150
- From 1 July 2012: EEI < 125
- From 1 July 2015: EEI < 110

[74] Directive 96/57/EC of the European Parliament and of the Council of 3 September 1996 on energy efficiency requirements for household electric refrigerators, freezers and combinations thereof.

Energy labelling for refrigerators, freezers and their combinations was first introduced by the Directive 92/75/EC. In 2003, Directive 2003/66/EC replaced Directive 94/2/EC which was implementing the Directive from 1992. In 2010, a new Directive for labelling (2010/30/EU) was established, and an updated version of the energy label for cold appliances was implemented by the Commission - Commission Delegated Regulation (EU) No 1060/2010. The regulation introduced a new energy efficiency class (A+++) and defined different EEI threshold values for A and A+ classes for the period December 2011 – 30 June 2014 and for the period from 1 July 2014 onwards as summarized in Table 10 and Table 11 reported below.

At this moment, there have been reached the last tiers of minimum efficiency requirements established by the legislation in force. Therefore, it can be inferred that the eco-design requirements limit sales of compression-type[75] refrigerating appliances to classes A+, A++ and A+++ since July 2014.

**Table 10: EU Energy efficiency classes for household refrigerating appliances from December 2011 to 30 June 2014. Source: EC**

| A+++ | A++ | A+ | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|---|
| EEI<22 | 22≤ EEI <33 | 33≤ EEI <**44** | **44**≤ EEI <55 | 55≤ EEI <75 | 75≤ EEI <95 | 95≤ EEI <110 | 110≤ EEI <125 | 125≤ EEI <150 | EEI≥150 |

**Table 11: EU Energy efficiency classes for household refrigerating appliances from 1 July 2014. Source: EC**

| A+++ | A++ | A+ | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|---|
| EEI<22 | 22≤ EEI <33 | 33≤ EEI <**42** | **42**≤ EEI <55 | 55≤ EEI <75 | 75≤ EEI <95 | 95≤ EEI <110 | 110≤ EEI <125 | 125≤ EEI <150 | EEI≥150 |

At the moment, there is an ongoing preparatory review study as household refrigeration appliances were identified as a "high or medium" priority product group, requiring further (extensive/comprehensive) revision studies, because their energy saving potential is significant (at least 5TWh/year in 2030) in EU-28 and a revision of the corrections factors established to calculate the EEI, of the product categories considered to establish the energy efficiency classes and of the harmonised standard applied to measure the energy consumption of products might be needed[76].

Some relevant data concerning evolutions in the energy performances of cold appliances are reported in the reminder of this subchapter. Refrigerators data appearing in this subchapter covers refrigerators with and without freezer compartment, but no stand-alone freezers. The data are formed by sales data of 21 EU countries[77].

Figure 73 shows the trend of market penetration of the different energy efficiency classes within the refrigerator market based on the sales data over the period from 2004 to 2014. During the mentioned period there had been continuous improvements in refrigerator efficiency levels, it can be observed that classes B and C decreased their

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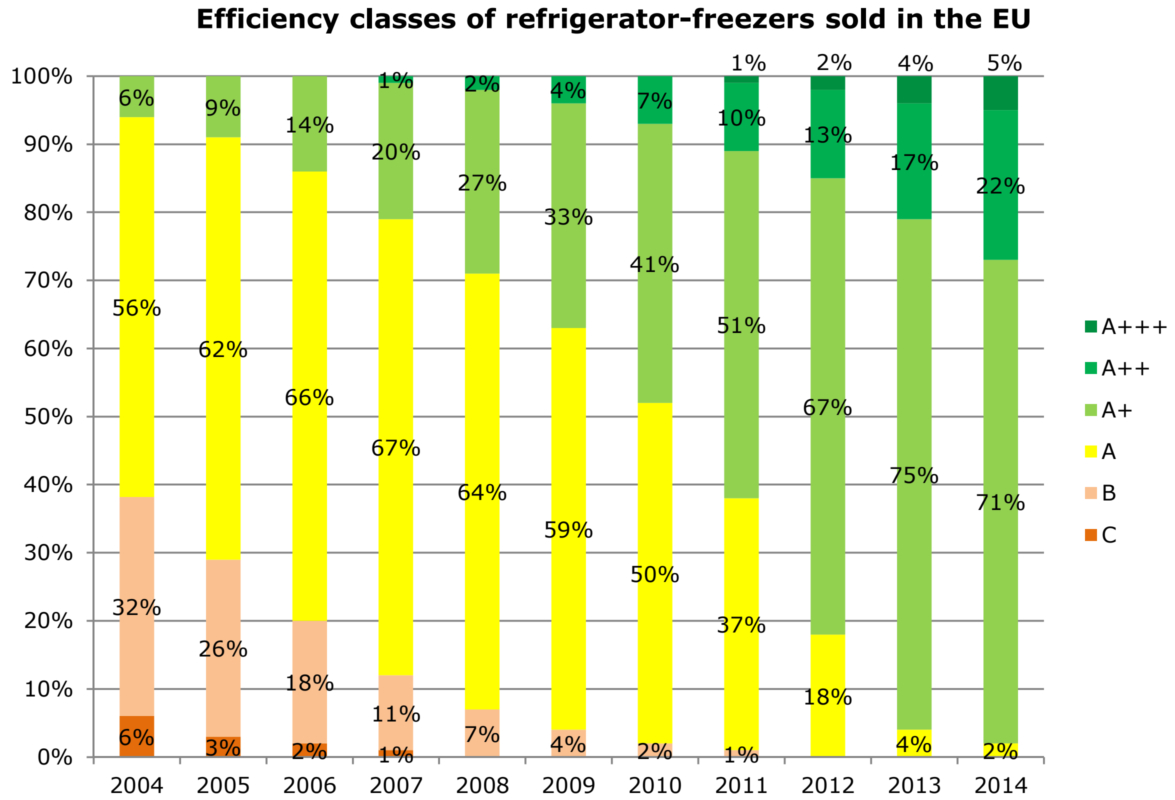
[75] Which account for over 90% of the market share of refrigerating appliances.

[76] For further information visit: www.ecodesign-fridges.eu

[77] AT, BE, CZ, DE, DK, ES, FI, FR, GB, GR, HR, HU, IE, IT, NL, PL, PT, RO, SE, SI, SK.

share and were not any more represented in the market since 2012 and 2008 respectively. Similar trends had observed for class A products which accounted only for 2% of the market share in 2014. The refrigerating appliances with higher presence in the market are the class A+ which account over 70% of the market. Efficiency classes A++ and A+++ are increasing their shares slowly year after year. In 2014 they accounted for 22% (class A++) and 5% (class A+++) of the market.

**Figure 73: Energy efficiency classes of refrigerators-freezers in the EU (21 countries), 2004-2014. Source: topten.eu from GfK [17]**




There has been a significant reduction of 25% in the average energy consumption of refrigerator-freezers in the same period of time, 2004-2014, as shown by Figure 74.

Across the EU, the average declared energy consumption of sold refrigerators was 231 kWh/year in 2014. The highest reduction was from 2011 to 2012 (circa -5%), while the average reduction rate is around 2.8% per year.

Average declared capacity of refrigerator-freezers has not suffered important changes and has increased by 8 litres (3%) from 2004 to 2014 (Figure 75); considering the compartments (fridge and freezer) individually, there has been an increase of +5% in freezer compartment and +2% in fridge compartment, 4 litres each. In 2014, the average volume of refrigerator-freezer sold was 270 litres, divided into 197 litres for the fridge and 73 litres for the freezer compartment.

**Figure 74: Average energy consumption of refrigerator-freezer sold in the EU (21 countries), 2004-2014. Source: topten.eu from GfK [18]**

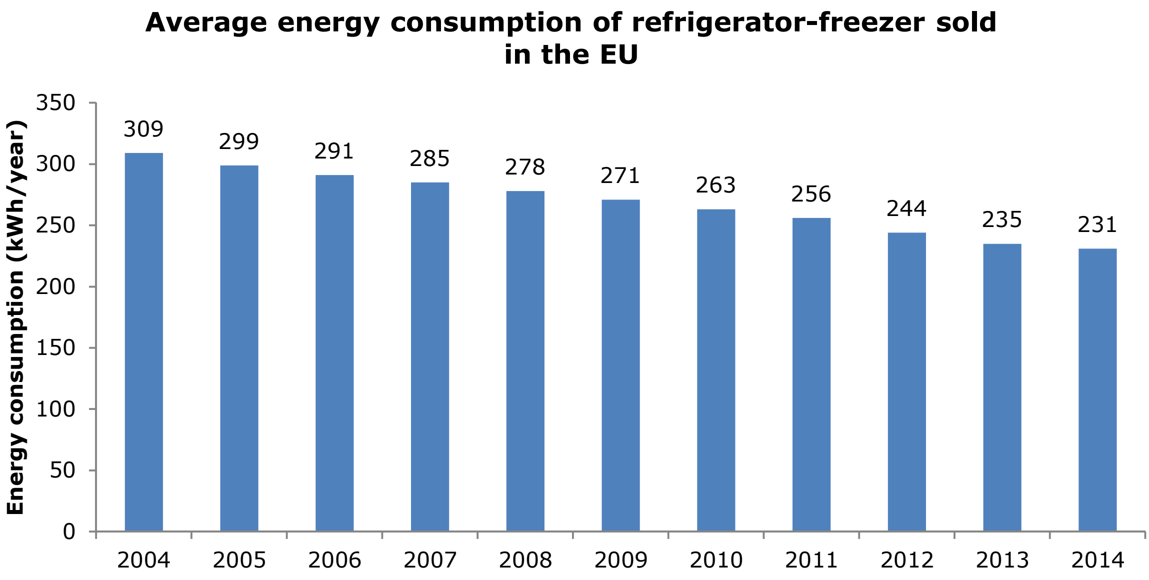
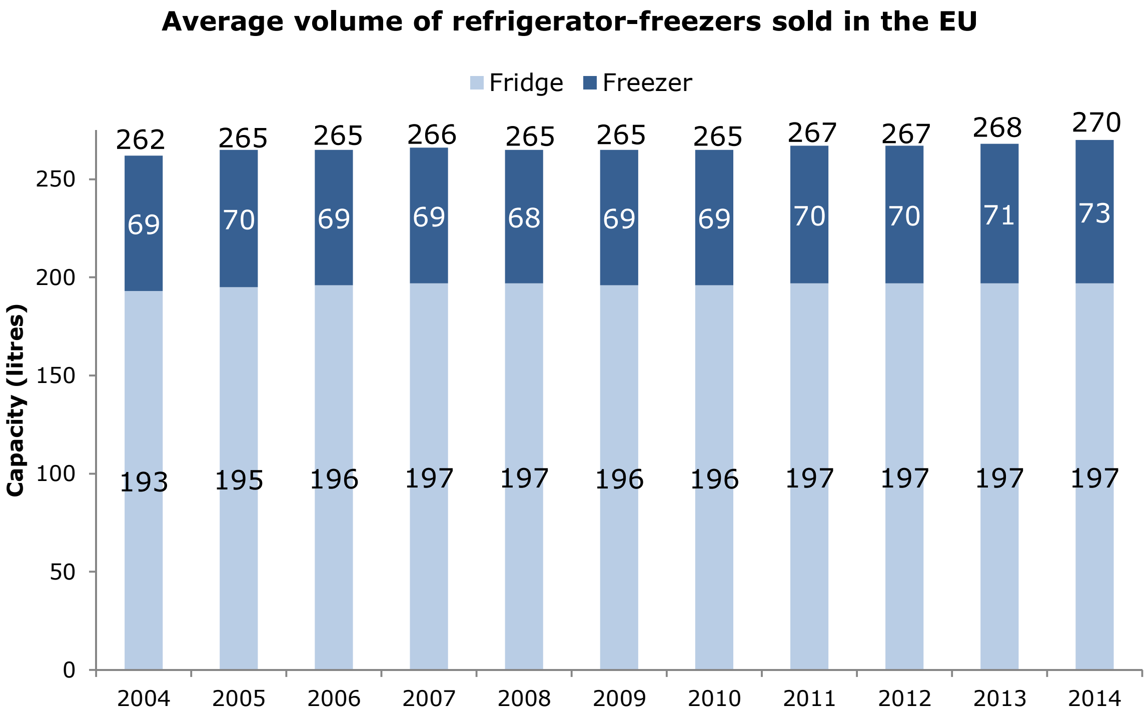



**Figure 75: Average volume of refrigerator-freezers sold in the EU (21 countries), 2004-2014. Source: topten.eu from GfK [18]**

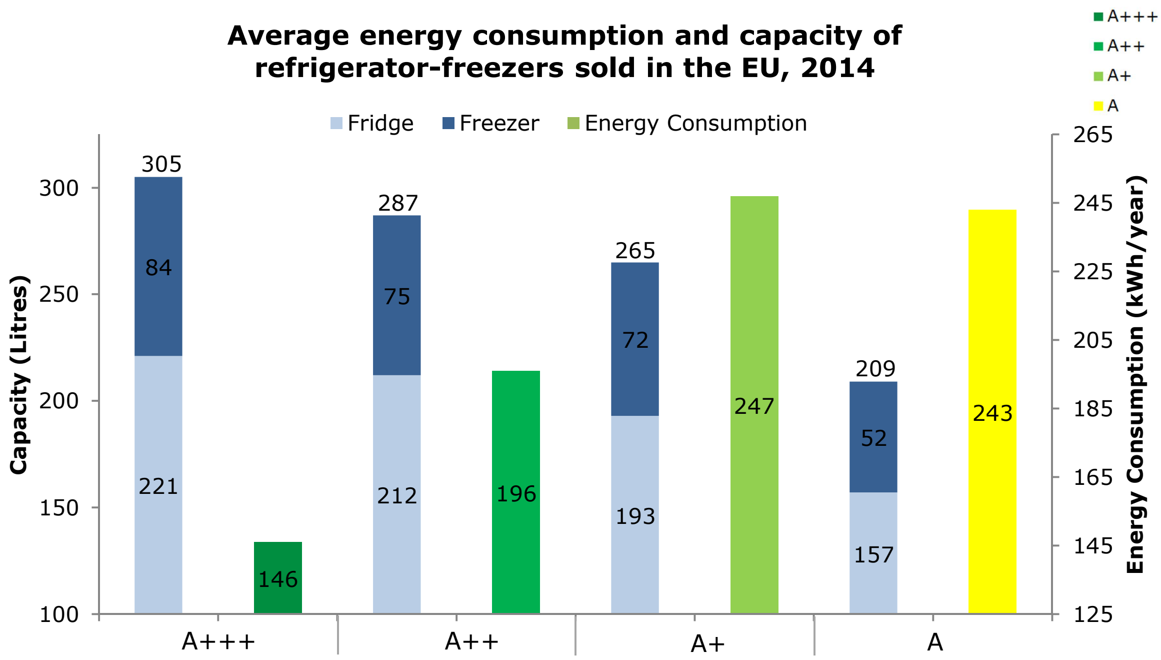



Looking at average energy consumption and capacity of refrigerator-freezers sold by efficiency class (Figure 76), it can be observed that energy consumption differences between efficiency classes are remarkably significant for refrigerator-freezers: a move from A+ to A++ provides on average with 21% of electricity savings, a move from A+ to A+++ saves 41% of electricity.

Average capacity of refrigerator-freezers sold indicates that despite their low declared energy consumption; the most energy efficient (class A+++) are the largest refrigerators. As per this trend, it is expected that average volume of refrigerator sales

(Figure 75) will keep its increasing trend as the most efficient classes (i.e. A+++ and A++) will also gain higher market shares in the future.

**Figure 76: Average energy consumption and volume of refrigerator-freezers sold per efficiency class in the EU (21 countries), 2014. Source: topten.eu from GfK [18]**



#### 4.5.1.2 Washing machines

The washing machines market has reached the saturation level with penetration rates of up to 100% in all EU-28 countries. As in the case of refrigerator-freezers, the washing machine market is hence characterised by a high level of substitution of old appliances, rather than by an increase in the overall stock. The efficiency improvement continues mainly due to the increase in awareness about energy consumption, the energy label and minimum efficiency requirements resulting in a real market transformation across EU-28 countries.

The first energy label for household washing machines was introduced in 1995[78]. It labelled the products with classes from A to G. The label was based on a ratio kWh/kg efficiency definition – being 0.19kWh/kg the threshold of class A. The energy consumption was defined based on full load test at 60ºC. In 2010, the Energy Label was amended with classes from A+ to A+++. With that new regulation (2010/1061/EU), the efficiency definition was changed and the label classes are now based on an Energy Efficiency Index (EEI) based on an annual energy consumption considering low power modes and tests at 40ºC and with partial load, in addition to the full load 60ºC programme.

Eco-design requirements for household washing machines have been set by Commission Regulation (EU) No 1015/2010 which does not apply to household combined wash-driers. It is indeed planned to address eco-design requirements for this specific product category in a separate regulation implementing Directive 2009/125/EC [19].

There have been two eco-design tiers for household washing machines, these are:

- From 1 December 2011:
  - Ban of efficiency classes B products and below;
  - Limitation of water consumption depending on capacity[79];
  - Limitation of washing efficiency index > 1.03 (old washing performance class A)

- From 1 December 2013:
  - Ban of class A;
  - More restricted limitation of water consumption depending on capacity than in the previous tier[80];
  - 20ºC programme mandatory in all new products.

The following table shows the EEI values for the different energy efficiency classes presently considered.

**Table 12: Energy efficiency classes for washing machines in the EU. Source: EC**

| A+++ | A++ | A+ | A | B | C | D |
|---|---|---|---|---|---|---|
| EEI<46 | 46≤ EEI <52 | 52≤ EEI <59 | 59≤ EEI <68 | 68≤ EEI <77 | 77≤ EEI <87 | EEI≥87 |

Figure 77 shows for different EU countries[77] the market share of the different efficiency classes of washing machine sold between 2004 and 2014.

The energy labelling has been a success since the market sales show that over 60% of the market share was taken by the two most efficient efficiency classes in 2014; the

[78] Directive 95/12/EC

[79] Refer to Annex II of Regulation (EU) No 1015/2010 for further information about calculation methods of the different efficiency indexes.

[80] 6kg machines: 11,000 litres/year; 7kg: 11,550 litres/year; 8kg: 12,100 litres/year; 9kg: 12,600 litres/year.

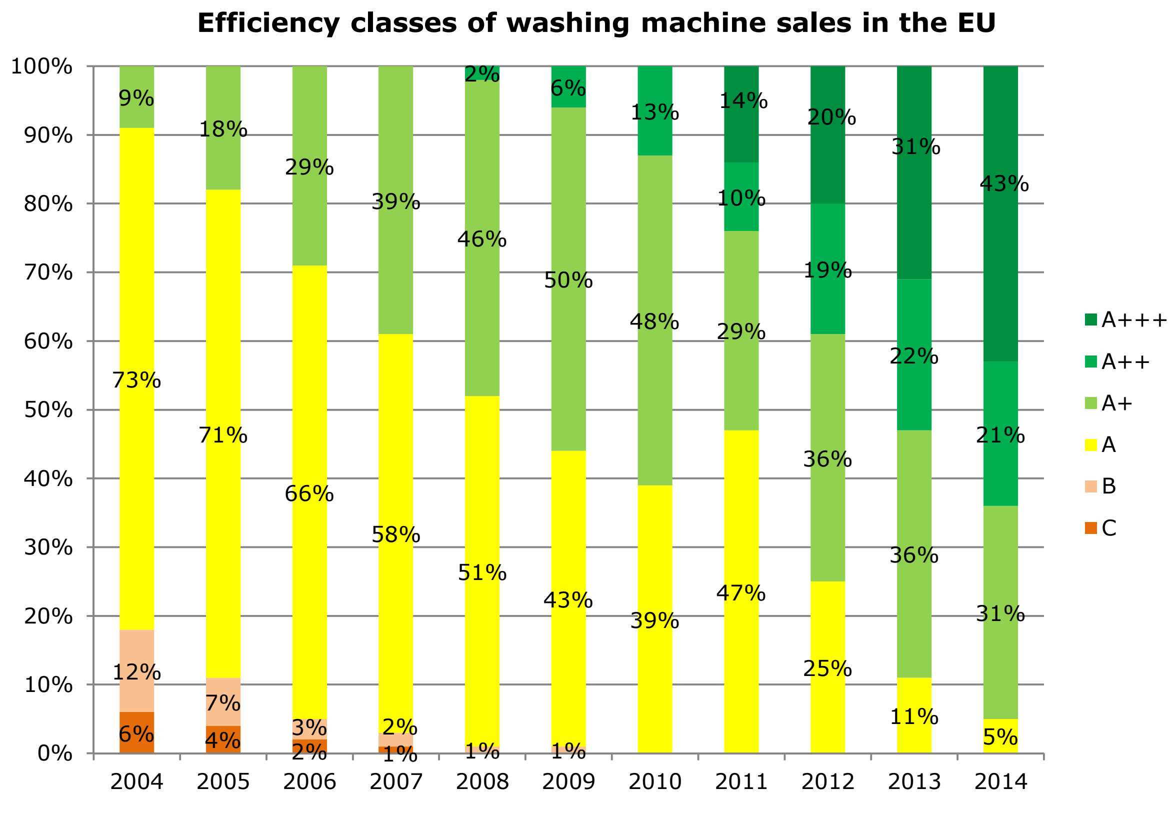
efficiency development of washing machines happened much faster than initially expected, as over 80% of the market was already in the most efficient classes in 2004.

A decrease in class B washing machine sales can be observed from 2004 to 2009, with a vanishing of these labels about two years before class B eco-design ban as of December 2011.

In 2014, class A+++ has got the highest share of the market for the first time (43%), followed by class A+ (31%). The highest share was instead for class A+ (36%) and was followed by A+++ (31%), A++ (22%) and A (11%) share in 2013.

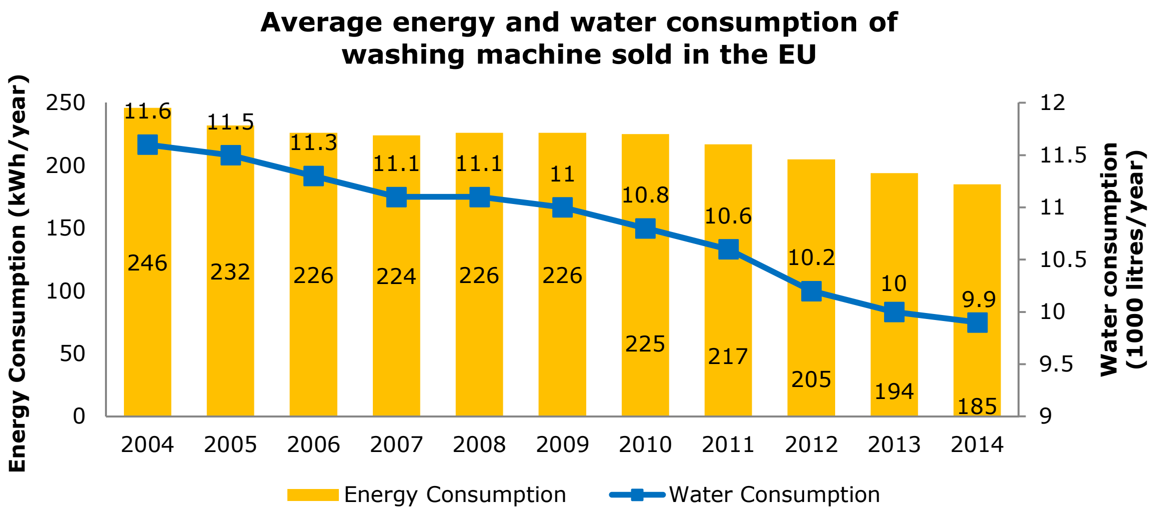
The household washing machines energy label related both to electricity and the water consumption performances. Figure 78 shows that during the eleven-years period considered (2004-2014) there has been, on average, an improvement in both parameters. After a reduction from 2004 – 2006, average annual energy consumption remained stable until 2011, when it started to go down with the introduction of the current energy label. The average annual energy consumption for washing machine sales in 2014 was 185kWh/year which represents a reduction of 25% compared to 2004, while the average annual water consumption was 9.9 thousand litres which also represents a decrease of 15% for the same period.

**Figure 77: Energy efficiency classes of washing machines sold in the EU (21 countries), 2004-2014. Source: topten.eu from GfK [20]**



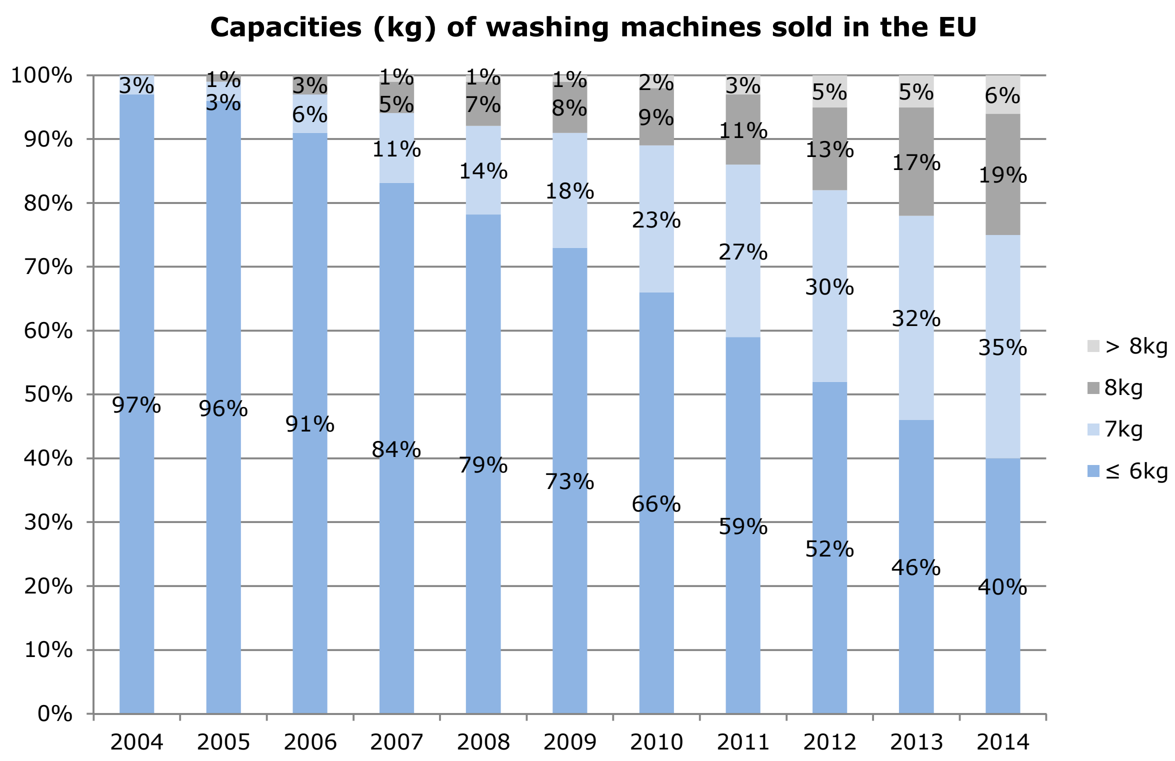

Note: Classes A+, A++ and A+++ were officially introduced in 2011; before 2011, GfK (data source) categorized as A+ and A++ whatever was in principle declared respectively as 'A-10%' and as 'A-20%'. Reported sales shares for these classes before 2011 have therefore to be taken with caution.

**Figure 78: Average energy and water consumption of washing machine sold in the EU (21 countries), 2004-2014. Source: topten.eu from GfK [18]**




Note: Before 2011/12 the energy and water consumptions were declared in kWh/cycle and litres/cycle. The values have been multiplied by 220 by GfK (data source). This is the number of annual cycles assumed for the declaration on the 2010 Energy Label which applied from December 2011. Since the new declaration also includes partial loads, 40ºC cycles and low-power modes consumption, the values are not 100% comparable. While the exact values have to be taken with caution, this chart can show the general trends before and after 2011.

**Figure 79: Capacities (kg) of washing machine sold in the EU (21 countries), 2004-2014. Source: topten.eu from GfK [18]**



Back in 2004, nearly all washing machines were for 6kg of laundry or less. An increasing trend to larger capacities started afterwards. In 2014, 60% of all washing machines sold across the EU were declared to be designed for washing 7kg laundry or more.

It is not clear if the trend to large washing machines is coming from changed consumer demand or rather from the market offer [18]. It is questionable if washing habits are changing so suddenly to washing larger loads, especially since the average household size in terms of person per household is declining – see chapter 4.1, Figure 39.

As shown in Figure 80, the average energy consumption of washing machine sold in the A+++ efficiency class saved 13% of the energy consumed by A+ products in 2014, while A++ products consumed basically the same annual energy as A+ products. A move from class A to A+++ saves 23% of electricity; this indeed is remarkably different from other household appliances such as refrigerators where a step of one single class provides with a similar reduction of consumption. The lowest average water consumption of washing machine sold was for class A+ products in 2014 with 9 thousand litres per year, while A+++ and A++ registered both 10 thousand litres of average annual water consumption.

Figure 81 complements the analysis by giving size differences between efficiency classes. It can be observed that most efficient washing machines are the biggest washing machines. In 2014, only 18% of class A+++ models had a rated capacity equal or below 6kg, in contrast with 71% of the sold washing machines in efficiency classes A+ or A.

It has to be finally pointed out that, while these declared energy consumption values are valuable for comparing models with each other, they do not necessarily exactly reflect how much energy washing machines are consuming in reality. Washing habits by users turn into a key element as they may lead to higher energy and water consumptions, for instance, when choosing programmes different from the test programmes or running washing cycles with partial loads (e.g. 2-3kg in 8kg machines).

**Figure 80: Average energy and water consumption of washing machine sold in the EU (21 countries), 2014. Source: topten.eu from GfK [18]**

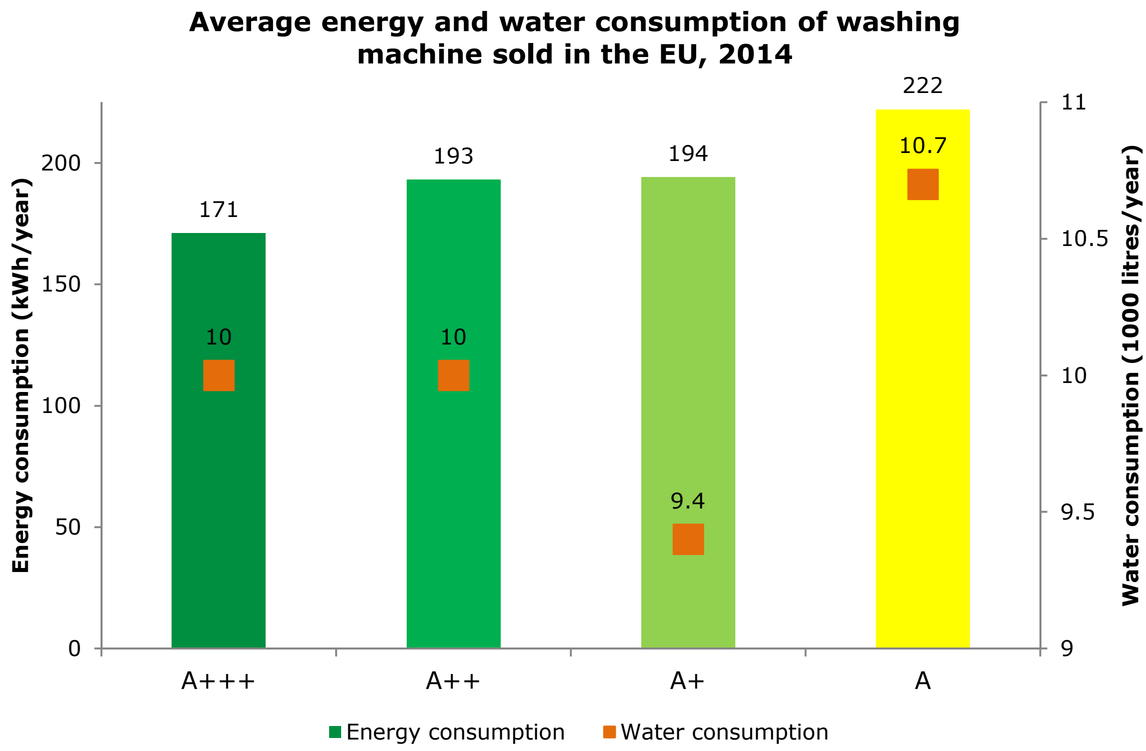
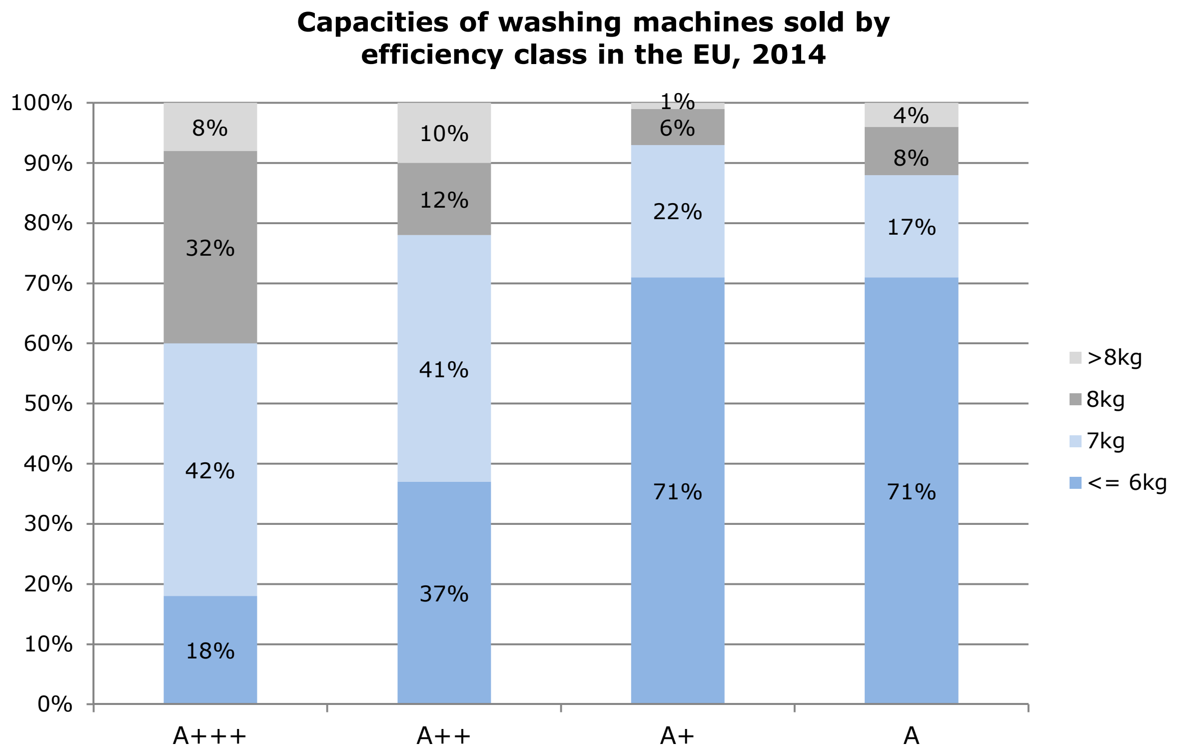


**Figure 81: Capacities of washing machines sold by efficiency class in the EU (21 countries), 2014. Source: topten.eu from GfK [20]**




### 4.5.1.3 Tumble driers

The market of tumble driers did not transform as fast as other appliances markets (for example the cold appliance market). Household tumble driers account for a significant part of total residential energy consumption. There is great potential to further reduce the energy consumption of household tumble driers. Many tumble driers sold in the EU are still less efficient compared to other appliances sold. Nevertheless, a development leading to a more energy efficiency market can be observed.

Energy Label for tumble driers was first adopted in 1995, and became compulsory in April 1996 [21]. The Energy Label classification system from A to G, rated tumble driers according to the simple ratio kWh/kg (consumption per cycle divided by the capacity) as measured at full load and with 60% of initial moisture content. Vented and condensing driers[81] are covered by separate classification schemes. Only after the entrance in the market of heat pump driers (in the year 2000) the threshold 0.48 kWh/kg for condenser drier energy efficiency class was reached.

Commission Regulation No 392/2012 revised the Energy Label for these products in 2012, and introduced the classes A+ to A+++. This new Energy Label became compulsory as of June 2013. The Label's classification system was modified and a new Energy Efficiency Index was introduced for the tumble drier's rating. This EEI represents the ratio between a model annual energy consumption and a reference model's (of the

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[81] Tumble driers evaporate the moisture by blowing hot dry air through the laundry. The air is heated up by electric heating element. There are two different basic technologies that exist to remove the evaporated water:
- Vented driers (open systems) blow the exhaust air (initially air from the room) outdoors. This can cause disturbing smells, steam and noise at the external outlet.
- Condensing driers (closed systems) use a heat exchanger cooled by interior air to condense water from the warm moist air in the drier. Condensing driers with an integrated heat pump, so-called 'heat pump driers' are the most energy efficient driers, consuming only about half of the electricity of conventional condensing driers [18].

same capacity) energy consumption expressed in percentage[82]. While on the previous Label the energy consumption was declared on a per cycle basis, the annual energy consumption is declared on the current Label. Information of parameters such as the duration of the standard drying cycle, the rated capacity of the drier model and the noise level generated by the standard cycle are also provided by the Energy Label. For condenser driers, also the condensation efficiency and the condensation efficiency class are indicated.

In 2012, Eco-design requirements for electric mains-operate and gas-fired household tumble driers and built-in household tumble driers (including those sold for non-household use) were also established by the Commission Regulation No 932/2012. This Regulation includes general eco-design requirements concerning information to be disclosed by manufacturers that were introduced on 1 November 2014 and specific requirements that were established on 1 November 2013 and 1 November 2015.

**Table 13: EU energy efficiency label classes for tumble driers since June 2013. Source: EC**

| A+++ | A++ | A+ | A | B | C | D |
|---|---|---|---|---|---|---|
| EEI<24 | 24≤ EEI <32 | 32≤ EEI <42 | 42≤ EEI <65 | 65≤ EEI <76 | 76≤ EEI <85 | EEI≥85 |

For tumble driers the following minimum requirements regarding energy efficiency were implemented:

Since November 2013, eco-design tier 1:

- At least energy efficiency class C (EEI<85)
- At least energy efficiency class D (at 60% initial moisture content)

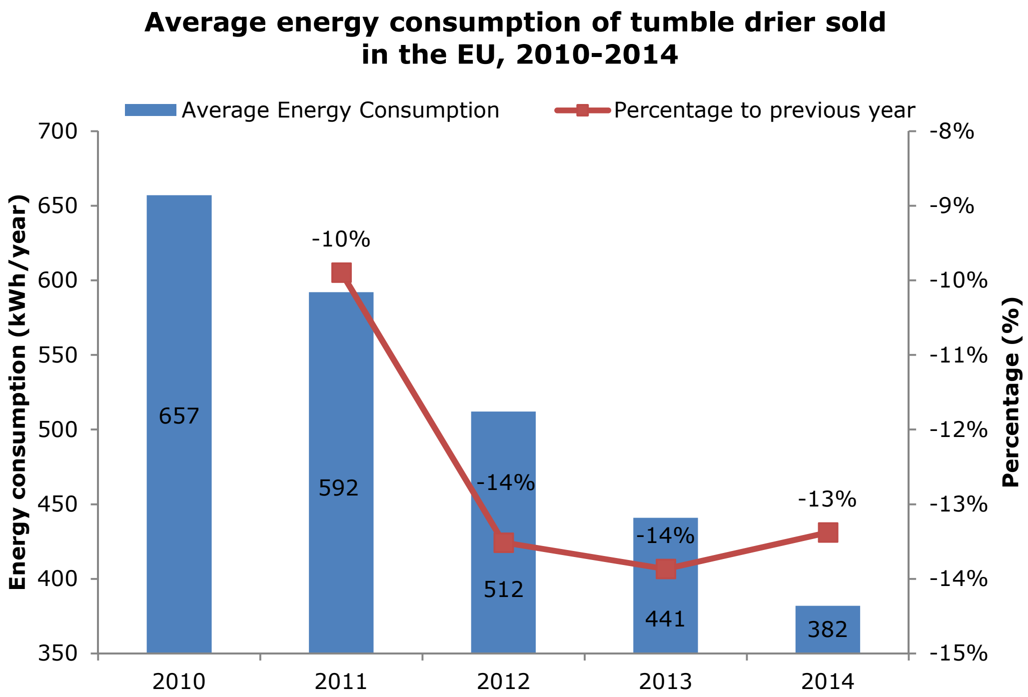
Since November 2015, eco-design tier 2:

- At least energy efficiency class B (EEI<76)
- At least energy efficiency class C (at 70% initial moisture content)

Nowadays, vented drier models can reach class B, so this technology has not disappeared from the market after the second eco-design tier, despite the fact that heat pump driers (condensing driers) are much more efficient.

[82] The EEI calculation formula assumes 160 drying cycles per year (around three per week; tested with cotton), of which four out of seven are assumed to be operated with a half load and including low power modes (off and stand-by mode).

**Figure 82: Average energy consumption of sold tumble driers in the EU (10 countries)[83], 2010-2014. Source: GfK Retail and Technology Retail Panel [15]**




Average energy consumption of sold tumble driers has maintained a decreasing trend during the last 5 years (Figure 82). The reduction of 42% from 2010 to 2014 highlights an improvement in the efficiency levels due, among other, to eco-design and labelling measures implemented in the recent years.

As for the washing machines, user habits represent a key factor to take into account when the actual annual energy consumption of these products has to be estimated[84].

Figure 83 shows the market share of sold heat pump tumble driers across the EU for the year 2014. It can be seen that the highest share is taken by class B models (34%) while top three energy classes (i.e. A+ to A+++) account 40% of the tumble drier sales. Class A+++ models still represent a low market share (2%).

As for the washing machines, the average loading capacity of tumble driers has been increasing as well. In the year 2000, the average capacity of models available was 4.9kg. In 2008, i.e. eight years later, the average capacity was 6.6kg [16]. Data from 2014 (Figure 84) shows that the most efficient heat pump tumble driers are the biggest models. Over 40% of A++ and A+ are tumble driers are of 8kg or larger capacity.

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[83] AT, BE, DE, ES, FR, GB, IT, NL, PO, SE.

[84] For instance, low partial load (below half filling-load) cycles may lead to waste of electricity.

**Figure 83: Efficiency classes of heat pump tumble drier sold in EU (21 countries), 2014. Source: topten.eu from GfK [22]**

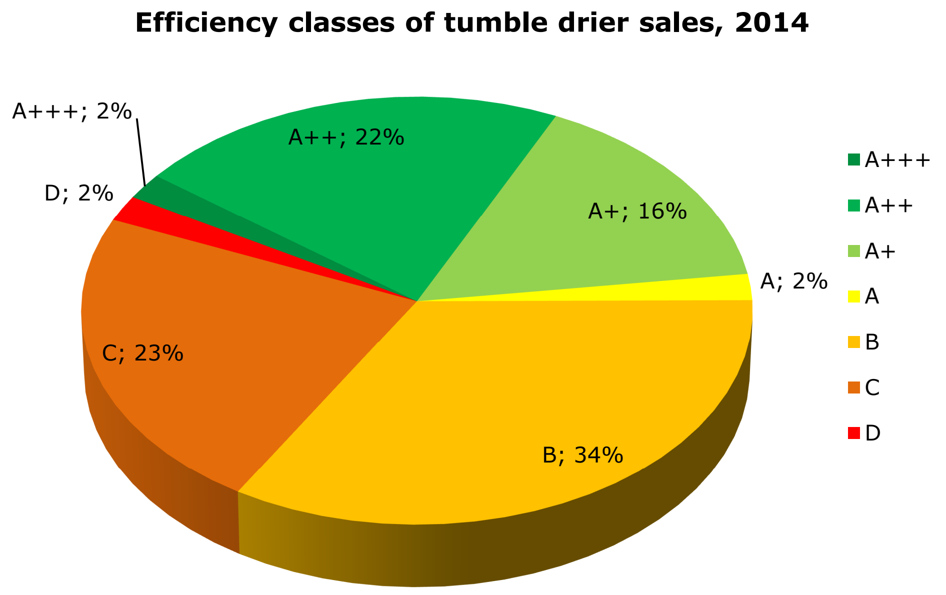
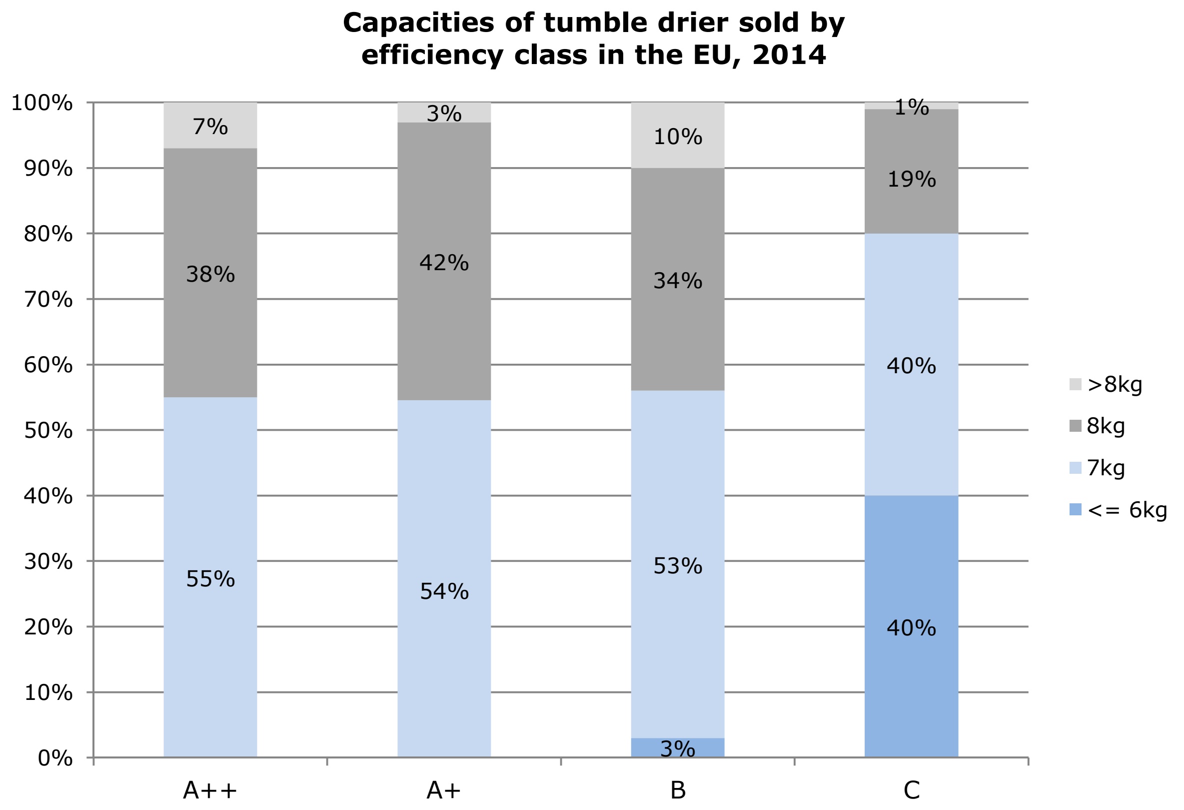



**Figure 84: Capacities of heat pump tumble drier sales in EU by efficiency class (21 countries), 2014. Source: topten.eu from GfK [22]**



#### 4.5.1.4 Dishwashers

In the EU-28 dishwashers have a lower saturation level than other major appliances (e.g. refrigerators and washing machines). Penetration differs from country to country and is around 50-60% [23]. In 2000, at European level, the total energy consumption of all dishwashers in the stock was 22.1 TWh/year. In 2010, ten years later, it was 26.7 TWh/year. This increasing of the consumption (21%) is bound to a larger stock size [24]. Between 2001 and 2005 there has been only a relatively small efficiency progress in the dishwasher market. The efficiency improvements started to be visible after the year 2005.

The so called "Omnibus" review study of 2014 prepared for the European Commission estimated the potential savings by household dishwashers at 1.4 TWh/year in 2030 [25].

Commission Regulation (EU) No 1016/2010 implementing the Eco-design Directive 2009/125/EC introduced minimum eco-design requirements for household dishwashers. This measure entered into force since December 2011. In this report only the eco-design requirements regarding energy usage (here electricity consumption) are considered and water consumption is not analysed. The minimum efficiency performance standards are calculated in accordance with the number of place settings of the household dishwashers (the most common model being the one with 12 place settings). There requirements are introduced gradually over a period of five years (2011-2016) as follows:

From 1 December 2011:

- The EEI[85] shall be less than 71 (class A) except for models with a rated capacity of 10 place settings and a width equal to or less than 45 cm for which the EEI shall be less than 80 (class B).

From 1 December 2013:

- The EEI shall be less than 63 (class A+) for household dishwashers with a rated capacity equal to or higher than 11 place settings and for models with a rated capacity of 10 place setting and a width bigger than 45 cm.
- The EEI shall be less than 71 (class A) for household dishwashers with a rated capacity of 10 place settings and a width equal to or less than 45cm.

From 1 December 2016:

- The EEI shall be less than 63 (class A+) for household dishwashers with a rated capacity of 8 and 9 place settings and for household dishwashers with a rated capacity of 10 place settings and a width equal to or less than 45 cm.

In addition to comply with minimum energy efficiency standards, producers of household dishwashers have to provide a booklet with information regarding the power consumption of the off-mode and of the left-on mode, the most energy efficient washing programmes and indicative information about energy and water consumption of the main washing programmes.

Energy labelling for household dishwashers was first implemented in 1997 by Commission Directive 97/17/EC following Council Directive 92/75/EC. The Directive implemented an energy label with energy classes from A to G. Directive 97/17/EC was replaced by Commission Delegated regulation (EU) No 1059/2010 supplementing Directive 2010/30/EU with regard to energy labelling of household dishwashers. The new regulation introduced three new energy classes A+, A++ and A+++ as of 20 December 2011.

[85] The EEI (Energy Efficiency Index) of a household dishwasher is the ratio of its annual energy consumption and the annual energy consumption of a standard equivalent model with same rated capacity.

**Table 14: Energy efficiency classes for household dishwashers in the EU. Source: EC**

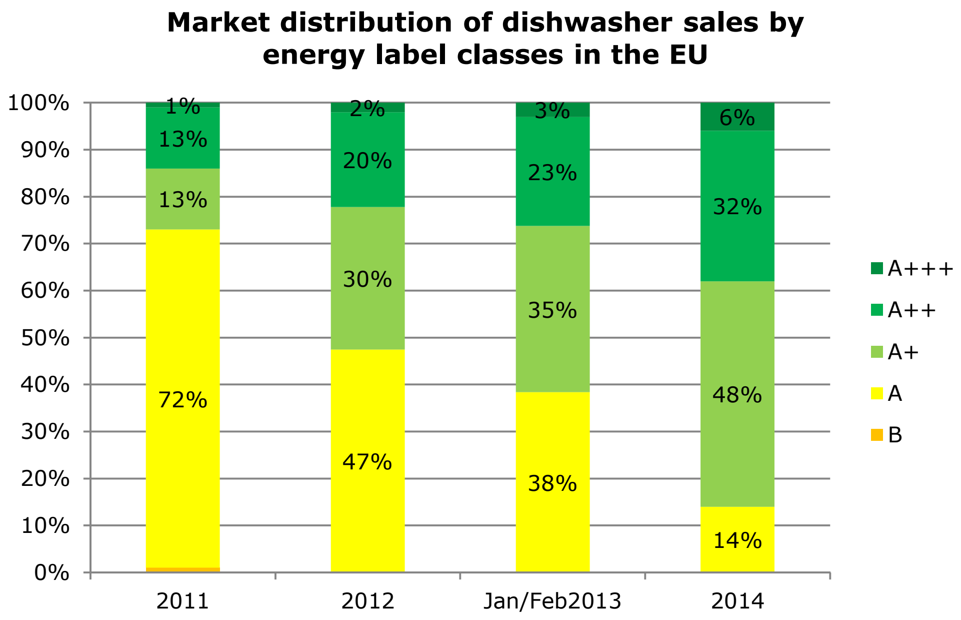
| A+++ | A++ | A+ | A | B | C | D |
|---|---|---|---|---|---|---|
| EEI<50 | 50≤ EEI <56 | 56 ≤ EEI < 63 | 63 ≤ EEI < 71 | 71 ≤ EEI < 80 | 80 ≤ EEI < 90 | EEI ≥ 90 |

In the last years, sold household dishwashers show an increasing market penetration of top two efficiency classes, i.e. A++ and A+++ (Figure 85). In 2014, 38% of dishwasher sales were class A++ or A+++, while in 2011 these two classes accounted 14% of the market share.

Class A+ models are the models with the highest market share. To be noted the reduction of sales of class A products which decreased its market share from 72% (2011) to 14% (2014) in favour of more efficient products.

The average energy consumption dishwasher sold across the EU has been continuously decreasing year after year in the period 2010-2014 in a quasi-linear trend with a yearly reduction rate above 1% as shown in Figure 86. In 2014, the average annual energy consumption of sold dishwasher was 272 kWh and achieved 285 kWh in 2010 so registering a reduction rate of 4.6% through the mentioned period.

**Figure 85: Market distribution of dishwashers sold by energy label classes in the EU (10 countries), 2011-2014. Source: GfK [15], [25]**



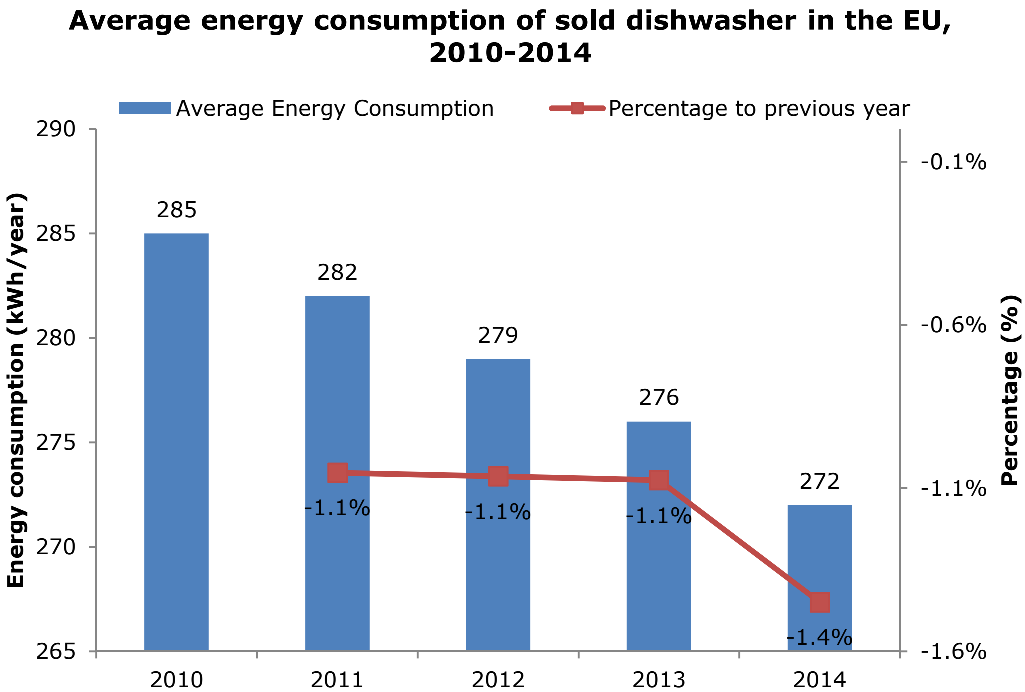

In 2014, an exploratory study aiming to provide a prioritisation and indication of extensiveness of review activities for existing regulations identified household dishwashers as a "medium priority" group, in contrast with other groups of products such as lighting products, domestic cold appliances or domestic washing machines which were identified as "high priority" [25].

A review study, preparing revisions of the regulations for dishwashers started in 2014 and is expected to end in 2016[86]. Further development on highly efficient dishwashers is

[86] Further information in the study's website: http://susproc.jrc.ec.europa.eu/Dishwashers/index.html

expected in the future as BAT allow, nowadays, exceeding the A+++ threshold by 40% [26][87].

**Figure 86: Average energy consumption of sold dishwashers in the EU (10 countries), 2010-2014. Source: GfK Retail and Technology Retail Panel [15]**




## 4.5.2 Other appliances

This chapter covers the energy efficiency status of other household appliances out of the MDA category but under the eco-design and labelling directives. These other energy-related products include cooking appliances and vacuum machines.

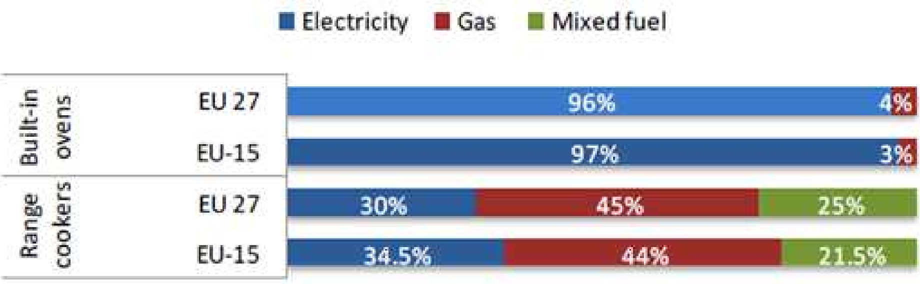
### 4.5.2.1 Cooking appliances

Cooking appliances group domestic ovens, domestic hobs (gas-fired, electric or mixed) and domestic range hobs. The total electricity consumption for electric cooking was estimated to be around 60 TWh (electric hobs and grills together) in 2007 [16].

In 2011, the following preparatory Study for Eco-design Requirements of EuPs was carried out under Lot 22: Domestic and commercial ovens in the context of the Directive 2005/32/EC on the Eco-design of Energy-using Products [27]. This study showed that 96% of installed built-in ovens were running with electricity and 4 % with gas. For range cookers the share of electricity was 30% whereas 45% were running with gas and 25% with mixed fuel (see figure below). Electricity consumption of cooking appliances is therefore a substantial portion of total residential energy consumption due to cooking appliances.

[87] More information can be found under: www.topten.eu

**Figure 87: Electric ovens and range cookers stock distribution in the EU-27, 2007. Source: Bio Intelligence Service [27]**




In 2014, new eco-design requirements for domestic ovens, hobs and range hoods were introduced by the Commission Regulation (EU) No 66/2014. This Regulation covers domestic ovens (including when incorporated in cookers), domestic hobs and domestic electric range hoods, including when sold for non-domestic purposes and excludes appliances which offer 'microwave heating' function, small ovens, portable ovens, heat storage ovens, ovens which are heated with steam as a primary heating function, covered gas burners in hobs, outdoor cooking appliances, appliances designed for use only with gases such as propane and butane and grills.

It came into force February 2014 and establishes the following minimum performance requirements which are introduced gradually in three tiers in order to provide a sufficient timeframe for manufacturers to redesign products subject to the Regulation.

The eco-design tiers for energy efficiency, air flow and illumination are differentiated by product category as follows [28]:

*For domestic ovens (both electric and gas ovens):*

- From 1 year after the entry into force: $EEI_{cavity} < 146$
- From 2 years after the entry into force: $EEI_{cavity} < 121$
- From 5 years after the entry into force: $EEI_{cavity} < 96$

*For domestic hobs using electricity:*

- From 1 year after the entry into force: $EC_{electric\ hob} < 210$
- From 2 years after the entry into force: $EC_{electric\ hob} < 200$
- From 5 years after the entry into force: $EC_{electric\ hob} < 195$

Being $EC_{electric\ hob}$ expressed in energy per kilogram (Wh/kg)

*For domestic gas-fired hobs:*

- From 1 year after the entry into force: $EE_{gas\ hob} > 53$
- From 2 years after the entry into force: $EE_{gas\ hob} > 54$
- From 5 years after the entry into force: $EE_{gas\ hob} > 55$

Being $EE_{gas}$ expressed in percentage (%)

*For domestic range hoods:*

- From 1 year after the entry into force: $EEI_{hood} < 120$; and $FDE_{hood} > 3$
- From 2 years after the entry into force: $EEI_{hood} < 110$; and $FDE_{hood} > 5$
- From 5 years after the entry into force: $EEI_{hood} < 100$; and $FDE_{hood} > 8$

Where $EEI_{cavity}$ and $EEI_{hood}$ represent the Energy Efficiency Index limits for cavities of domestic ovens and domestic range hoods respectively; $EC_{electric\ hob}$, the maximum energy consumption limits for electric hobs; $EE_{gas\ hob}$, the minimum energy efficiency limits for gas-fired hobs and $FDE_{hood}$, the fluid dynamic efficiency for domestic range hoods.

- Air flow: from 1 year after the entry into force, the domestic range hoods with a maximum air flow in any of the available settings higher than 650 $m^3/h$ shall automatically revert to an air flow lower than or equal to 650 $m^3/h$ in a time $t_{limit}$ as defined in Annex II of the relevant eco-design Regulation.

- Illumination of the lighting: from 1 year after entry into force, for range hoods which provide for lighting of the cooking surface, the average illumination of the lighting system on the cooking surface ($E_{middle}$) shall be higher than 40 lux when measured under standard conditions.

At the same time, a new Energy Label was introduced by the Commission Regulation (EU) No 65/2014. It establishes the energy efficiency classes of domestic ovens (including when incorporated in cookers), domestic hobs and domestic electric range hoods excluding the same products categories (above-mentioned) than the eco-design Regulation.

The energy efficiency classes are based on different Energy Efficiency Indexes, each of them calculated out of different parameters. These parameters include, among others, the ratio between the Annual Energy Consumption and the Standard Annual Energy consumption of a similar capacity model, the flow rate of air, the average illumination level among others.

The following tables (Table 15 and Table 16) show the energy efficiency classes definition for the different product types. As illustrated in Table 16, for domestic range hoods the most stringent energy efficiency classes are introduced gradually from 2015 to 2020 in different tiers; in each of those label tiers where suppliers deem appropriate, they may apply the next Label tier (i.e. label 2 from 1 January 2015; label 3 from 1 January 2018 and so on), so helping reach the last label tier (Label 4) earlier than scheduled, and therefore producing a greater potential for energy savings by 2020.

**Table 15: Energy efficiency classes of domestic ovens from 1 January 2015. Source: EC**

| A+++ | A++ | A+ | A | B | C | D |
|---|---|---|---|---|---|---|
| $EEI_{cavity} < 45$ | $45 \leq EEI_{cavity} < 62$ | $62 \leq EEI_{cavity} < 82$ | $82 \leq EEI_{cavity} < 107$ | $107 \leq EEI_{cavity} < 132$ | $132 \leq EEI_{cavity} < 159$ | $EEI_{cavity} \geq 159$ |

**Table 16: Energy efficiency classes of domestic range hoods by label tiers. Source: EC**

Label 1: from 1 January 2015

| A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| $EEI_{hood} < 55$ | $55 \leq EEI_{hood} < 70$ | $70 \leq EEI_{hood} < 85$ | $85 \leq EEI_{hood} < 100$ | $100 \leq EEI_{hood} < 110$ | $110 \leq EEI_{hood} < 120$ | $EEI_{hood} \geq 120$ |

Label 2: from 1 January 2016

| A+ | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| $EEI_{hood} < 45$ | $45 \leq EEI_{hood} < 55$ | $55 \leq EEI_{hood} < 70$ | $70 \leq EEI_{hood} < 85$ | $85 \leq EEI_{hood} < 100$ | $100 \leq EEI_{hood} < 110$ | $EEI_{hood} \geq 110$ |

Label 3: from 1 January 2018

| A++ | A+ | A | B | C | D | E |
|---|---|---|---|---|---|---|
| $EEI_{hood} < 37$ | $37 \leq EEI_{hood} < 45$ | $45 \leq EEI_{hood} < 55$ | $55 \leq EEI_{hood} < 70$ | $70 \leq EEI_{hood} < 85$ | $85 \leq EEI_{hood} < 100$ | $EEI_{hood} \geq 100$ |

Label 4: from 1 January 2020

| A+++ | A++ | A+ | A | B | C | D |
|---|---|---|---|---|---|---|
| $EEI_{hood} < 30$ | $30 \le EEI_{hood} < 37$ | $37 \le EEI_{hood} < 45$ | $45 \le EEI_{hood} < 55$ | $55 \le EEI_{hood} < 70$ | $70 \le EEI_{hood} < 85$ | $EEI_{hood} \ge 85$ |

For domestic range hoods, the mentioned labelling Regulation also introduce efficiency classes related to fluid dynamic efficiency ($FDE_{hood}$), the lighting efficiency ($LE_{hood}$) and the grease filtering efficiency ($GFE_{hood}$), all three classifications being based on an A to G scheme (from most to least efficient). The calculation methodologies for all mentioned indexes can be found in the Annex II of the Regulation.

The combined effect of the provisions set out in the eco-design and energy labelling regulations for domestic ovens, hobs and range hoods is expected to result in annual primary energy savings of 27 PJ/a in 2020, increasing up to 60 PJ/a by 2030 [29].

#### 4.5.2.2 Vacuum cleaners

The annual electricity consumption of vacuum machines was estimated to have been 18 TWh in the Union in 2005 and was expected to achieve 34 TWh in 2020. The European Union decided to take specific measures in order to reduce the energy consumption of these products, as a preparatory study showed a significant potential for energy consumption reduction [30].

In 2013, minimum performance requirements were established for the vacuum cleaners by the Commission Regulation (EU) No 666/2013. The eco-design requirements are introduced gradually in order to provide a sufficient timeframe for manufacturers to re-design their products. This eco-design Regulation affects electric mains-operated vacuum cleaners, including hybrid vacuum cleaners[88]; excluding wet, wet and dry, battery operated, robot, industrial, or central vacuum cleaners, floor polishers and outdoor vacuums.

Introduced eco-design requirements relate to energy consumption in the use phase, dust pick-up, dust re-emission, sound power level (noise) and durability. These requirements are introduced gradually in the following two tiers [31]:

From 1 September 2014

- Annual energy consumption shall be less than 62.0 kWh/year;
- Rated input power shall be less than 1 600 W;
- Dust pick up on carpet ($dpu_c$) shall be greater than or equal to 0.70. This limit shall not apply to hard floor vacuum cleaners;
- Dust pick up on hard floor ($dpu_{hf}$) shall be greater than or equal to 0.95. This limit shall not apply to carpet vacuum cleaners.

From 1 September 2017

- Annual energy consumption shall be less than 43,0 kWh/year;
- Rated input power shall be less than 900 W;
- Dust pick up on carpet ($dpu_c$) shall be greater than or equal to 0.75. This limit shall not apply to hard floor vacuum cleaners;
- Dust pick up on hard floor ($dpu_{hf}$) shall be greater than or equal to 0.98. This limit shall not apply to carpet vacuum cleaners;
- Dust re-emission shall be no more than 1,00 %;
- Sound power level shall be less than or equal to 80 dB(A);

[88] Hybrid vacuum cleaner is defined as a vacuum cleaner that can be powered by both electric mains and batteries.

- The hose, if any, shall be durable so that it is still useable after 40 000 oscillations under strain;
- Operational motor lifetime shall be greater than or equal to 500 hours.

The calculation methodologies for all the mentioned parameters, i.e. annual energy consumption, rated input power, dust pick up on carpet, dust pick up on hard floor, dust re-emission rate, sound power level, durability of the hose and operational motor lifetime can be found in the Annex II of the relevant eco-design Regulation.

In September 2014, an energy label entered into force for commercialised vacuum cleaners [32]. It was introduced by the Commission Regulation (EU) No 665/2013. It affects to the same vacuum cleaner categories than the eco-design Regulation. As for the eco-design requirements, the energy labels for vacuum cleaners are introduced gradually by two tiers as follows:

**Table 17: Energy efficiency classes of vacuum cleaners from 1 September 2014. Source: EC**

| A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| AE≤28.0 | 28.0 < AE ≤ 34.0 | 34.0 < AE ≤ 40.0 | 40.0 < AE ≤ 46.0 | 46.0 < AE ≤ 52.0 | 52.0 < AE ≤ 58.0 | AE > 58.0 |

**Table 18: Energy efficiency classes of vacuum cleaners from 1 September 2017. Source: EC**

| A+++ | A++ | A+ | A | B | C | D |
|---|---|---|---|---|---|---|
| AE≤10.0 | 10.0 < AE ≤ 16.0 | 16.0 < AE ≤ 22.0 | 22.0 < AE ≤ 28.0 | 28.0 < AE ≤ 34.0 | 34.0 < AE ≤ 40.0 | AE > 40.0 |

The annual energy consumption (AE) expressed in kWh/year has differentiated calculations depending on the vacuum cleaner usage i.e. for carpet vacuum cleaners, for hard floor vacuum cleaners and for general-purpose vacuum cleaners. This calculation methodology can be found in the Annex II of eco-design regulation.

The Energy Label provides also with additional information about other performance parameters such as cleaning performance and dust re-emission, both classified according to an A (most efficient) to G (least efficient) scheme.

When focusing on cylinder-type vacuum cleaners, i.e. the main segment of vacuum cleaners to which the energy label is applied[89], it can be observed that its EU market is mostly built on high wattage models. Low wattage offer is nevertheless raising also due to the above mentioned regulations (see Figure 88). In 2012, only 24.4% of the vacuum cleaners sold had rated wattage under 1,600 W, which is the maximum power input allowed from 1 September 2014. In 2014, two years later, this share rose until 32.9% and in the year from June 2014 to May 2015, this share reached more than half of the market sales (53.9%). A steep increase in the sales of low wattage products can be observed since September 2014 when the labelling was implemented (Figure 89). While in September 2014 low wattage sales accounted for 34.4% of the market, their share was 80.8% already in May 2015. These two figures prove that the market has been largely renewed with the implementation of the energy label and the eco-design regulations.

[89] Over 60% of the market sales in 2014 accounting their subcategories, i.e. cylinder bagged and bag-less types.

**Figure 88: Market distribution of vacuum cleaners sold by wattage in the EU (25 countries)[90], January 2012 – May 2015. Source: GfK Retail and Technology Panel [33]**

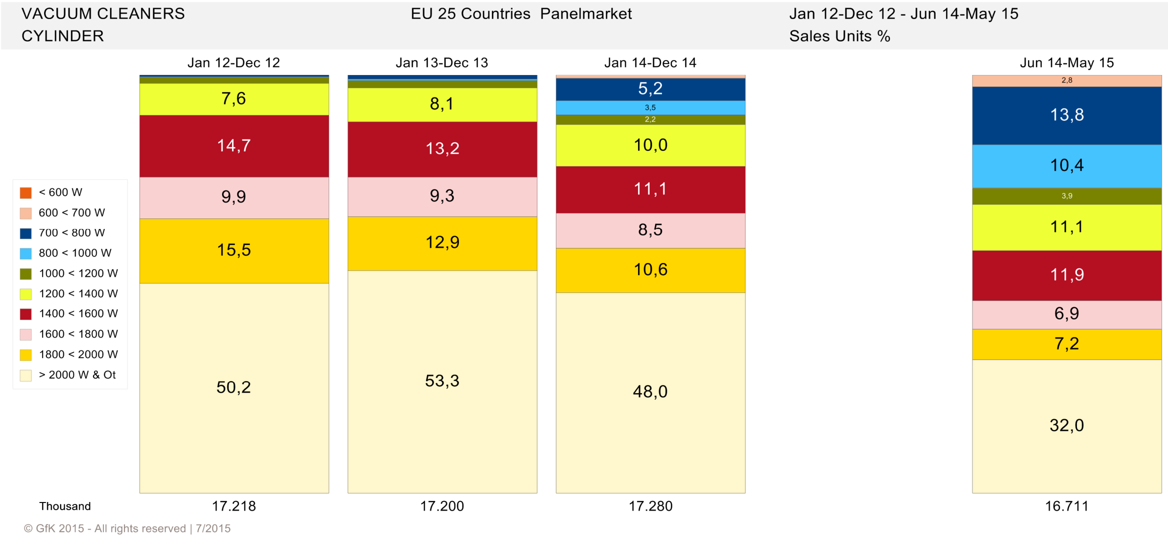



**Figure 89: Monthly market distribution of sold vacuum cleaners by wattage in the EU-25, July 2013 – May 2015. Source: GfK Retail and Technology Panel [33]**

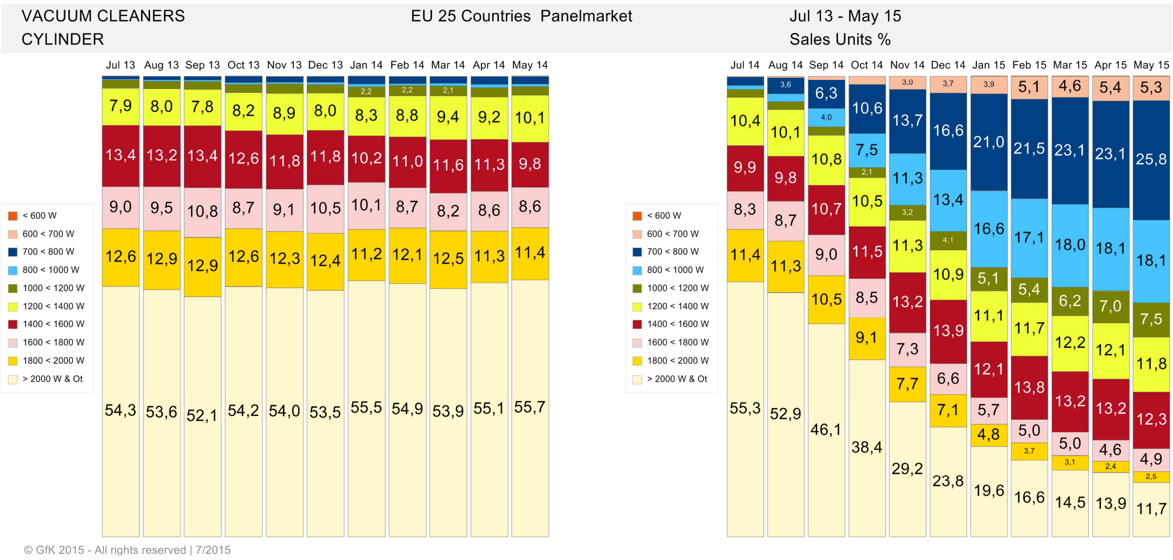



Figure 90 shows that the energy efficiency class A was already the first class of the market, accounting for 39% of sales volume in the 25 analysed European Union countries between June 2014 and May 2015. Concerning introduced classification schemes related to other performance parameters, e.g. dust re-emission, 30% of the sold vacuum machines were labelled as class A within the dust re-emission classification scheme in the period June 2014-May 2015 as illustrated in Figure 91[91].

[90] AT, BE, CZ, DK, DE, EE, ES, FI, FR, GB, GR, HR, HU, IE, IT, NL, LT, LU, LV, PL, PT, RO, SE, SI, SK.

[91] The presence of so many products under the class A immediately after energy label and eco-design regulations implementation is not necessarily caused by the implementation of these regulations.

**Figure 90: Market Distribution of vacuum cleaners sold by efficiency class, June 2014 - May 2015. Source: GfK Retail and Technology Panel**

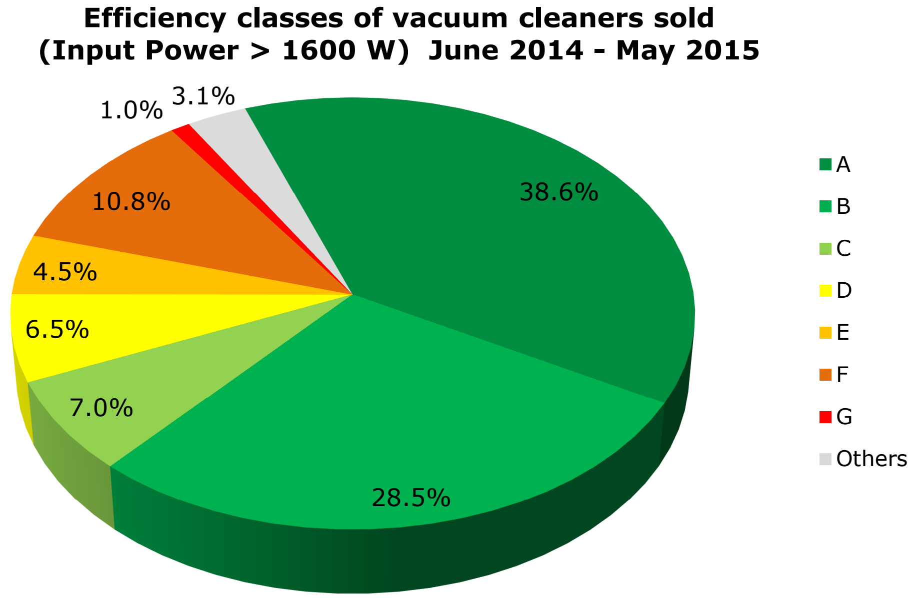
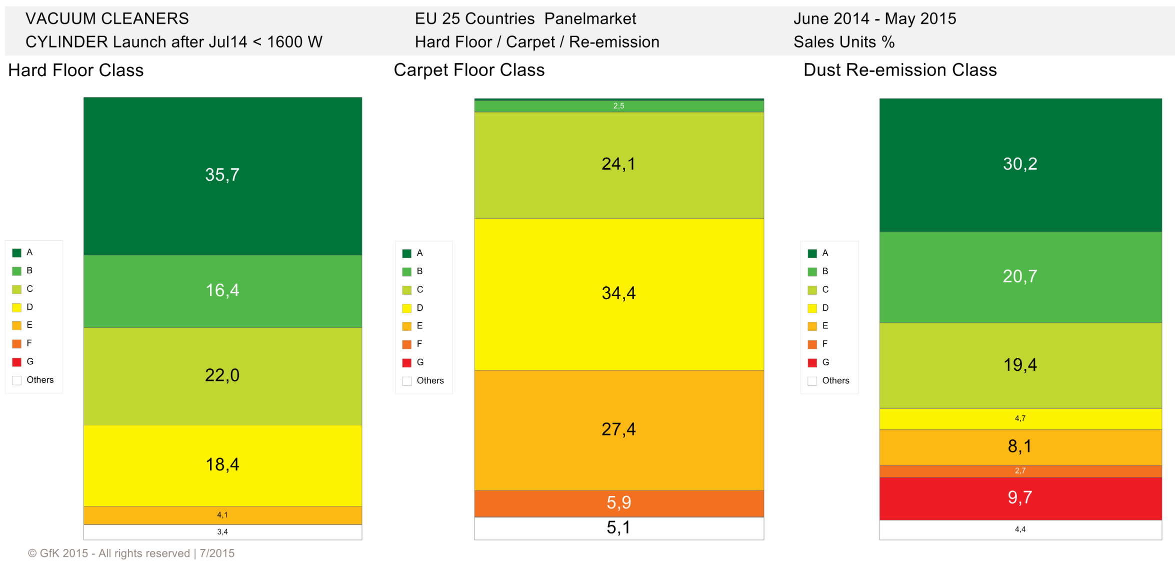



**Figure 91: Market distribution of vacuum cleaners sold by Hard Floor, Carpet Floor and Dust Re-emission classes. Source: GfK Retail and Technology Panel [33]**




The impact assessment of the eco-design Directive[92] indicates that the average power level of vacuum cleaners rose from 1275 Watts in 1990 up to 1500 Watts in 2005 and could have reached 2300 W in 2020 without the implementation of the related energy label and eco-design requirements. Similarly, the impact assessment shows that the average annual electricity consumption of one vacuum cleaner, used one hour per week, amounted to 60 kWh/year in 1990 and could have reached 120 kWh/year in 2020. Vacuum cleaners market assessments show that for period June 2014-May 2015 the

[92] The impact assessment document can be found in the following link: http://ec.europa.eu/smart-regulation/impact/ia_carried_out/docs/ia_2013/swd_2013_0240_en.pdf

average maximum power level was 917 Watts and the average annual electricity consumption was 34.5 kWh/year [33].

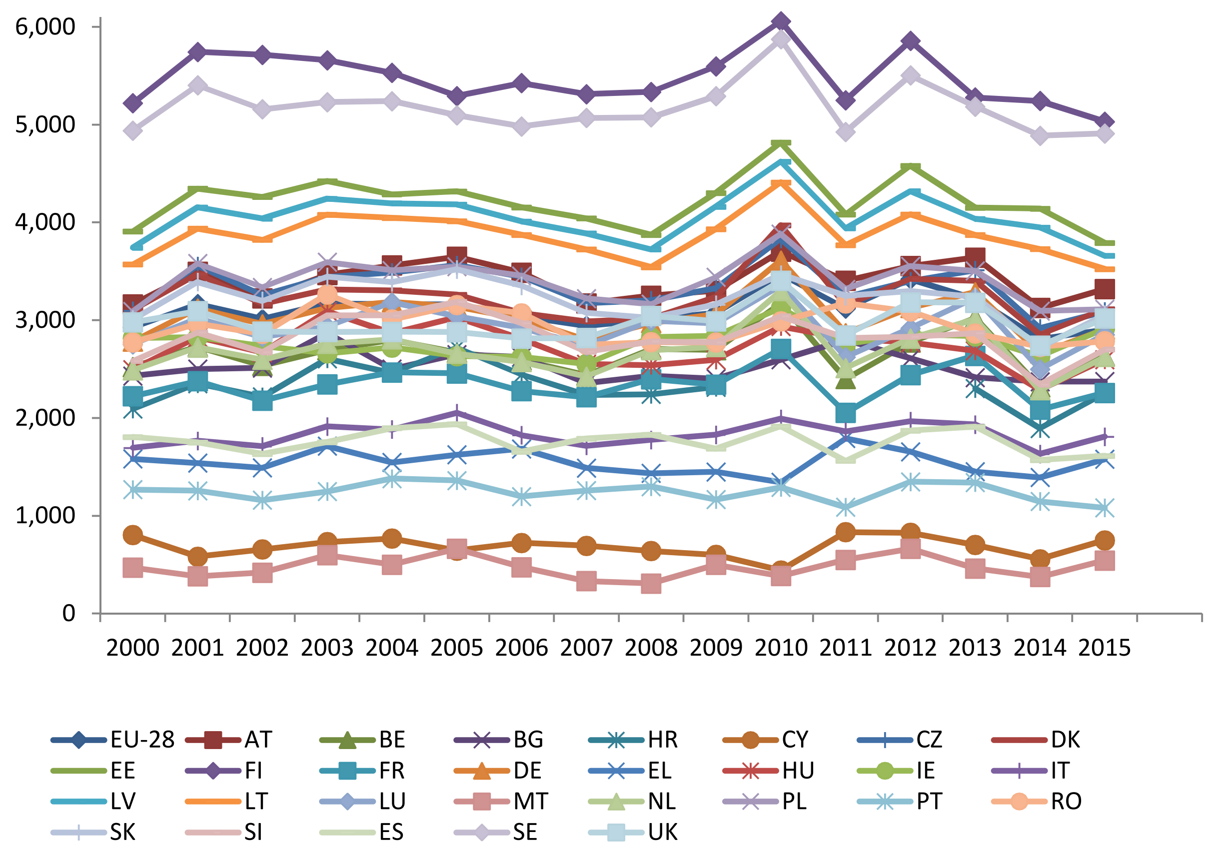
A review of the adopted measures is planned for 2018, when new studies to evaluate the implementation of new energy efficiency improvement measures will be finalised. With more efficient vacuum cleaners under the EU energy labelling and eco-design requirements, Europe can also save up to 20 TWh of electricity per year by 2020; It also means over 6 million tonnes of $CO_2$ are avoided [31].

### 4.5.3 Heating and cooling appliances

This chapter covers the energy efficiency status of heating and cooling appliances. The energy efficiency status of energy-related products such as space heating systems and boilers, residential room air conditioners and electric water heaters is introduced hereunder.

Space heating consumes most of the electricity used by consumers in the residential sector, this consumption being generated by electric boilers, heat pumps, radiators and other electric heating appliances. The market for cooling (air-conditioning) is instead turning from a small to a medium size market and keeps growing in the EU [2]. Energy consumption for heating and cooling appliances strongly depends on climatic and weather conditions which can be monitored via heating degree days as illustrated below.[93]

**Figure 92: Actual heating degree days in the EU-28 Member States[94]. Source: Eurostat**




[93] This dependence is smaller for highly isolated buildings.

[94] Data concerning degree days in Croatia in 2010, 2011 and 2012 are not available in Eurostat and are hence not reported in the graph.

#### 4.5.3.1 Space heating

Space heating represents the largest electricity consumer in the residential sector. Its electricity consumption was estimated to be around 150 TWh/year in 2007 [16], and was generated by electrical heating systems (e.g. electric boilers and radiators) and ancillary electrical equipment used by heating appliances fuelled by e.g. gas or oil. When including gas boilers, the annual energy consumption related to space heaters and combination heaters was estimated to achieve 12,089 PJ (about 289 Mtoe of final energy consumption) in the Union in 2005, corresponding to 698 Mt $CO_2$ emissions. Unless specific measures would have been taken, their annual energy consumption was expected to achieve 10,688 PJ in 2020 [34].

Due to the strong competition between electric-fuelled, gas-fuelled boilers and heat pumps and due to the fact that water boilers and space heating equipment are becoming more efficient over the years, the energy efficiency of space heating has been increased. However, there are other factors that contribute to increase its total consumption. During the last years, households have for example become smaller (less persons per household) and at the same time the average size of dwelling as measured in square meter per person has increased.

In 2013, eco-design requirements for space and combination heaters were introduced by the Commission Regulation (EU) No 813/2013. This regulation covers boiler space heaters, cogeneration space heaters, heat pump space heaters providing heat to water-based central heating systems for space heating purposes, boiler combination heaters and heat pump combination heaters providing heat to water-based central heating systems for space heating purposes and heat to deliver hot drinking and sanitary water. These heaters are designed to use gaseous or liquid fuels, including from biomass, electricity and ambient or waste heat[95].

The eco-design Regulation applies to space heaters and combination heaters with a rated heat output ≤ 400 kW, including those integrated in packages of space heater, temperature control and solar device or packages of combination heater, temperature control and solar device. Its requirements relate to seasonal space heating energy efficiency, water heating energy efficiency, sound power level and emissions of nitrogen oxides. These are gradually introduced in 3 tiers which respectively starting from September 26th of the years 2015, 2016 and 2018 as shown in the following tables:

[95] Commission Regulation (EU) No 813/2013 applies to all space and combination heaters, not to residential heaters only.

**Table 19: Eco-design requirements for seasonal space heating energy efficiency in space and combination heaters from 26 September 2015. Source: EC**

| |
|---|
| **Fuel boiler space heaters with rated heat output ≤ 70 kW and fuel boiler combination heaters with rated heat output ≤ 70 kW, with the exception of type B1[96] boilers with rated heat output ≤ 10 kW and type B1 combination boilers with rated heat output ≤ 30 kW:** |
| The seasonal space heating energy efficiency shall not fall below 86 %. |
| **Type B1 boilers with rated heat output ≤ 10 kW and type B1 combination boilers with rated heat output ≤ 30 kW:** |
| The seasonal space heating energy efficiency shall not fall below 75 %. |
| **Fuel boiler space heaters with rated heat output > 70 kW and ≤ 400 kW and fuel boiler combination heaters with rated heat output > 70 kW and ≤ 400 kW:** |
| The useful efficiency at 100 % of the rated heat output shall not fall below 86 %, and the useful efficiency at 30 % of the rated heat output shall not fall below 94 %. |
| **Electric boiler space heaters and electric boiler combination heaters:** |
| The seasonal space heating energy efficiency shall not fall below 30 %. |
| **Cogeneration space heaters:** |
| The seasonal space heating energy efficiency shall not fall below 86 %. |
| **Heat pump space heaters and heat pump combination heaters, with the exception of low-temperature heat pumps:** |
| The seasonal space heating energy efficiency shall not fall below 100 %. |
| **Low-temperature heat pumps:** |
| The seasonal space heating energy efficiency shall not fall below 115 %. |

**Table 20: Eco-design requirements for seasonal space heating energy efficiency in space and combination heaters from 26 September 2017. Source: EC**

| |
|---|
| **Electric boiler space heaters and electric boiler combination heaters:** |
| The seasonal space heating energy efficiency shall not fall below 36 %. |
| **Cogeneration space heaters:** |
| The seasonal space heating energy efficiency shall not fall below 100 %. |
| **Heat pump space heaters and heat pump combination heaters, with the exception of low-temperature heat pumps:** |
| The seasonal space heating energy efficiency shall not fall below 110 %. |
| **Low-temperature heat pumps:** |
| The seasonal space heating energy efficiency shall not fall below 125 %. |

[96] 'type B1 boiler' means a fuel boiler space heater incorporating a draught diverter, intended to be connected to a natural draught flue that evacuates the residues of combustion to the outside of the room containing the fuel boiler space heater, and drawing the combustion air directly from the room.

**Table 21: Eco-design requirements for water heating energy efficiency in combination heaters. Source: EC**

From 26 September 2015 the values shall not fall below the following values:[97]

| Declared load profile | 3XS | XXS | XS | S | M | L | XL | XXL | 3XL | 4XL |
|---|---|---|---|---|---|---|---|---|---|---|
| Water heating energy efficiency | 22% | 23% | 26% | 26% | 30% | 30% | 30% | 32% | 32% | 32% |

From 26 September 2017 the values shall not fall below the following values:

| Declared load profile | 3XS | XXS | XS | S | M | L | XL | XXL | 3XL | 4XL |
|---|---|---|---|---|---|---|---|---|---|---|
| Water heating energy efficiency | 32% | 32% | 32% | 32% | 36% | 37% | 38% | 60% | 64% | 64% |

All parameters' definitions can be found in the Annex 1 of the Regulation.

Energy labelling requirements for space and combination heaters were introduced in 2013 by the Commission Regulation No 811/2013. The Regulation introduces a new labelling scale from A +++ to G for the space heating function of boiler space heaters, cogeneration space heaters, heat pump space heaters, boiler combination heaters and heat pump combination heaters. While classes from A to G cover the various types of conventional boilers when not combined with cogeneration or renewable energy technologies, classes A + and A ++ are supposed to promote the use of cogeneration and renewable energy sources. The regulation also sets out that further classes A +++ and A + should be added after four years (i.e. September 2019) to the seasonal space heating and water heating classes, respectively, to accelerate the market penetration of high-efficiency space heaters and combination heaters using renewable energy sources.

The labelling requirements apply to space heaters and combination heaters with a rated heat output ≤ 70 kW, packages of space heater ≤ 70 kW, temperature control and solar device and packages of combination heater ≤ 70 kW, temperature control and solar device.

The energy efficiency classes for heat pumps are ranked according to the seasonal coefficient of performance (SCOP)[98]. The threshold values for the different energy labels are shown in the following tables [35].

[97] The water heating load profiles of combination heaters are specified in Annex III, Table 7 of the related Regulation and take into account the useful energy content, the useful water flow rate and the useful water temperature. The load profiles, 3XS to 4XL are ordered according to the reference energy (defined as the sum of the useful energy content of water draw-offs, expressed in kWh, in a particular load profile).

[98] Also known as seasonal primary energy ratio, means the overall coefficient of performance of a heat pump space heater or heat pump combination heater using electricity or the overall primary energy ratio of a heat pump space heater or heat pump combination heater using fuels, representative of the designated heating season, calculated as the reference annual heating demand divided by the annual energy consumption.

**Table 22: Seasonal space heating energy efficiency classes of heaters, with the exception of low-temperature heat pumps and heat pump space heaters for low-temperature application. Source: EC**

| A+++ | A++ | A+ | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|---|
| $\eta_s \geq 150$ | $125 \leq \eta_s < 150$ | $98 \leq \eta_s < 125$ | $90 \leq \eta_s < 98$ | $82 \leq \eta_s < 90$ | $75 \leq \eta_s < 82$ | $36 \leq \eta_s < 75$ | $34 \leq \eta_s < 36$ | $30 \leq \eta_s < 34$ | $\eta_s < 30$ |

**Table 23: Seasonal space heating energy efficiency classes of low-temperature heat pumps and heat pump space heaters for low-temperature application. Source: EC**

| A+++ | A++ | A+ | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|---|---|
| $\eta_s \geq 175$ | $150 \leq \eta_s < 175$ | $123 \leq \eta_s < 150$ | $115 \leq \eta_s < 123$ | $107 \leq \eta_s < 115$ | $100 \leq \eta_s < 107$ | $61 \leq \eta_s < 100$ | $59 \leq \eta_s < 61$ | $55 \leq \eta_s < 59$ | $\eta_s < 55$ |

The combined effect of the eco-design and labelling requirements is expected to result by 2020 in estimated annual final energy savings of about 1,900 PJ (about 45 Mtoe), corresponding to around 110 Mt $CO_2$ emissions, and a reduction in annual nitrogen oxides emissions of about 270 kt $SO_x$ equivalent, compared to what would happen if no measures were taken [35].

#### 4.5.3.2 Residential air conditioners

The European market for air-conditioning systems is still growing substantially. The stock is far from reaching saturation levels [16]. The European residential air conditioners are mostly based on a vapour compression cycle and are driven by grid electricity [36].

Residential room air conditioners electricity consumption was estimated to be around 30 TWh/year in the EU in 2005. Unless specific measures would have been taken, annual energy consumption was expected in 2005 to achieve 74 TWh in 2020. The preparatory study also identified possible refrigerant leakage as a significant environmental aspect to take into account due to associated direct greenhouse gas emissions, representing on average 10-20 % of the combined direct and indirect greenhouse gas emissions [37].

In 2012, eco-design requirements for residential room air conditioners were introduce by the Commission Regulation (EU) No 206/2012. It addresses electric mains-operated air conditioners with a rated capacity of ≤ 12 kW for cooling, or heating if the product has no cooling function, and comfort fans with an electric fan power input ≤ 125W[99].

The requirements refer to energy consumption in use phase and sound power level. Energy efficiency requirements are established according to the rated Energy Efficiency Ratio (EER), representing the declared capacity for cooling divided by the rated power input for cooling and the Coefficient of Performance (COP) representing the declared capacity for hearing divided by the rated power input for heating. Specific minimum energy efficiency requirements are set for double duct AC and single duct AC. These requirements are gradually introduced in 2 tiers which set the minimum values of the

[99] The Regulation No 206/2012 covers all kind of air conditioners under that definition, not residential air conditioners only.

declared efficiencies starting from 1 January of the years 2013 and 2014. The requirements are established as follows:

**Table 24: Eco-design requirements for minimum energy efficiency for residential air conditioning systems from 1 January 2013. Source: EC**

For single and double duct air conditioners:

| | Double duct air conditioners | | Single duct air conditioners | |
|---|---|---|---|---|
| | $EER_{rated}$ | $COP_{rated}$ | $EER_{rated}$ | $COP_{rated}$ |
| If GWP of refrigeration > 150 | 2.40 | 2.36 | 2.40 | 1.80 |
| If GWP of refrigeration ≤ 150 | 2.16 | 2.12 | 2.16 | 1.62 |

For air conditioners except single and double duct air conditioners:[100]

| | SEER | SCOP (average heating season) |
|---|---|---|
| If GWP of refrigeration > 150 | 3.60 | 3.40 |
| If GWP of refrigeration ≤ 150 | 3.24 | 3.06 |

**Table 25: Eco-design requirements for minimum energy efficiency for residential air conditioning systems from 1 January 2014. Source: EC**

| | Air conditioners, expect double and single duct air conditioners | | Double duct air conditioners | | Single duct air conditioners | |
|---|---|---|---|---|---|---|
| | SEER | SCOP (average heating season) | $EER_{rated}$ | $COP_{rated}$ | $EER_{rated}$ | $COP_{rated}$ |
| If GWP of refrigeration > 150 for < 6 kW | 4.60 | 3.80 | 2.60 | 2.60 | 2.60 | 2.04 |
| If GWP of refrigeration ≤ 150 for < 6 kW | 4.14 | 3.42 | 2.34 | 2.34 | 2.34 | 1.84 |
| If GWP of refrigeration > 150 for 6-12 kW | 4.30 | 3.80 | 2.60 | 2.60 | 2.60 | 2.04 |
| If GWP of refrigeration ≤ 150 for 6-12 kW | 3.87 | 3.42 | 2.34 | 2.34 | 2.34 | 1.84 |

Air conditioning systems are also under energy labelling requirements which were introduced in 2011 by the Commission Regulation No 626/2011. The energy labelling Regulation addresses to air-to-air air-conditioners up to 12 kW of cooling power output (or heating power output, if only heating function is provided). The Regulation introduces two energy efficiency scales based on the primary function and on specific aspects important to consumer. The efficiency testing is applied to a seasonal efficiency measurement method as the air conditioners are used mainly in part-load conditions. The range of energy efficiency classes displayed is established from A to G energy efficiency class scale with a '+' added on the top of the scale every two years starting

[100] This category refers to air conditioners covered by the relevant Regulation with different typology than single and double duct units.

from 1 January 2013 until the A+++ class is reached. For single and double duct air conditioners a range from an A+++ to D scale is established.

The combined effect of energy labelling set out in this Regulation and of Regulation implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to eco-design requirements for air conditioners is expected to result in annual electricity savings of 11 TWh by 2020, compared to the situation if no measures are taken [38].

The following tables show the energy efficiency classes as defined in the relevant regulation:

**Table 26: Energy efficiency classes for energy labelling requirements of air conditioners except single and double duct systems. Source: EC**

| Energy Efficiency Class | SEER | SCOP |
|---|---|---|
| **A+++** | SEER ≥ 8.50 | SCOP ≥ 5.10 |
| **A++** | 6.10 ≤ SEER < 8.50 | 4.60 ≤ SCOP < 5.10 |
| **A+** | 5.60 ≤ SEER < 6.10 | 4.00 ≤ SCOP < 4.60 |
| **A** | 5.10 ≤ SEER < 5.60 | 3.40 ≤ SCOP < 4.00 |
| **B** | 4.60 ≤ SEER < 5.10 | 3.10 ≤ SCOP < 3.40 |
| **C** | 4.10 ≤ SEER < 4.60 | 2.80 ≤ SCOP < 3.10 |
| **D** | 3.60 ≤ SEER < 4.10 | 2.50 ≤ SCOP < 2.80 |
| **E** | 3.10 ≤ SEER < 3.60 | 2.20 ≤ SCOP < 2.50 |
| **F** | 2.60 ≤ SEER < 3.10 | 1.90 ≤ SCOP < 2.20 |
| **G** | SEER < 2.60 | SCOP < 1.90 |

**Table 27: Energy efficiency classes for energy labelling requirements of single and double duct air conditioning systems. Source: EC**

| Energy Efficiency Class | Double ducts | | Single ducts | |
|---|---|---|---|---|
| | **EERrated** | **COPrated** | **EERrated** | **COPrated** |
| **A+++** | ≥ 4.10 | ≥ 4.60 | ≥ 4.10 | ≥ 3.60 |
| **A++** | 3.60 ≤ EER < 4.10 | 4.10 ≤ COP < 4.60 | 3.60 ≤ EER < 4.10 | 3.10 ≤ COP < 3.60 |
| **A+** | 3.10 ≤ EER < 3.60 | 3.60 ≤ COP < 4.10 | 3.10 ≤ EER < 3.60 | 2.60 ≤ COP < 3.10 |
| **A** | 2.60 ≤ EER < 3.10 | 3.10 ≤ COP < 3.60 | 2.60 ≤ EER < 3.10 | 2.30 ≤ COP < 2.60 |
| **B** | 2.40 ≤ EER < 2.60 | 2.60 ≤ COP < 3.10 | 2.40 ≤ EER < 2.60 | 2.00 ≤ COP < 2.30 |
| **C** | 2.10 ≤ EER < 2.40 | 2.40 ≤ COP < 2.60 | 2.10 ≤ EER < 2.40 | 1.80 ≤ COP < 2.00 |
| **D** | 1.80 ≤ EER < 2.10 | 2.00 ≤ COP < 2.40 | 1.80 ≤ EER < 2.10 | 1.60 ≤ COP < 1.80 |
| **E** | 1.60 ≤ EER < 1.80 | 1.80 ≤ COP < 2.00 | 1.60 ≤ EER < 1.80 | 1.40 ≤ COP < 1.60 |
| **F** | 1.40 ≤ EER < 1.60 | 1.60 ≤ COP < 1.80 | 1.40 ≤ EER < 1.60 | 1.20 ≤ COP < 1.40 |
| **G** | < 1.40 | < 1.60 | < 1.40 | < 1.20 |

#### 4.5.3.3 Water heaters

A water heater is defined as a product connected to an external supply of drinking water to generate heat and take this water to desired temperature levels. The hot water is typically used for cooking, cleaning, and bathing.

Electric water heaters consumed 73 TWh corresponding to 8.7% of the total electricity consumption of the EU-27 in 2009. The JRC estimates show that in 2007 the installed stock of electric water heaters in the EU-27 was around 119 million units (out of a total of 267 million units of domestic water heaters) out of which 29 million units were electric instantaneous and 90 million of units were electric water heaters with storage. In the same year, around 2 million solar water heater units were installed [16].

The preparatory study on eco-design of water heaters[101] estimated that the average efficiency[102] of the water heater stock was 34% in 2005. According to different proposed scenarios, the stock in efficiency in 2020 will remain the same be improved to 36% to 82% depending on the implementation of eco-design measures [34].

The energy consumption of water heaters and hot water storage tanks can be reduced by applying existing cost- effective non-proprietary technologies which lead to a reduction in the combined costs of purchasing and operating these products [39].

Annual final energy consumption related to water heaters and hot water storage tanks was estimated to have been 2,156 PJ (51 Mtoe) in the EU in 2005, corresponding to 124 Mt $CO_2$ emissions. Unless specific measures would have been taken, the annual energy consumption was expected to be 2,243 PJ in 2020 [40].

Europe has implemented the most stringent standards regarding eco-design and energy labelling requirements for water heaters and water storage tanks in the recent years, leading by example over other economies such as India, China and US [41].

In 2013, eco-design requirements for water heaters and hot water storage tanks were introduced by the Commission Regulation (EU) No 814/2013. It addresses water heaters with a rated heat output ≤ 400 kW and hot water storage tanks with a storage volume ≤ 2,000 litres, including those integrated in packages of water heater and solar device.

The requirements refer to energy consumption in use phase and (for heat pump water heaters) sound power level. In addition, for water heaters using fossil fuels, emissions of nitrogen oxides, carbon monoxide and hydrocarbons are also covered. Energy consumption standing losses are also addressed as they are a significant environmental aspect of hot water storage tanks. These requirements are gradually introduced in 3 tiers which set the minimum values of the indicated performance (efficiency) requirements starting from 26 September of the years 2015, 2017 and 2018 as follows[103]:

First phase (from 26 September 2015):

- Minimum performance of 22% (3XS loads), 23% (XXS loads), 26% (XS and S loads), 30% (M, L and XL loads), and 32% (XXL, 3XL and 4XL load profiles).

Second phase (from 26 September 2017):

- Minimum performance of 32% (3XS, XXS, XS and S loads), 36% (M loads), 37% (L, XL, XXL and 3XL loads), and 38% (4XL load profiles).

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101 Including electric and non-electric water heaters

102 Efficiency is set as the ratio between the useful (output) power and the input power

103 The water heating energy efficiency are calculated based on load profiles specified in Annex III, Table 1 of the relevant Regulation and take into account the useful energy content, the useful water flow rate and the useful water temperature. The load profiles, 3XS to 4XL are ordered according to the reference energy (defined as the sum of the useful energy content of water draw-offs, expressed in kWh, in a particular load profile).

Third phase (from 26 September 2018):

- Minimum performance of 60% for XXL loads and 64% for 3XL and 4XL loads.

Lower minimum energy efficiency requirements are also set for the water heaters with smart controls for the first and second implementation phase in the above mentioned eco-design Regulation.

Energy labelling requirements were also introduced in 2013 by the Commission Regulation (EU) No 812/2013. It established an energy efficiency classes range from A to G for conventional water heaters, solar water heaters and heat pump water heaters and for hot water storage tanks. A dynamic class A+ is added to the classification after two years to accelerate the market penetration of the most efficient water heaters and hot water storage tanks. In addition energy labels for water heaters and hot water storage tanks, the legislation introduces the energy efficiency classes A++ and A+++ for packages of water heaters/hot water storage tanks with solar devices.

The sound power level of a water heater could be an important factor for end-users. Information on sound power levels is therefore included on the labels of water heaters.

**Figure 93: Water heating energy efficiency classes introduced by Regulation (EU) No 812/2013. Source: EC[104]**

**Water heating energy efficiency classes of water heaters, categorised by declared load profiles, $\eta_{wh}$ in %**

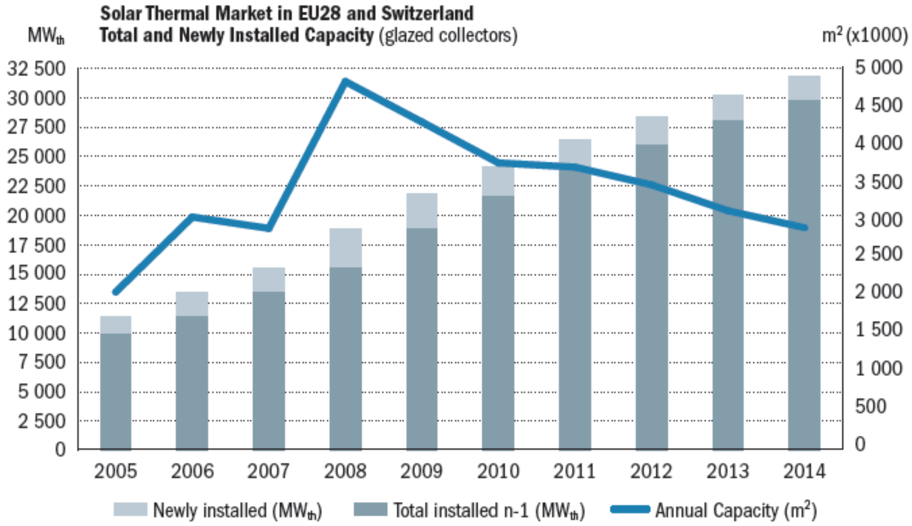
| | 3XS | XXS | XS | S | M | L | XL | XXL |
|---|---|---|---|---|---|---|---|---|
| A+++ | $\eta_{wh} \geq 62$ | $\eta_{wh} \geq 62$ | $\eta_{wh} \geq 69$ | $\eta_{wh} \geq 90$ | $\eta_{wh} \geq 163$ | $\eta_{wh} \geq 188$ | $\eta_{wh} \geq 200$ | $\eta_{wh} \geq 213$ |
| A++ | $53 \leq \eta_{wh} < 62$ | $53 \leq \eta_{wh} < 62$ | $61 \leq \eta_{wh} < 69$ | $72 \leq \eta_{wh} < 90$ | $130 \leq \eta_{wh} < 163$ | $150 \leq \eta_{wh} < 188$ | $160 \leq \eta_{wh} < 200$ | $170 \leq \eta_{wh} < 213$ |
| A+ | $44 \leq \eta_{wh} < 53$ | $44 \leq \eta_{wh} < 53$ | $53 \leq \eta_{wh} < 61$ | $55 \leq \eta_{wh} < 72$ | $100 \leq \eta_{wh} < 130$ | $115 \leq \eta_{wh} < 150$ | $123 \leq \eta_{wh} < 160$ | $131 \leq \eta_{wh} < 170$ |
| A | $35 \leq \eta_{wh} < 44$ | $35 \leq \eta_{wh} < 44$ | $38 \leq \eta_{wh} < 53$ | $38 \leq \eta_{wh} < 55$ | $65 \leq \eta_{wh} < 100$ | $75 \leq \eta_{wh} < 115$ | $80 \leq \eta_{wh} < 123$ | $85 \leq \eta_{wh} < 131$ |
| B | $32 \leq \eta_{wh} < 35$ | $32 \leq \eta_{wh} < 35$ | $35 \leq \eta_{wh} < 38$ | $35 \leq \eta_{wh} < 38$ | $39 \leq \eta_{wh} < 65$ | $50 \leq \eta_{wh} < 75$ | $55 \leq \eta_{wh} < 80$ | $60 \leq \eta_{wh} < 85$ |
| C | $29 \leq \eta_{wh} < 32$ | $29 \leq \eta_{wh} < 32$ | $32 \leq \eta_{wh} < 35$ | $32 \leq \eta_{wh} < 35$ | $36 \leq \eta_{wh} < 39$ | $37 \leq \eta_{wh} < 50$ | $38 \leq \eta_{wh} < 55$ | $40 \leq \eta_{wh} < 60$ |
| D | $26 \leq \eta_{wh} < 29$ | $26 \leq \eta_{wh} < 29$ | $29 \leq \eta_{wh} < 32$ | $29 \leq \eta_{wh} < 32$ | $33 \leq \eta_{wh} < 36$ | $34 \leq \eta_{wh} < 37$ | $35 \leq \eta_{wh} < 38$ | $36 \leq \eta_{wh} < 40$ |
| E | $22 \leq \eta_{wh} < 26$ | $23 \leq \eta_{wh} < 26$ | $26 \leq \eta_{wh} < 29$ | $26 \leq \eta_{wh} < 29$ | $30 \leq \eta_{wh} < 33$ | $30 \leq \eta_{wh} < 34$ | $30 \leq \eta_{wh} < 35$ | $32 \leq \eta_{wh} < 36$ |
| F | $19 \leq \eta_{wh} < 22$ | $20 \leq \eta_{wh} < 23$ | $23 \leq \eta_{wh} < 26$ | $23 \leq \eta_{wh} < 26$ | $27 \leq \eta_{wh} < 30$ | $27 \leq \eta_{wh} < 30$ | $27 \leq \eta_{wh} < 30$ | $28 \leq \eta_{wh} < 32$ |
| G | $\eta_{wh} < 19$ | $\eta_{wh} < 20$ | $\eta_{wh} < 23$ | $\eta_{wh} < 23$ | $\eta_{wh} < 27$ | $\eta_{wh} < 27$ | $\eta_{wh} < 27$ | $\eta_{wh} < 28$ |

The combined effect of the eco-design and energy labelling requirements for water heaters, hot water storage tanks and packages of water heater and solar device is expected to result in estimated annual energy savings of about 450 PJ (11 Mtoe) by 2020, corresponding to around 26 Mt $CO_2$ emissions, and a reduction in annual nitrogen oxides emissions of some 130 kt SOx equivalent, compared to what would happen if no measures would have been taken.

Starting from recent years, the presence of solar thermal heating systems in the EU market has continuously increased. However, a reduction in the newly installed capacity was registered in 2014 (net increase by 1.6 $GW_{th}$). The thermal installed capacity registered in the year 2014 was 31,840 $MW_{th}$, which represents an increase of 5.3% compared with the total installed capacity in 2013.

104 'water heating energy efficiency' ($\eta_{wh}$) means the ratio between the useful energy provided by a water heater and the energy required for its generation, expressed in %.

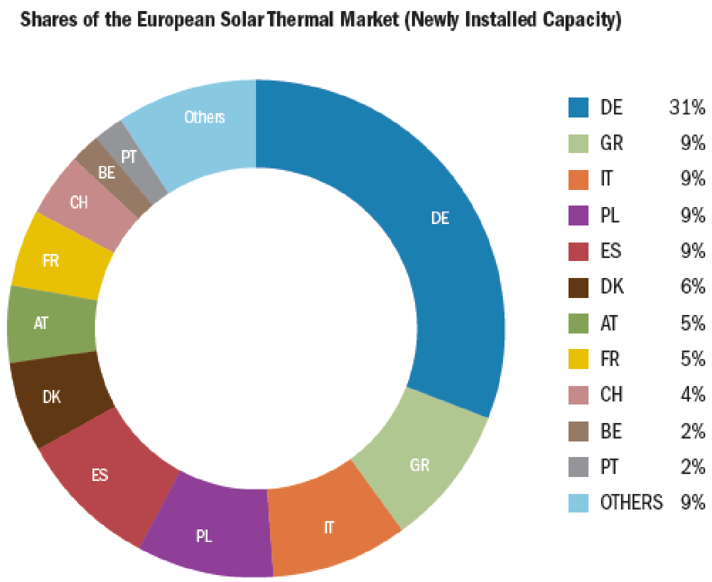
**Figure 94: Total and newly installed capacity of solar glazed collectors in the EU-28 and Switzerland, 2005-2014. Source: ESTIF [42][105]**




Despite the continuous growth in the total installed capacity, the European solar heating and cooling market continues undergoing a slowdown of sales in its main EU markets. There are several main factors behind this sluggish performance, including the low gas prices, difficult access to finance for consumers, slow-moving construction sector, less public support schemes for solar thermal and competition from other energy sources [42].

Germany was the EU-28 Member State with the highest share of newly installed capacity in 2014, accounting for more than 31%; followed by Great Britain, Italy, Poland, and Spain which accounted for 9% share each in 2014 as illustrated in Figure 95.

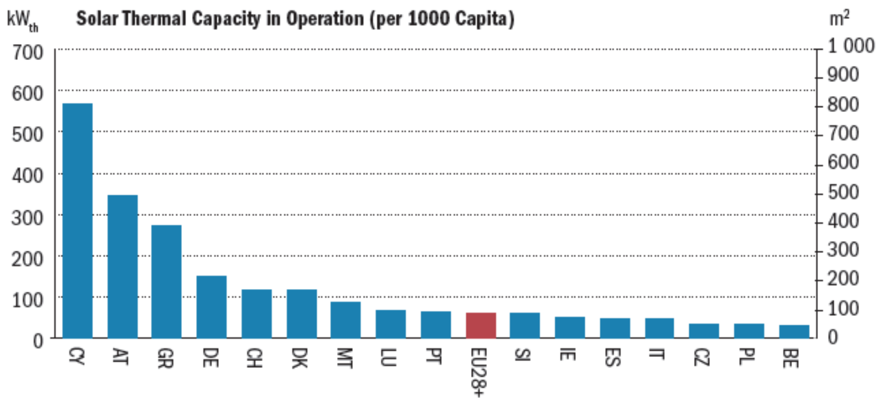
**Figure 95: Shares of the Solar Thermal Market (newly installed capacity) in the EU-28 and Switzerland, 2014. Source: ESTIF [42]**




[105] The annual capacity refers to newly installed panels only.

The solar thermal capacity in operation per each 1,000 inhabitants in 2014 is showed in the following figure. It can be observed that Cyprus was the State which registered the highest capacity per 1,000 inhabitants (567.4 $kW_{th}$). Austria (345.6 $kW_{th}$) was second, and Greece (271.2 $kW_{th}$) third. In contrast, Belgium (30.9 $kW_{th}$), Poland (31.8 $kW_{th}$) and Czech Republic (33.7 $kW_{th}$) were the countries with the lowest rates in the same year. The average EU-28[106] value registered was instead 61.4 $kW_{th}$.

**Figure 96: Solar thermal capacity in Operation per 1 000 inhabitants in the EU-28 and Switzerland, 2014. Source: ESTIF**




[106] It includes Switzerland besides the EU-28 Member States.

### 4.5.4 Lighting

Lighting represents around 10% of the residential electricity consumption, being the third main consumer after heating and cold appliances [16].

Electricity consumed for lighting purposes has reduced by 7.8% (6.55 TWh) in the EU-28 during the period from 2000 to 2013. The maximum over the analysed period took place in 2003 when the lighting consumption was estimated to be 86.74 TWh. From 2003 to 2007, lighting electricity consumption was around 86 TWh. Since 2007 a continuous reduction has been observed and lighting electricity consumption reached 77.13 TWh in 2013 (i.e. it totally decreased by 10.1% during this period).

**Figure 97: Residential average electricity consumption for lighting purposes in the EU-28, 2000-2013. Source: Odyssee**

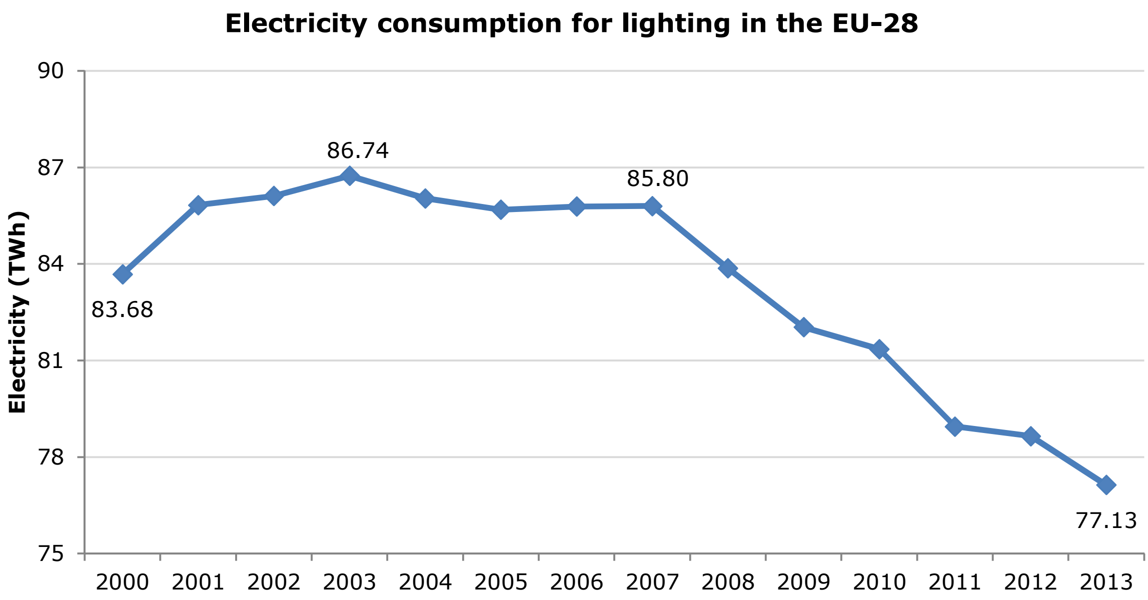
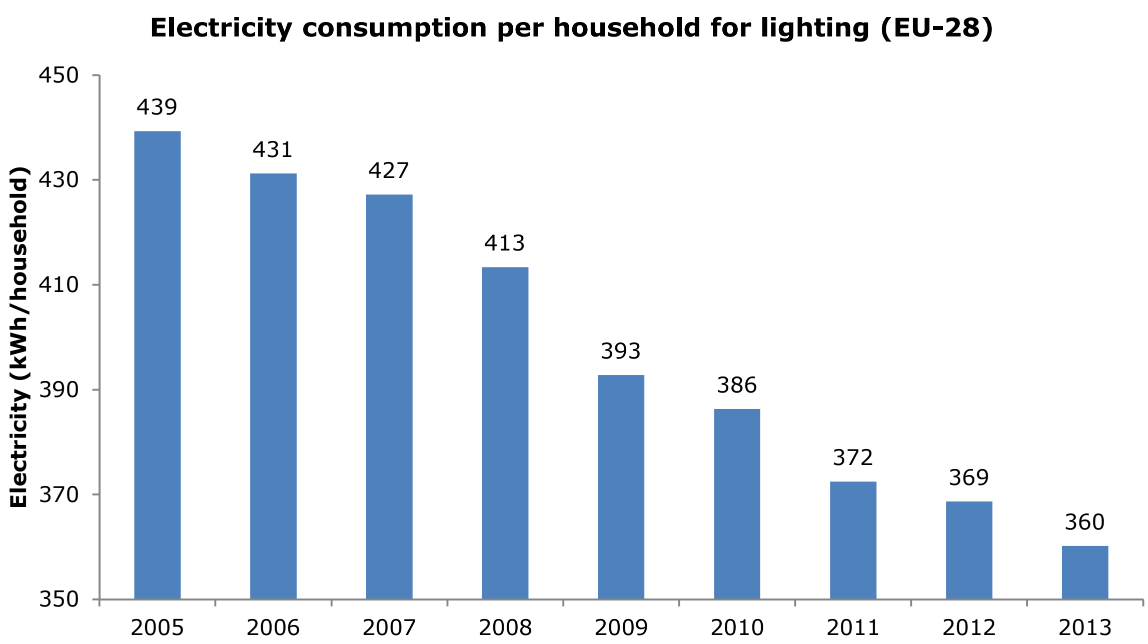



**Figure 98: Electricity consumption per households for lighting purposes in the EU-28, 2005-2013. Source: JRC from Eurostat and Odyssee data**



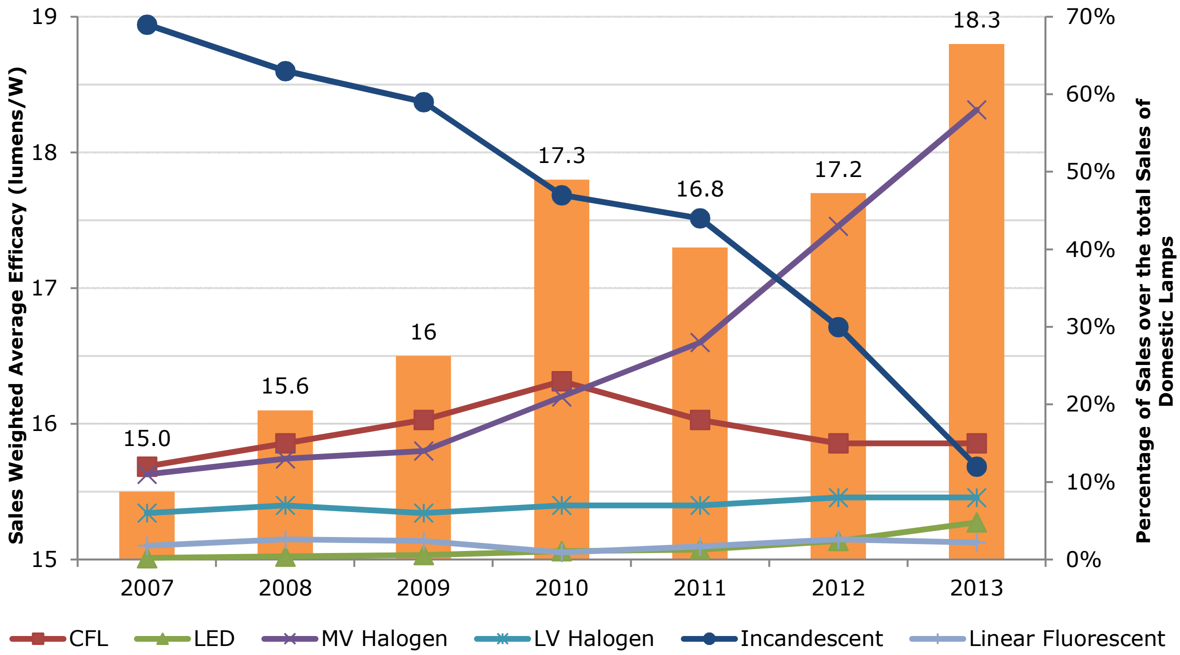
The annual electricity consumption per household for lighting purposes was estimated to be 360 kWh in the EU-28 in 2013. Since 2005, the value of this indicator has also decreased continuously registering a total decrease of 18.0% (corresponding to 79 kWh) in 2013 as illustrated in Figure 98.

Household lamp technologies include LED, incandescent lamps (GLS), halogen lamps, self-ballasted compact fluorescent lamps (CFL), and to some extent, also single and double capped fluorescent lamps without integrated ballast and high density discharge lamps [43].

Domestic lighting market sales data show that MV Halogen lamps are the most sold lighting technology. MV halogen lamps registered 58% (270.3 million units; out of which 259.4 million units were single ended type, while the rest double ended) of the totally sold domestic lamps in the EU[107] in 2013; followed by Compact Fluorescent Lamps which accounted for 15% (68.2 million units; out of which 66.6 million were self-ballasted CFLs and the rest pin based CFLs), and very closed by incandescent lamps (12%; 57 million units) in the same year (see Figure 99).

In the period 2007-2013, the sales of incandescent lamps have reduced the most (by 85.4%). This is the result of their progressive phasing out which was introduced by the Eco-design Directive 2005/32/EC. Over the analysed period, CFLs (both self-ballasted and pin based) have also reduced their sales volume by 2%. In contrast, MV halogen lamps (both single and double ended) have increased by 227.5%. LED lamps (both retrofit lamps and dedicated lamps) have instead registered an increase by 2,140% (from 1 million units sold in 2007 to 22.4 million units) during the same period.

**Figure 99: Percentage sold of domestic lamps by light source technology and sales weighted average luminous efficacy (lumens per Watt) in the EU-28[107], 2007-2013. Source: IEA - 4E Mapping & Benchmarking Project [44]**




LED lighting is the technology which is expected to further grow in the following years and the one with the brightest future perspectives [45]. LED lamps represent one of the most efficient solutions available today for improving energy efficiency in residential lighting. Its high luminous efficacy level (lm/W), mercury free content, and long lifetime are some of the most important added values of this technology in comparison to other

[107] Data reported belong to the following EU-28 MSs: AT, BE, FR, DE, UK (only Great Britain), IT, and NL.

light source technologies (e.g. LED lamps last 5-25 times longer the traditional GLS lamps) [43]. Despite their advantages of LED technology, the higher LED technology price (e.g. compared to CFLs) is however a still significant purchasing barrier in the residential sector.

Nevertheless, the average European price of the LEDs is decreasing and it is expected to keep this trend also in the future as shown by the following table:

**Table 28: Mains-Voltage LED retrofit lamp, efficacy and unitary price projections EU 2012-2025. Source: CLASP [46]**

| Year | 2012 | | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lm/W | 58 | | 93 | 99 | 105 | 112 | 118 | 125 | 130 | 134 | 138 | 142 | | 169 |
| Price (€) | 18.0 | | 10.0 | 9.0 | 8.5 | 8.0 | 7.5 | 7.0 | 6.5 | 6.0 | 5.5 | 5.0 | | 2.5 |

In 2012, an average MV LED retrofit lamp had a rated luminous efficacy of 58 lm/W and a cost of 18.0 Euro. The projections up to 2030 show how the efficacy will progressively increase and the cost will drop as a result of the maturity of the products and technology. The projection for 2030 is that the luminous efficacy will reach 169 lm/W and the cost will fall to 2.5 Euro.

Retrofit and dedicated LED sales achieved same levels in 2013 (10.8 and 10.6 million units respectively) as illustrated in the following figure. In case of linear fluorescent lamps, the T8 linear fluorescent tubes had the largest sales (81%) in domestic lighting, while 19% of the share was covered by T5 linear fluorescent tubes in 2013. In case of MV CFLs, 97.7% of total sales were made by self-ballasted CFLs and the remainder share was made by pin based CFLs. For MV halogens lamps, the single ended halogen lamps accounted for 87.3% of the sales, whilst the rest was covered by double ended halogen lamps in 2013.

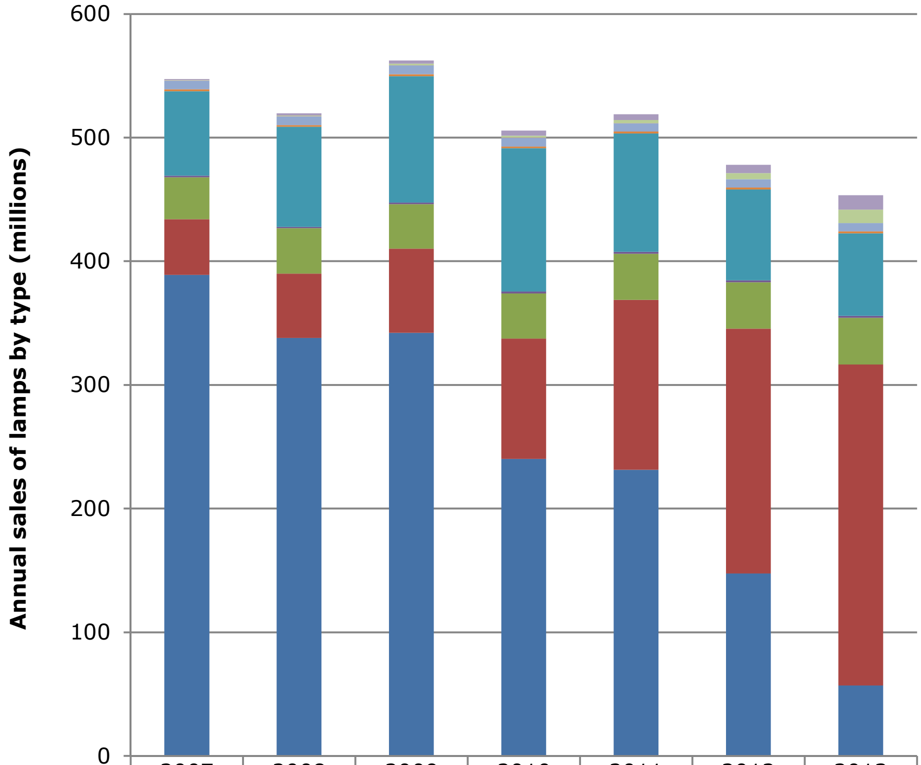
In terms of sales per power range for the year 2013, the highest sales of incandescent lamps were for incandescent lamps between 26 Watts and 40 Watts which amounted to 27.63 million units. Among halogen technology lamps, the power range 29-43 W for MV halogen single ended was ranked first and registered 132.35 million units sold; 101-150 W wattage was the most sold for MV halogen double ended (2.79 million units); and the power range 0-34 W was the most sold for halogen low voltage lamps (27.98 million units) as illustrated in Figure 101.

With regard to Compact Fluorescent Lamps, lamps between 9 and 11 Watts were the most sold lamps (19.23 million units) among self-ballasted CFLs. For pin based CFLs, lamps between 9 and 11 Watts were also the most requested one.

For linear fluorescent tubes, the most sold lamps are the lamps up to 28 Watts in case of T5 technology and their sales amounted to 1.62 million units in 2013. In case of T8 technology, linear fluorescent tubes above 31 Watts were instead the most sold.

For SSL LED, the wattage range from 2 to 4 Watts registered the highest sales regarding retrofit LED (3.999 million units sold); whilst the power ranges from 4 to 8 Watts was the top sale (4.398 million units) in the dedicated LED lamps category (see Figure 102).

**Figure 100: Annual sales of lamps by technology type in the EU, 2007-2013. Source: IEA - 4E Mapping & Benchmarking [47]**




| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|
| Dedicated LED | 0.8 | 1.7 | 2.6 | 4.2 | 4.6 | 6.7 | 11.4 |
| Retrofit LED | 0.2 | 0.5 | 1.1 | 1.7 | 2.5 | 5 | 11 |
| MV Linear FL (T12) | 0.4 | 0.2 | 0.1 | 0.1 | 0.1 | 0 | 0 |
| MV Linear FL (T8) | 7 | 7.1 | 7.2 | 7 | 6.6 | 6.6 | 6.8 |
| MV Linear FL (T5) | 1.4 | 1.4 | 1.5 | 1.4 | 1.5 | 1.5 | 1.6 |
| MV Self-Ballasted CFLs | 68.5 | 80.8 | 102.3 | 116 | 96 | 73.6 | 66.6 |
| MV Pin Based CFLs | 1.1 | 1.2 | 1.4 | 1.3 | 1.4 | 1.5 | 1.6 |
| MV Halogens (double ended) | 34.1 | 36.6 | 35.8 | 36.7 | 37.4 | 37.7 | 37.9 |
| MV Halogens (single ended) | 44.9 | 52.2 | 68.2 | 97.3 | 137.4 | 198 | 259.4 |
| MV Incandescents (GSL) | 389 | 337.9 | 342.1 | 240.1 | 231.3 | 147.4 | 57 |

**Figure 101: Sold lamps in million units (incandescent and halogen technology) by power range in the EU, 2013. Source: IEA - 4E Mapping & Benchmarking [47]**

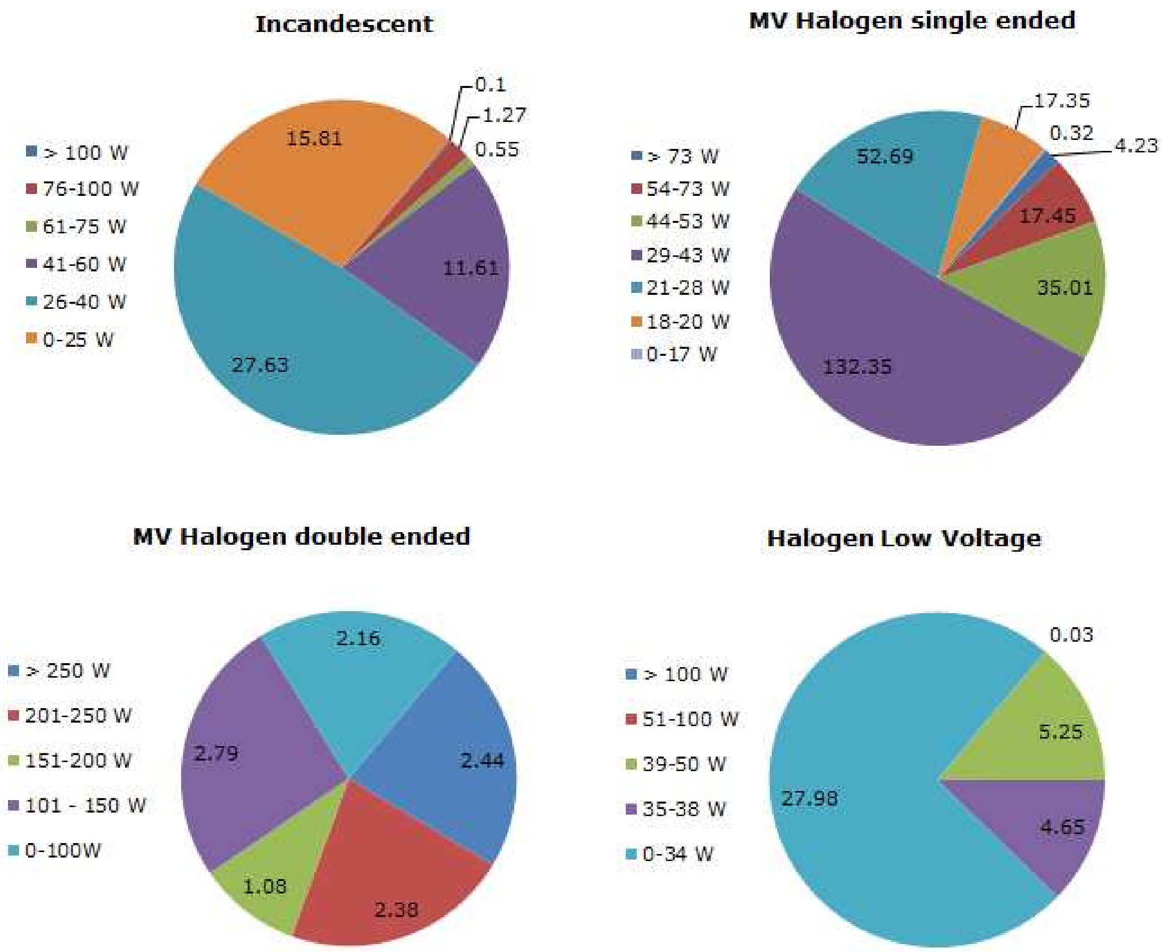
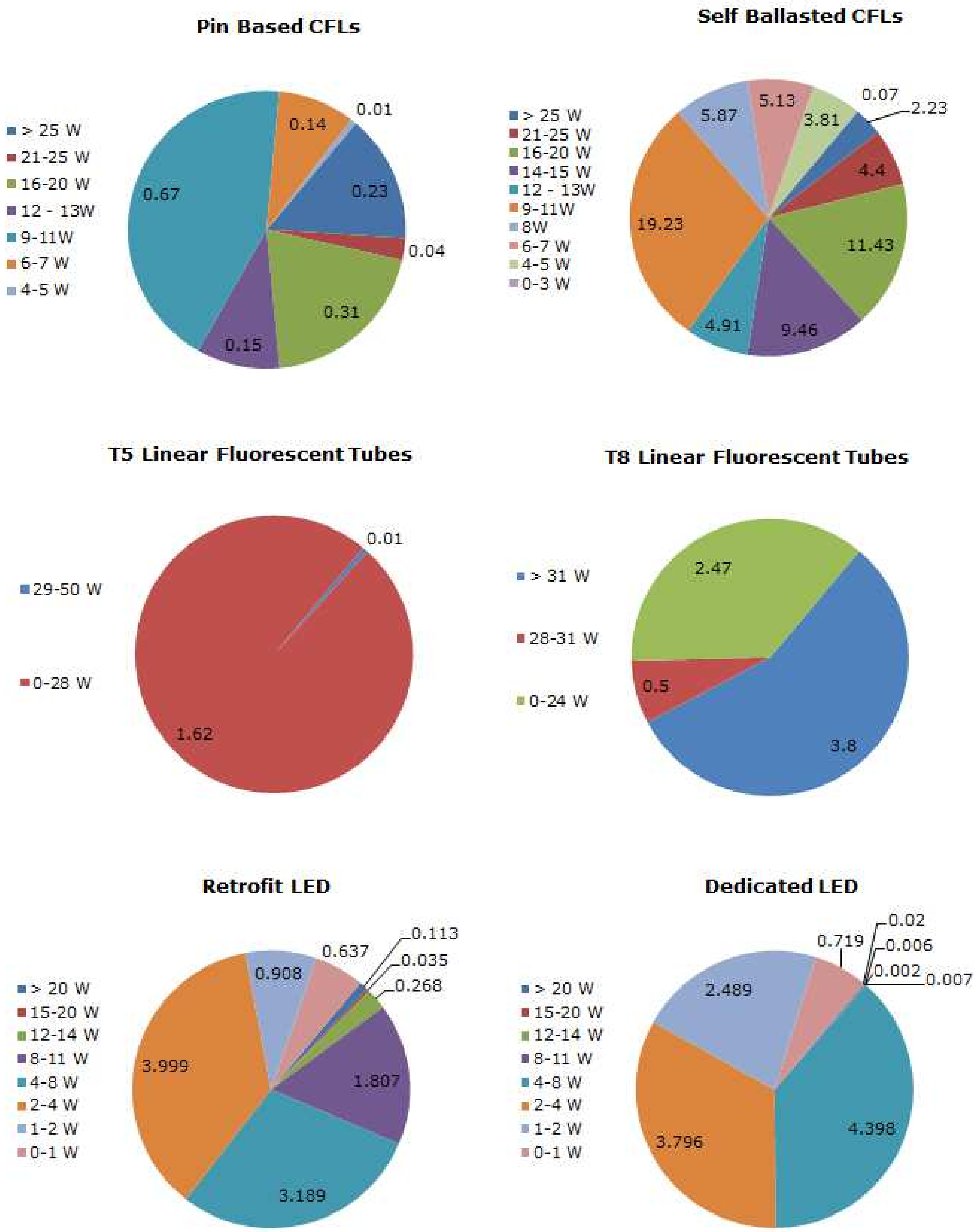


**Figure 102: Sold lamps in million units (CFL, Linear Fluorescent and LED technology) by power range in the EU, 2013. Source: IEA - 4E Mapping & Benchmarking [47]**



EU regulations affecting the energy efficiency of domestic lighting are mostly represented by eco-design and energy labelling regulations. These are: the Commission Regulation (EC) No 244/2009 with regard to eco-design requirements for non-directional household lamps; the Commission Regulation (EU) No 1194/2012 with regard to eco-design requirements for directional lamps, light emitting diode lamps and related equipment; and the Commission Regulation (EU) No 874/2012 on energy labelling of electrical lamps and luminaries.

In 2009, the Regulation No 244/2009 introduced minimum performance requirements for non-directional lamps[108] in the framework of the eco-design Directive 2005/32/EC. The annual electricity consumption of non-directional household lamps was estimated to be 112 TWh in 2007, corresponding to 45 Mt $CO_2$ emissions. Its energy consumption would have increased up to 135 TWh in 2020 if no measure would have been implemented.

Alike the electricity consumption, the mercury emitted in the different life cycle phases of installed lamps, including the use-phase and the end of life of CFLs (80 % of which were assumed not to be recycled or properly disposed), was estimated to be 2.9 tonnes in 2007 and to increase to 3.1 tonnes in 2020 under a business as usual (BAU) scenario.

The Regulation No 244/2009 aimed to increase the market penetration of energy efficient electrical lamps leading to estimated energy savings of 39 TWh in 2020, compared to the BAU scenario [48].

Eco-design requirements for non-directional household lamps are introduced progressively in 6 different stages starting from 1 September of the years 2009, 2010, 2011, 2012, 2013 and 2016.

**Table 29: Eco-design requirements for non-directional lamps. Source: EC**

| Application date | Maximum rated power for a given rated luminous flux (Φ)[109] (W) | |
|---|---|---|
| | Clear lamps | Non-clear lamps |
| **Stages 1 to 5** | $0.8 \cdot (0.88\sqrt{\Phi}+0.049\Phi)$ | $0.24\sqrt{\Phi}+0.0103\Phi$ |
| **Stage 6** | $0.6 \cdot (0.88\sqrt{\Phi}+0.049\Phi)$ | $0.24\sqrt{\Phi}+0.0103\Phi$ |

Additional functionality requirements are introduced in the stages from 1 to 5. These can be found in the Annex II of the relevant Regulation.

The Regulation No 1194/2012 was introduced in 2012 for setting the eco-design requirements of directional lamps. The combined effect of the eco-design requirements set out in the mentioned Regulation and in the energy labelling Regulation for direction lamps (see below) is expected to result in annual electricity savings of 25 TWh by 2020 among directional lamps, compared to a BAU scenario.

The eco-design requirements for directional lamps are gradually established in 3 stages starting from 1 September of the years 2013, 2014 and 2016.

[108] 'Directional lamp' means a lamp having at least 80% light output within a cone with angle of 120º. Non-directional lamp' means a lamp that is not a directional lamp.
[109] Luminous flux (Φ) is measured in lumens.

**Table 30: Eco-design requirements for directional lamps. Source: EC**

From 1 September 2013 (stage 1):

| Application date | Maximum energy efficiency index (EEI) | | | |
|---|---|---|---|---|
| | MV filament lamps | Other filament lamps | High-intensity discharge lamps | Other lamps |
| **Stage 1** | If $\Phi_{use}$ > 450 lm: 1.75 | If $\Phi_{use} \leq$ 450 lm: 1.20<br>If $\Phi_{use}$ > 450 lm: 0.95 | 0.50 | 0.50 |

From 1 September 2014 (stage 2) and from 1 September 2016 (stage 3):

| Application date | Maximum energy efficiency index (EEI) | | | |
|---|---|---|---|---|
| | MV filament lamps | Other filament lamps | High-intensity discharge lamps | Other lamps |
| **Stage 2** | 1.75 | 0.95 | 0.50 | 0.50 |
| **Stage 3** | 0.95 | 0.95 | 0.36 | 0.20 |

Additional energy efficiency requirements are introduced for lamp control gears in the stages 2 and 3. Also, functionality requirements are introduced in the stages 1 and 3 for directional CFLs and for non-directional and directional LED lamps (for LED lamps only from stage 1). Further details regarding these requirements can be found in the Annex III of the relevant Regulation.

The Regulation No 874/2012 on energy labelling of electrical lamps was also implemented in 2012. This Regulation applies to filament lamps, fluorescent lamps, high-intensity discharge lamps, and LED lamps and LED modules. The energy labelling for electrical lamps is introduced in an A++ to E scale range established according to an Energy Efficiency Index (EEI) based on the power consumption of the lamps [49]. The different energy efficiency classes are reported below:

**Table 31: Energy Efficiency Classes for lamps in the Commission Regulation 874/2012. Source: EC**

| ENERGY EFFICIENCY CLASSES FOR LAMPS | | |
|---|---|---|
| | **EEI for non-directional lamps** | **EEI for directional lamps** |
| **A++** | EEI ≤ 0.11 | EEI ≤ 0.13 |
| **A+** | 0.11 < EEI ≤ 0.17 | 0.13 < EEI ≤ 0.18 |
| **A** | 0.17 < EEI ≤ 0.24 | 0.18 < EEI ≤ 0.40 |
| **B** | 0.24 < EEI ≤ 0.60 | 0.40 < EEI ≤ 0.95 |
| **C** | 0.60 < EEI ≤ 0.80 | 0.95 < EEI ≤ 1.20 |
| **D** | 0.80 < EEI ≤ 0.95 | 1.20 < EEI ≤ 1.75 |
| **E** | EEI > 0.95 | EEI > 1.75 |

The EEI (Energy Efficiency Index) is calculated from the quotient between the rated correct power and the reference power obtained from the useful luminous flux of the model by applying specific formulae. The corrected factors for the rated power and the reference power calculation methodology can be found in the Annex VII of the relevant Regulation.

Concerning incandescent lamps, the eco-design Directive 2005/32/EC established the progressive phasing out of incandescent bulbs in the period between 2009 and the end of September 2012[110]. The pashing out of incandescent bulbs started in 2009 and finished in the end of September 2012 (see Table 32). This progressive pashing out (see Figure 100) reflected in the progressive decrease of sales illustrated in the previous paragraphs. Nevertheless, incandescent lamps remained with a share in the sales in 2013 as per the residual stock.

The following table shows the progressive phasing out phases for incandescent light bulbs in the European Union.

**Table 32: Timeline of Incandescent light bulbs banning in the EU**

| | |
|---|---|
| Sept. 2009 | •Phased out for incandescent light bulbs of 100W and above as well as frosted incandesncent light bulbs |
| Sept. 2010 | •Phased out of 60W incandescent bulbs |
| Sept. 2012 | •Phased out of 25W and 40W incandescent bulbs |
| End 2012 | •All incandescent light-bulbs phased out |

When the incandescent bulbs phase-out was planned in 2009, the EU-28 MSs agreed that also the inefficient halogen lamps should be phased-out from 1 September 2016. However, the European Commission proposed to postpone the phase-out of inefficient 'D'-class halogen lamps by two years to 1 September 2018. The proposal was agreed by the Member States on April 2015.

That means that from 1 September 2018 onwards, some non-directional mains-voltage halogen lamps (mainly the pear-shaped ones) will no longer be brought to the market. This decision does not affect to directional halogen lamps (spotlights).

[110] EC Press Release IP/08/1909

## 4.6 Overview – Residential sector

The residential sector accounted for 24.80% of the EU-28 total final energy consumption in 2014. This energy consumption sets the residential sector as the third energy consuming sector after transportation and industry sector.

The final residential energy consumption in the EU-28 shows a reduction of 9.5% from 2000 to 2014. The EU-28 average final residential energy per capita for the year 2014 is 0.519 toe per capita; it represents a fall of 16.8% compared to the year 2005. With regard to the residential energy mix, the main fuel types which contributed to final residential energy consumption in the EU-28 in 2014 were gas (35.0%), electrical energy (25.6%) and renewable energies (15.3%).

A major part of the EU's buildings are in high density areas, this representing a strong argument for utilising district heating in Europe. District heating plants production shows different trends for EU-15 and NMS-13 areas. While in the EU-15 the total energy consumption from district heating plants has grown by 27.5% for the period 2000-2014, in the NMS-13 it has undergone a drop by 38% in the same period. These divergent trends might be partly explained by the use of more efficient technologies in CHP-DH plants in the NMS-13 and by the promotion of DH as a competitive solution for heating systems in the EU-15.

There are several additional factors which must be considered, at least qualitatively, when analysing residential energy statistics. These factors are related to economic growth, population growth, weather conditions or living conditions (e.g. average size of persons per household). For instance, a positive correlation is often observed between the residential energy consumption (final energy, electricity and gas consumptions) and the heating degree days. Other factors such as income levels may also contribute to explain the differences in the registered trends. When focussing on residential sector, energy indicators and ratios based on GDP values might not be as representative as other parameters like disposable income of households or adjusted gross disposable income as these variables are more closely related to the purchasing power of the inhabitants.

The final residential electricity consumption in the EU-28 has grown by 9.42% in the period 2000-2014. The increased has been more pronounced in the NMS-13 (18.39%) than EU-15 (8.26%). There are notable differences across EU-28 Member States. The lowest growth rate has been registered by Belgium (-20.20%) and the highest growth rate in Spain (62.11%). It is clear a change in the growing trends during the financial and economic crisis which peaked in 2007-2008.

The average EU-28 residential electricity consumption per household for the year 2014 is 3,622 kWh per household. This value represents a drop by 11.96% for the 10-year period between 2005 and 2014. In 2014, the average EU-28 amount of electrical energy consumed for heating purposes reached 1,349 kWh per household and the electrical energy used for domestic appliances and lighting purposes was 2,250 kWh per household. The average EU-28 expenses per dwelling for electricity were EUR 739.79 for the same year.

The electricity prices for household consumers follow an increasing trend; the average EU-28 electricity price has risen by 33% in the period between 2007-S2 and 2015-S1. In the second semester of 2013 the threshold of 0.20 EUR/kWh was exceeded reaching a value of 0.2022 EUR/kWh for household consumers, value with all levies and taxes included.

The electricity price is formed by a notable percentage of taxes and levies; the average EU-28 percentage level of taxes and levies was 32.2% in the year 2014.

In 2014, the final residential gas consumption in the EU-28 has dropped by 15.3% in comparison to year 2000. The trend is followed by both EU-15 and NMS-13 areas with growth rates of -15.7% and -11.9% respectively. Alike the final electricity consumption, there is a clear impact of the financial and economic crisis which have affected the gas consumption during and after the years 2007-2008.

The average EU-28 final residential gas consumption per household for the year 2014 is 0.43 toe per household. It represents a fall by 29.9% compared to the year 2005. The differences among the EU-28 Member States are significant. For instance, Luxembourg is the highest consumer per household (1.00 toe/hh) and Sweden the lowest consumer of gas per household (0.007 toe/hh). The average EU-28 expenses per dwelling for gas consumption were EUR 264.33 in 2014.

The prices of gas for household consumers have registered fluctuating growth rates and the average EU-28 price has increased by 29.5% between the second semester of 2007 and the first semester of 2015. The threshold of 0.05 EUR per kWh was exceeded in the second semester of 2012. The average EU-28 percentage level of taxes and levies included in the gas prices for household consumers was 22.7% for the year 2014.

With regard to energy-related products, the current legislative framework has already covered most of the main energy consuming product types through the eco-design and energy labelling directives.

At the residential level the energy-related products with the highest impact on energy consumption are domestic appliances (i.e. refrigerator-freezers, washing machines, tumble dryers, dishwasher machines, cooking appliances), heating and cooling appliances, lighting, ICT and electronic equipment.

Energy efficiency policies in the major appliances sector (i.e. refrigerators, freezers, washing machines, dishwashers) turned out to be very successful. The success is due to a combination of EU legislation (energy labelling, and minimum energy performance standards), national programmes and the initial voluntary agreements of manufacturers (CECED).

In 2014, 92% of the sold Major Domestic Appliances (MDA) were A+ or higher class, to be compared with the 51% registered in 2011. This fact confirms the success of the energy label for major domestic appliances.

Within MDA, the market share of washing machines in the A+++ class, has remarkably increased by 29% between 2011 (14%) and 2014 (43%). Dishwashers have also registered a strong progress. The top sale products were A+ and A++ in 2014 (48% and 32%), whilst 71% was A class in 2011. The share of refrigerating and freezing appliances under A+ or higher energy efficiency classes that were sold in 2014 amounted respectively to 98% and 96% of the total.

The average energy consumption of new products for the five top MDA (i.e. refrigerators, freezers, washing machines, dishwashers and tumble dryers) in the 5-years period from 2010 and 2014 has significantly reduced. The new appliances became significantly more efficient over this period. On average, the energy consumption reduction was by 11% in 2014 compared to 2010. Differentiating by MDA, tumble driers have reduced by 27% (6-7% per year) over that period; washing machines by 14%, cooling appliances by 12%, freezers by 10% and dishwashers by 4%.

A factor to consider at global EU level is that the so-called "must-have" appliances (e.g. washing machines and refrigerators) are now regularly purchased by nearly all EU families, while "nice-to-have" appliances (e.g. tumble driers and dishwashers) consume overall less energy consumption, simply because of total number of sold units, household penetration rates or longer lifetimes. For instance, cooling and washing machines categories accounted each for nearly 30% of the total fleet energy consumption in 2014.

The cold appliances market (refrigerators and freezers) is characterised by a high level of substitution of old appliances rather than by an increase of the existing stock. Over the last years, the refrigerator stock reached the saturation level with penetration rates of around 100% in almost all EU-28 countries.

In the period from 2004 to 2014, there has been a continuous improvement in refrigerator efficiency levels. Products of classes B and C were not any more represented in the market since 2012 and 2008 respectively. Class A products accounted only for 2% of the market in 2014, whilst they were 50% of the market in 2010 and 56% in 2004. The refrigerating appliances with higher presence in the market are the class A+ which cover over 70% of the market. Efficiency classes A++ and A+++ are increasing their market shares year after year. They accounted for 22% and 5% of the market sales respectively in 2014.

In terms of average energy consumption of combined refrigerator-freezers there has been a decrease by 25% over the period 2004-2014. An average refrigerator-freezer sold in the EU had an average declared energy consumption of 231 kWh/year in 2014.

Overall, the trends of refrigerator-freezers are: models are designed with a larger capacity, mainly by increasing freezer capacity. The higher energy classes have larger capacities. In 2014, an average A+++ model had 305 litres (84 litres for freezing and 221 litres for refrigeration) and registered an average declared energy consumption of 146 kWh/year.

The washing machines market has also reached the saturation level with penetration rates of up to 100% in all EU-28 countries. As in the case of refrigerator-freezers, the washing machine market is hence characterised by a high level of substitution of old appliances, rather than by an increase in the overall stock.

The efficiency development of washing machines happened much faster than initially expected as over 80% of the market was already in the most efficient classes in 2004. The energy labelling has been a success since the market sales show that over 60% of the market share was taken by the two most efficient efficiency classes (A+++ and A++) in 2014.

Class B washing machine sales could be observed until 2009. Their presence in the market was negligible about two years before class B eco-design ban as of December 2011. In 2014, class A+++ has got the highest share of the market for the first time (43%), followed by class A+ (31%). This situation represented a considerable change in comparison to the previous year when the highest share was instead for class A+ (36%) and was followed by A+++ (31%), A++ (22%) and A (11%) share.

In terms of average energy consumption of washing machines there has been a decrease by 25% over the period 2004-2014. An average washing machine sold in the EU had an average declared energy consumption of 185 kWh/year in 2014; whereas its average annual water consumption was 9.9 thousand litres, representing a decrease of 15% in comparison to 2004.

Overall, the major trends for washing machines are: models designed with a larger capacity. It is not clear if the trend to large washing machines is coming from changed consumer demand or rather from the changed market offer; 60% of all washing machines sold across the EU were declared to be designed for washing 7kg laundry or more in 2014. The largest models have a higher presence in the highest energy class. Only 18% of class A+++ models had a rated capacity equal or below 6kg, in contrast with 71% of the sold washing machines in efficiency classes A+ or A in 2014.

A development leading to a more energy efficiency market has been appreciated in the recent years also for household tumble driers, despite many tumble driers sold in the EU are still less efficient compared to other appliances sold.

The average energy consumption of sold tumble driers has decreased by 42% from 2010 to 2014. In 2014, the average declared energy consumption of a sold tumble drier in the EU was 382 kWh/year. The decreasing trend underlines the improvement in the efficiency levels due, among other, to eco-design and labelling measures implemented in the recent years. In the same year classes from A+ to A+++ accounted for 40% of the market; class A+++ models still represent a low market share (2%). Class B models registered 34% of the sold units.

As in the cases of other appliances (e.g. cold appliances and washing machines), tumble driers are increasing their capacity. In 2014, over 40% of A++ and A+ appliances were tumble driers with an 8kg or larger capacity.

In 2014, 38% of dishwasher sales were class A++ or A+++ (32% and 6% respectively). The average declared annual energy consumption of sold dishwashers in the EU was 272 kWh/year in 2014, representing a drop by 4.6% in comparison to 2010.

The European Commission is carrying out a review study for preparing revisions of the existing regulations for dishwashers. The study started in 2014 and is expected to end in 2016. Further development on highly efficient dishwashers is expected in the future as BATs allow, nowadays, exceeding the A+++ threshold by 40% in terms of average annual energy consumption.

Under the legislative framework of the Eco-design and Labelling Directives, cooking appliances, i.e. domestic ovens, hobs and range hoods, were addressed by specific regulations in 2014. In February 2014, a specific eco-design regulation was introduced. This regulation establishes minimum performance requirements in three gradual tiers to be respectively applied from 1, 2 and 5 years after the regulations implementation date.

At the same time, a new Energy Label was introduced. The labelling regulation establishes four tiers. From January 2015, the labelling scale is A+++ to D for domestic ovens and A-G for domestic range hoods. Then the energy efficiency labels for domestic range hoods scale up until reaching the classes from A+++ to D by 2020. These gradual stages are: from January 2016 (A+ to F), from January 2018 (A++ to E) and from January 2020 the mentioned top labelling range should be reached.

It is still very soon to appreciate the impact of the above mentioned regulations on these product types. The combined effect of the provisions set out in the eco-design and energy labelling regulations for domestic ovens, hobs and range hoods is expected to result in annual primary energy savings of 27 PJ/a in 2020, increasing up to 60 PJ/a by 2030

Vacuum cleaners are another appliance type covered by the eco-design and energy labelling regulations as of 2013. These regulations concern energy consumption in the use phase (they limit the maximum power input to 1,600W from 1 September 2014), dust pick-up, dust re-emission, sound power level and durability. Related requirements are introduced gradually in two tiers from 1 September of the years 2014 and 2017.

In September 2014, an energy label entered into force for commercialised vacuum cleaners. The related energy labelling regulation sets also two tiers for vacuum cleaners with different labelling ranges in each tier; from 1 September 2014 (A to G scale) and from 1 September 2017 (A+++ to D scale).

In the natural business year from June 2014 to May 2015, the average maximum power level of a vacuum cleaner sold in the EU was 917 Watts and its electricity consumption was 34.5 kWh/year.

The EU market of vacuum cleaners (referring to cylinder-type vacuum cleaners which are the main segment of vacuum cleaners to which the energy label is applied) is mostly built on high wattage models, although the low wattage offer is growing in share. A steep increase in the sales of low wattage products was observed since September 2014 when the labelling was implemented. In September 2014, the low wattage sales accounted for 34.4% of the market, while the share reached 80.8% in May 2015. It is a representative sign that the market has been largely renewed with the implementation of the energy label and the eco-design regulations.

Space heating equipment is the single largest electricity end-user in the residential sector; its electricity consumption was estimated to be around 150 TWh/year in 2007. Space heating appliances consume electricity directly (e.g. due to electric boilers and radiators) and indirectly due to monitoring and control equipment of other heating equipment fuelled by gas or oil.

During the last years, the energy consumption of this type of products has reduced due to factors such as the strong competition between electric-fuelled, gas-fuelled boilers and heat pumps and the energy efficiency increase of water boilers and space heating equipment.

In 2013, eco-design and labelling requirements for space and water heaters were introduced for space heaters and combination heaters with a rated heat output ≤ 400 kW. The requirements take into account the seasonal space heating energy efficiency, water heating energy efficiency, sound power level and emissions of nitrogen oxides. Minimum performance requirements are established in 3 progressive tiers, set from 26 September of the years 2015, 2016 and 2018. The labelling regulation established a new labelling scale from A ++ to G, where A to G classes cover the various types of conventional boilers when not combined with cogeneration or renewable energy technologies. The classes A + and A ++ are reserved to cogeneration and renewable energy-fuelled systems. A+++ should be added after four years to accelerate the market penetration of high-efficiency space heaters and combination heaters using renewable energy sources.

Residential air conditioners electricity consumption was estimated to be around 30 TWh/year in the EU in 2005. The European residential air conditioners are mostly on a vapour compression cycle and driven by grid electricity and their market is still growing substantially and has not reached saturation levels.

In 2011, labelling requirements were introduced for residential air-to-air conditioners up to 12 kW cooling power output. The regulation established an A to G energy efficiency class scale with a '+' added on the top of the scale every two years starting from September 2013 until the A+++ class is reached. For single and double duct air conditioners energy efficiency classes are established from an A+++ to D.

In 2012, eco-design requirements were introduced for residential electric mains-operated air conditioners with a rated capacity of ≤ 12 kW for cooling, or heating, and comfort fans with an electric fan power input ≤ 125W. The minimum performance requirements are set based on the Energy Efficiency Ratio (EER) and the rated Coefficient of Performance (COP) of the products in 2 tiers from 1 January of the years 2013 and 2014.

Electric water heaters accounted for 8.7% of EU total electricity consumption and consumed 73 TWh in 2009. The European Union is a leading by example economy as it has implemented the most stringent standards regarding eco-design and labelling policies for water heaters and water storage tanks during the recent years, ahead of other economies such as India, China and USA.

In 2013, eco-design and labelling requirements for water heaters with a rated heat output ≤ 400 kW and hot water storage tanks with a storage volume ≤ 2,000 litres were introduced. The eco-design requirements take into account the energy consumption in the use phase and (for heat pump water heaters) sound power level. In case of water heaters using fossil fuels the emissions of nitrogen oxides, carbon monoxide and hydrocarbons are also regulated. The related requirements are set in 3 tiers from 26 September of the years 2015, 2017 and 2018. The energy labelling requirements set an A to G labelling scale for conventional water heaters, solar water heaters and heat pump water heaters and for hot water storage tanks. The class A+ will be added after two years to accelerate the market penetration of the most efficient water heaters and hot water storage tanks. The classes A++ and A+++ will be addressed by water heaters and hot water storage tanks with large solar device only.

The combined effect of the eco-design and labelling requirements on water heaters and hot water storage tanks is expected to result by 2020 in estimated annual energy savings of about 450 PJ (11 Mtoe), corresponding to around 26 Mt $CO_2$ emissions, and a reduction in annual nitrogen oxides emissions of some 130 kt SOx equivalent.

The installed solar thermal capacity was 31,840 $MW_{th}$ in the EU in 2014, which represents an increase of 5.3% compared with 2013. Across the EU-28 MSs, Germany was the country with the highest share of newly installed capacity (31%); followed by Great Britain, Italy, Poland, and Spain which accounted for 9% each 2014 in comparison with 2013.

In 2014, the average EU-28 solar thermal capacity in operation per each 1,000 inhabitants was 61.4 $kW_{th}$. The MSs with the highest rate were Cyprus (567.4 $kW_{th}$); Austria (345.6 $kW_{th}$), and Greece (271.2 $kW_{th}$); whereas Belgium (30.9 $kW_{th}$), Poland (31.8 $kW_{th}$) and Czech Republic (33.7 $kW_{th}$) were the countries with the lowest rates in the same year.

Lighting accounts for around 10% of the residential electricity consumption, being the third main electricity consumer after heating and cold appliances.

The electricity consumption for lighting purposes has declined by 7.8% (6.55 TWh) in the EU-28 from 2000 to 2013. The maximum annual consumption over this period was registered in 2003 (86.75 TWh). In 2013, the electricity consumption for lighting in the EU-28 was 77.13 TWh.

The average annual electricity consumption per household for lighting was estimated to be 360 kWh per household in the EU-28 in 2013, representing a reduction by 18% (79 kWh per household a year) in comparison to 2005. Since 2005, a progressive reduction of this indicator has been observed.

Among the technologies for domestic lighting, the market sales statistics show that MV halogen lamps are the top sold lamp's type (58% of the total – 270.3 million units) in 2013; followed by CFLs (15% - 68.2 million units) and by incandescent lamps (12%; 57 million units).

In the period from 2007 to 2013, the sales of incandescent lamps have reduced the most (by 85.4%), due to their progressive phasing out introduced by eco-design regulations. CFLs (both self-ballasted and pin based) have also reduced their sales volume by 2% in the same period. On the other hand, MV halogen lamps (both single and double ended) have increased by 227.5%; and LED lamps (both retrofit lamps and dedicated lamps) which have registered a significant sales growth during the same period, an increased by 2,140% having been observed (from 1 million units sold in 2007 to 22.4 million units sold in 2013).

Retrofit and dedicated LED sales achieved same levels in 2013 (10.8 and 10.6 million units respectively) as illustrated in the following figure. In case of linear fluorescent lamps, the T8 linear fluorescent tubes had the largest sales (81%) in domestic lighting, while 19% of the share was covered by T5 linear fluorescent tubes in 2013. In case of MV CFLs, 97.7% of total sales were made by self-ballasted CFLs and the remainder share was made by pin based CFLs. For MV halogens lamps, the single ended halogen lamps accounted for 87.3% of the sales, whilst the rest was covered by double ended halogen lamps in 2013.In terms of power range for LED lamps, the wattage range from 2 to 4 Watts registered the highest sales for retrofit LED (3.999 million units sold); and the wattage range from 4 to 8 Watts was the top sale (4.398 million units) for dedicated LED lamps.

LED lighting is the technology which is expected to further grow in the following years and the one with the brightest future perspectives. LED lamps represent one of the most efficient solutions available today for improving energy efficiency in residential lighting. Its high luminous efficacy level (lm/W), mercury free content, and long lifetime are some of the most important added values of this technology in comparison to other light source technologies (e.g. LED lamps last 5-25 times longer the traditional GLS lamps). Despite their advantages of LED technology, the higher LED technology price (e.g. compared to CFLs) is however a still significant purchasing barrier in the residential sector; although the price projection indicate that LED prices will reduce leading to the bright future perspectives for that technology.

Three EU Regulations concerning eco-design and labelling requirements were introduced between 2009 and 2012. The energy labelling requirements established an A++ to E energy labelling scale for filament lamps, fluorescent lamps, high-intensity discharge lamps, and LED lamps and LED modules.

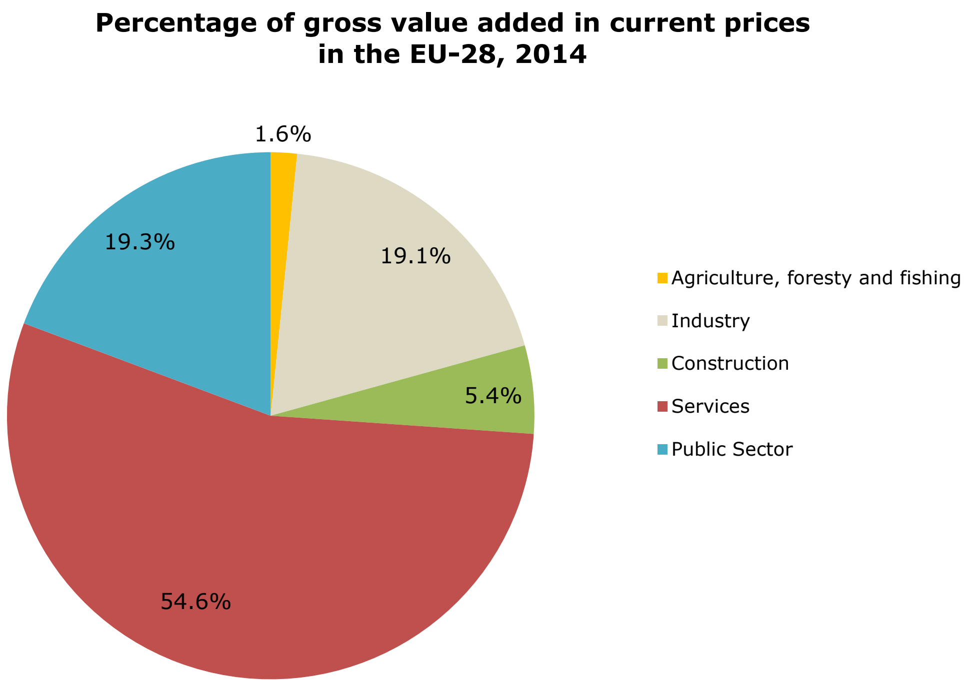
The phase-out of incandescent lamps in the European Union started in 2009 and finished in 2012. The phase-out of inefficient 'D'-class halogen lamps was initially foreseen for 2016. However, the banning of halogen lamps has been postponed by two years (until 1 September 2018) as per the agreement by the EU-28 MSs on April 2015.

# 5. Energy Consumption Trends in the Tertiary Sector

In this report, the tertiary sector refers to the public sector, professional, scientific and technical activities, services and commerce [111]. This chapter covers the energy consumption trends in the tertiary sector, with a focus on electricity and gas consumption trends. The usage of some technologies and appliances analysed for the residential sector are also present and used in the tertiary sector (e.g. heating and cooling systems, lighting systems, etc.)

The tertiary sector accounts for a large share of GDP in the European Union. Nearly 74% of the total gross value added is generated by the tertiary sector in 2014. The tertiary sector is also expected to further grow in importance during the next years due to: 1) the shift in end consumer preference towards services and (2) the demand for services from services firms. These factors point to a general tertiarization trend related to labour force and production [50].

**Figure 103: Percentage of gross value added in current prices by economic sector in the EU-28, 2014. Source: Eurostat**




Also employment rates registered in the recent years show that there have been changes which have provided opportunities for increased productivity in knowledge-intensive sectors, leading to additional possibilities for labour re-allocation and employment growth in certain sectors. Manual workers – in particular in manufacturing and agriculture – are however replaced in the process of automation (Figure 104)[112].

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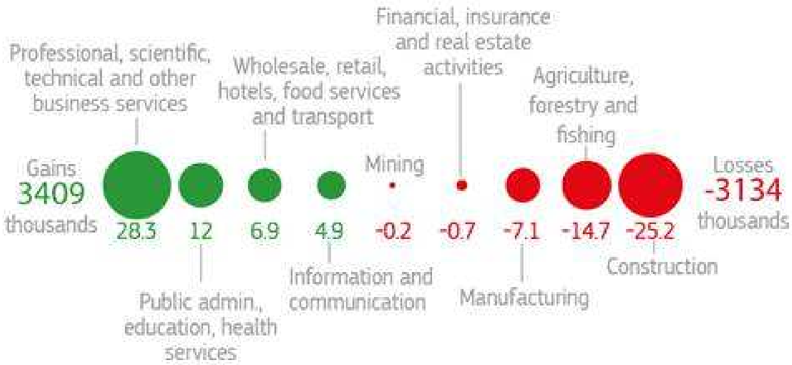
[111] This category is also known as the "commercial sector" and represents non-residential buildings in the services sector.

[112] Organization for Economic Cooperation and Development (2015), *OECD Science, Technology and Industry Scoreboard 2015: Innovation for growth and society*, Paris: OECD Publishing.

**Figure 104: Change in total employment in the EU-28, 2010-2014, absolute numbers. Source: OECD, 2015.**



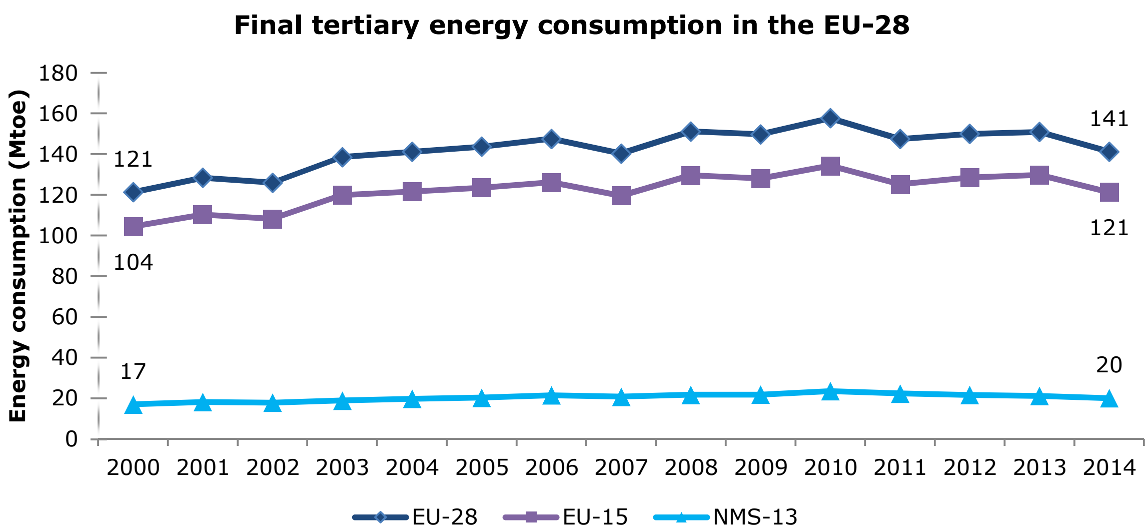

The figure above shows indeed that employment in the tertiary sector (i.e. professional, scientific and technical services, public administration and health services, wholesale, retail, etc.) has increased, while employment in other sectors (mostly manufacturing, construction, agriculture, forestry and fishing), has markedly decreased during the recent years.

## 5.1 Final energy consumption trends in the tertiary sector

The tertiary sector accounted for 13.31% of total final energy consumption in the year 2014. Considering its share in value added, this is relatively low compared to e.g. to the industry sector. This latter sector consumed 25.89% of total final energy but with a contribution of just 19%[113] to the total value added in 2014.

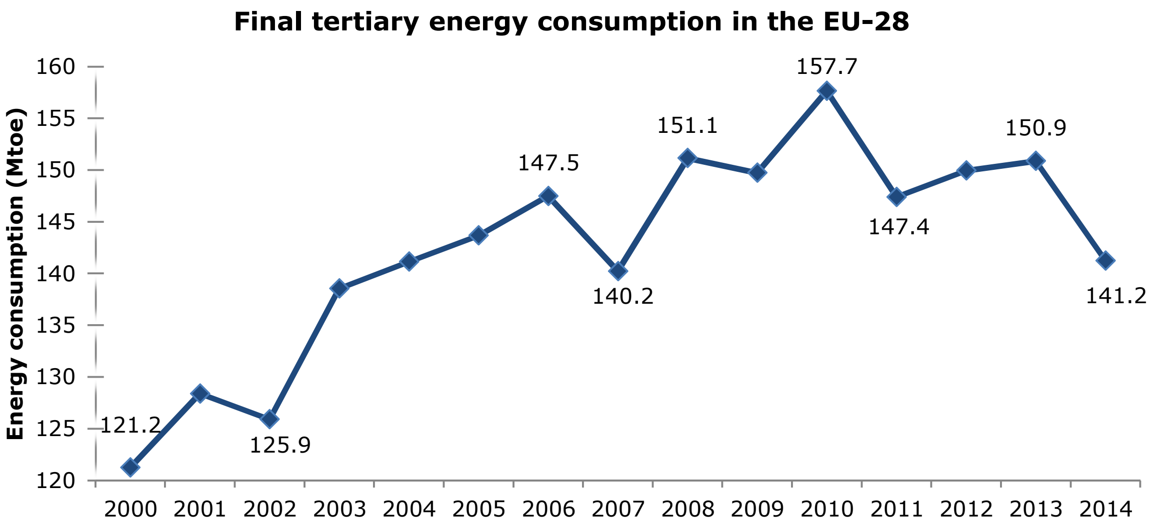
The final tertiary energy consumption in the EU-28 has grown by 16.5% in the 15-years period from 2000 to 2014. This increase has been followed by both EU-15 and NMS-13 areas which have grown their final energy consumption by 16.19% and 18.27% respectively. In 2014, the final tertiary energy consumption reached 141.2 Mtoe, out of which 85.9% (121.2 Mtoe) was consumed in EU-15 areas and 14.1% (20 Mtoe) was consumed in the NMS-13. The maximum consumption took place in the year 2010 when the EU-28 consumption reached 157.7 Mtoe as illustrated in Figure 105.

**Figure 105: Final tertiary energy consumption in the EU-28, 2000-2014. Source: Eurostat**



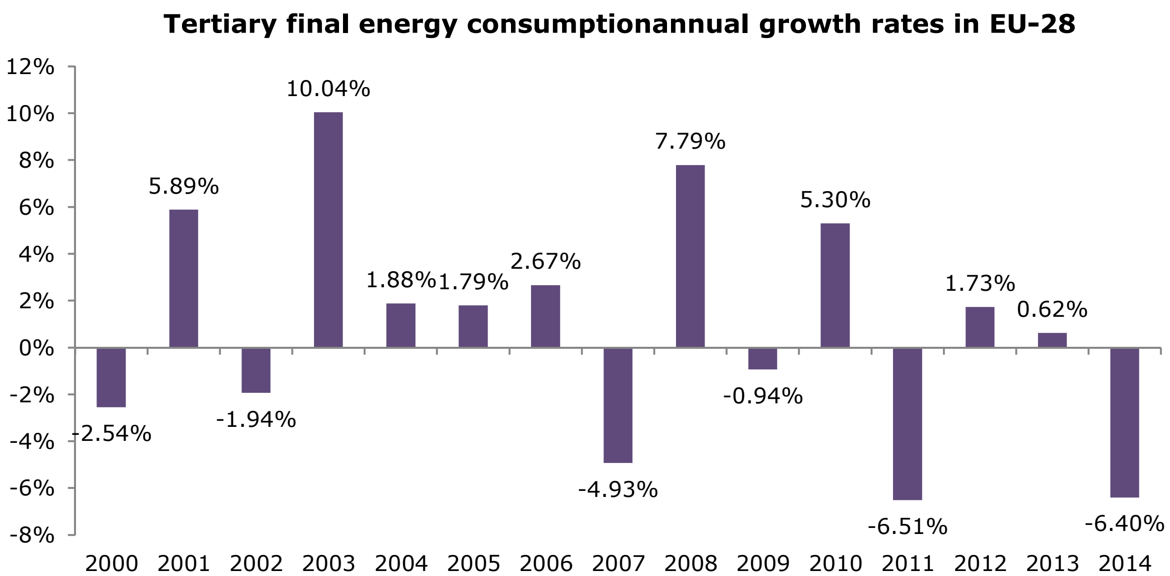

[113] Construction sector is accounted independently – see Figure 103.

**Figure 106: Final tertiary energy consumption in the EU-28, 2000-2014 (detailed). Source: Eurostat**



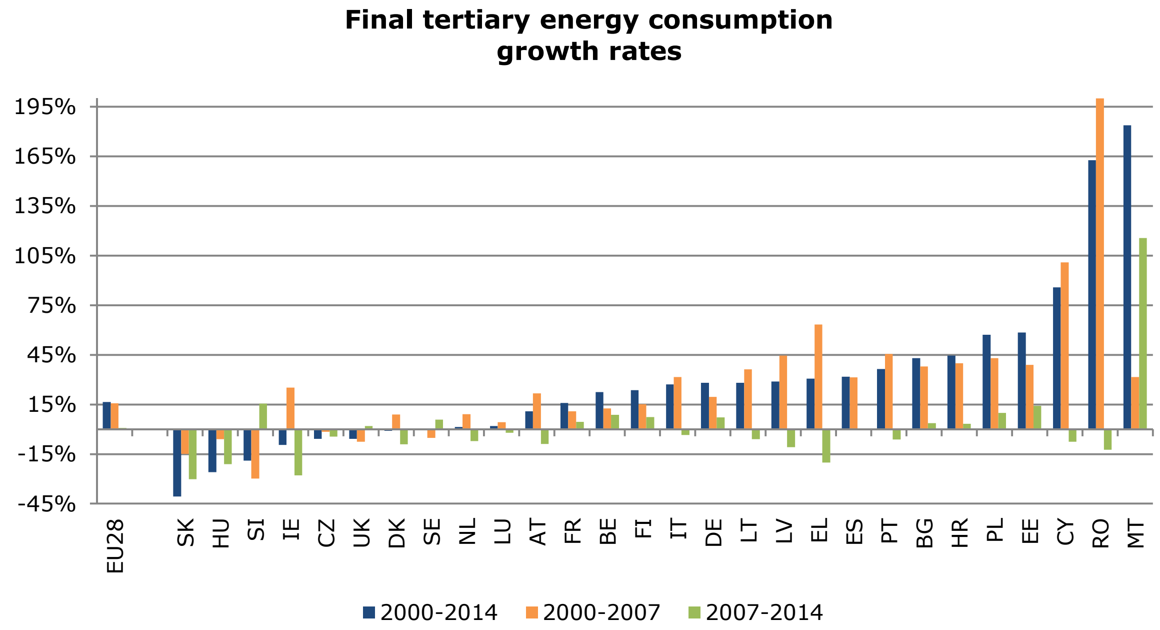

Looking at the growth rates along the same period, a general growing trend can be observed between 2000 and 2010 with the exception of the years 2002, 2007 and 2009. Notably, an increase by around 10% has been registered in 2003 in comparison to the previous year (Figure 107). 2003 was a year especially hot, fact which may explain the increase in the energy consumption (e.g. higher use of air-conditioning systems). Decreases registered in 2011 and 2014 have instead led the final tertiary energy consumption to 2007 levels.

**Figure 107: Tertiary final energy consumption annual growth rates in the EU-28, 2000-2014. Source: Eurostat**



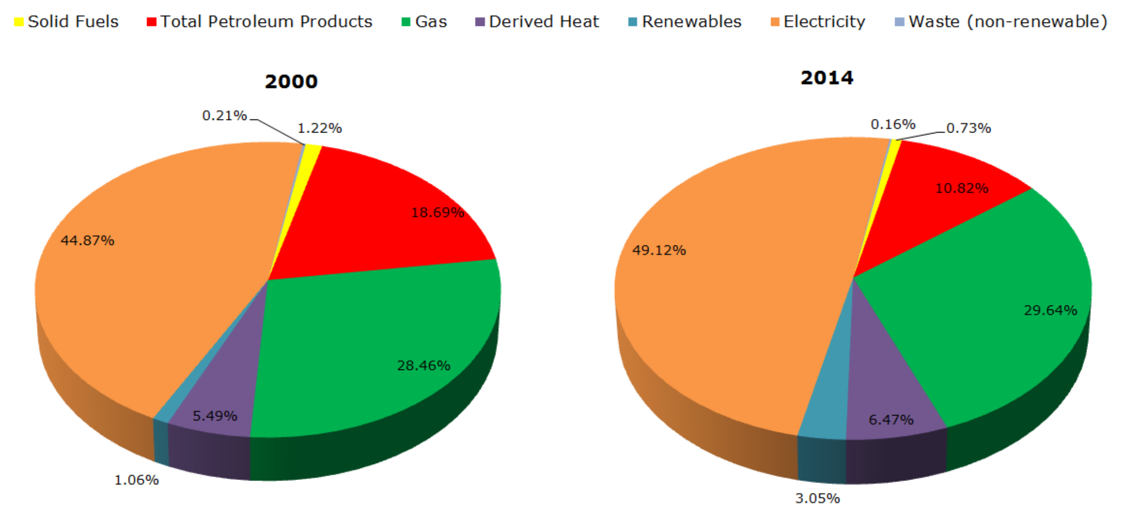

As previously mentioned, the EU-28 final tertiary energy consumption has grown by 16.5% in the last 15 years. Nevertheless, the growth rates are generally markedly different before and after 2007 which might be partially explained by the impact of the financial and economic crisis. The Member State with highest reduction rate of final tertiary energy consumption is Slovakia with -40.58%, followed by Hungary (-25.93%) and Slovenia (-18.88%). In contrast, the Member States which have undergone the highest growth rates in the service sector are Malta (183.83%), Romania (162.65%) and Cyprus (85.69%), all belonging to NMS-13 areas.

**Figure 108: Final tertiary energy consumption growth rates by MS in the EU-28; 2000-2014, 2000-2007 and 2007-2014. Source: Eurostat**




To be noted the significant changes in the growth rates in the different sub-periods in countries such as Romania, where the growth rate passed from +200% in the period 2000-2007, to -12.44% during 2007-2014 period, or Ireland, Greece, Latvia and Austria. Overall, the growth rates of Member States do not show as significant differences between the sub-periods (i.e. 2000-2007 and 2007-2014) as in other economic sectors. This might be the result of an on-going tertiarization process at European level.

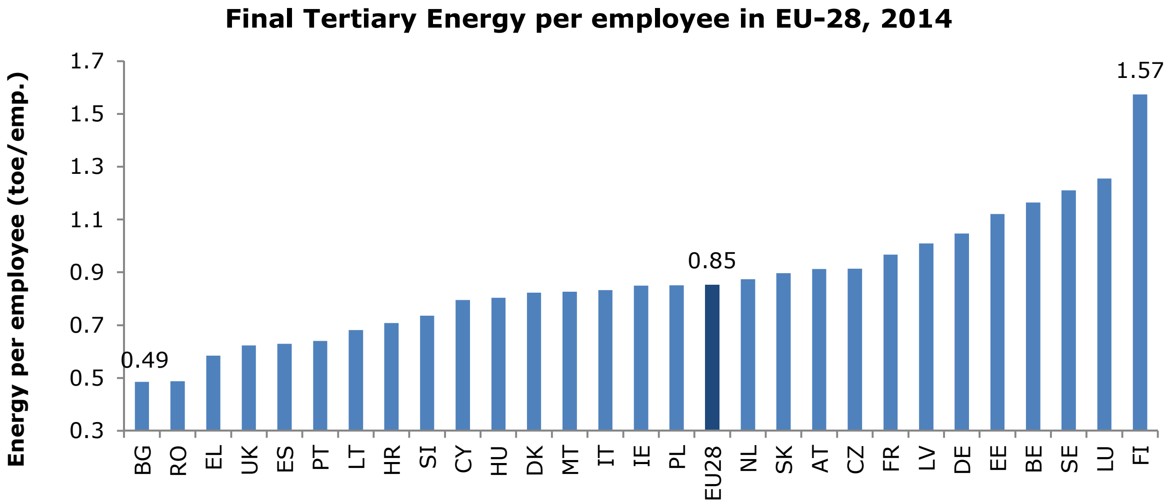
**Figure 109: Final energy mix in the tertiary sector in the EU-28, 2000 and 2014. Source: Eurostat**




The final energy mix in the tertiary sectors of EU-28 was mainly formed by three energy sources which accounted for above 90% of the total final energy consumption in 2014. Electricity has had the highest share (49.12%) and has been followed by gas (29.64%) and total petroleum products (10.82%). Other contributors to the energy mix have been heat (6.47%), renewables (3.05%), waste (0.73%) and solid fuels (0.16%)[26]. Changes from the scenario of year 2000 are mainly due to a reduction in the share petroleum products (-7.87%). Electricity (+4.25%) and gas (+1.18%) have instead acquired larger shares together with derived heat, renewables and solid fuels.

An interesting indicator to consider in the tertiary sector is the energy consumed per employee. The final average energy consumption per employee in the tertiary sector in the EU-28 was 0.85 toe per employee in 2014 (Figure 110).

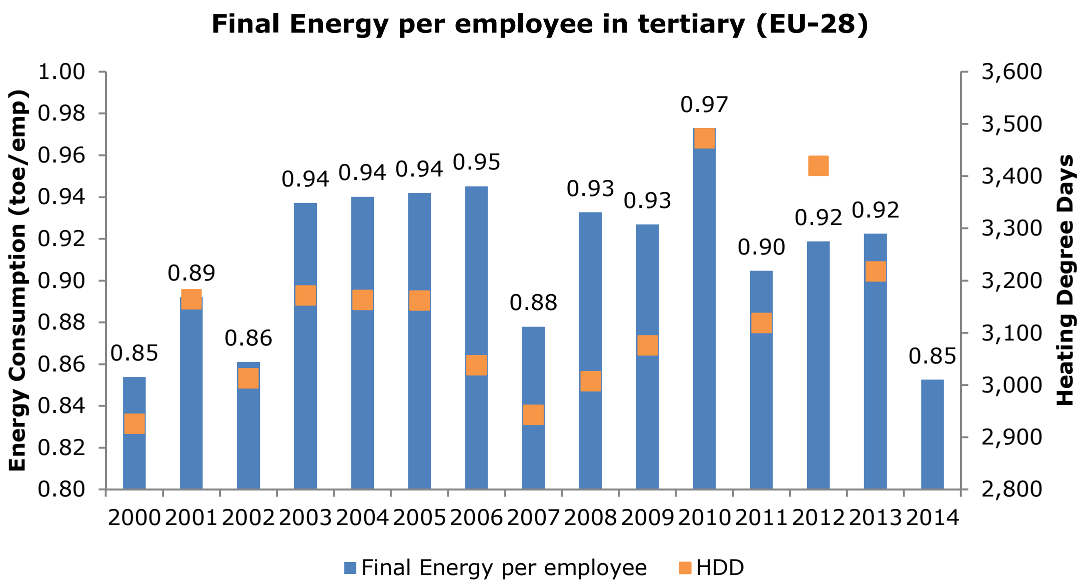
**Figure 110: Final energy consumption per employee in the tertiary sector in the EU-28 Member States, 2014. Source: Eurostat**




In 2014, the Member States with higher energy consumption per employee were Finland (1.57 toe/emp.), Luxembourg (1.25 toe/emp.), and Sweden (1.21 toe/emp.). On the other hand, Bulgaria and Romania (0.49 toe/emp.), Greece (0.58 toe/emp.) and the United Kingdom (0.62 toe/emp.) were the Member States with the lowest final tertiary energy consumption per employee.

Per employee final energy consumption has registered a same value (0.85 toe/emp.) in both years 2000 and 2014. Along this period (2000-2014), the maximum per employee final energy consumption was reached in 2010 (0.97 toe/emp.).

**Figure 111: Final energy consumption per employee in the tertiary sector and Heating Degree Days in the EU-28, 2000-2014. Source: Eurostat[60]**



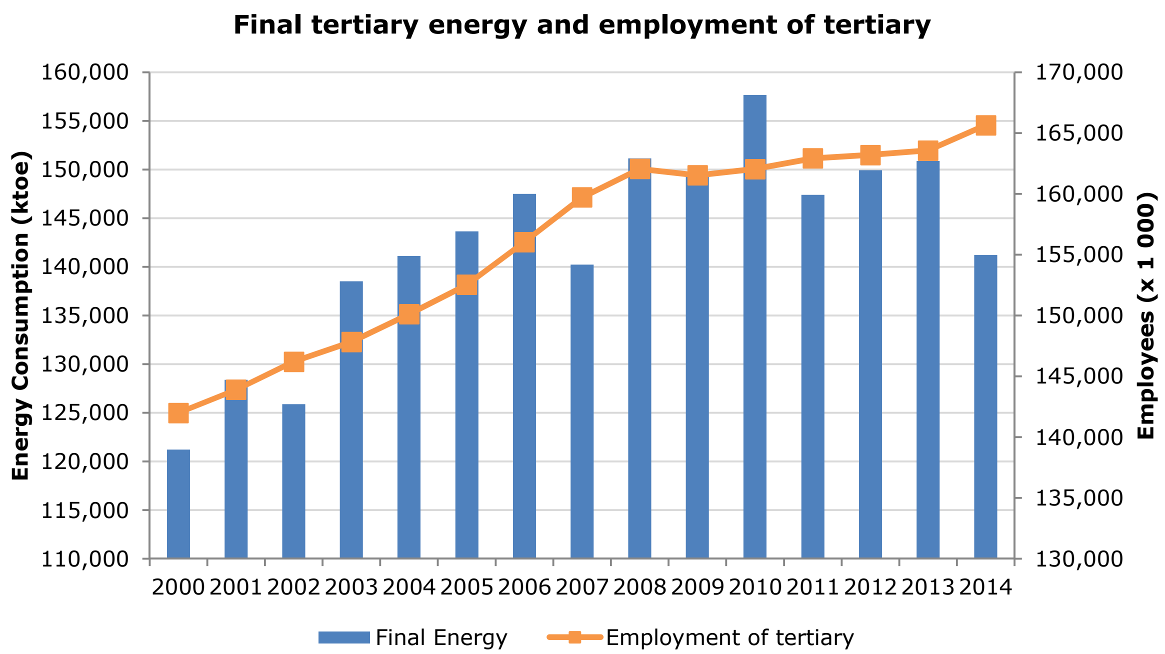
A qualitative analysis of the energy consumption trends per employee can be attempted by considering some influencing factors such as weather and climate conditions and employment values in the tertiary sector. The tertiary sector has created 23.6 million employees in the period from 2000 to 2014, representing a growth by 16.7%. There is a clear impact on the employment rate by the recent financial and economic crisis. A 14.1% growth rate was indeed registered during 2000-2010, whereas the employment growth rate was only 2.2% during 2010-2014. Despite this recent growth rate reduction, the tertiary sector continues however to constantly increase in the European Union.

Comfort conditions (e.g. temperature or humidity levels) are other key factors in the tertiary sector, as this includes to the public sector, professional, scientific and technical activities, services and commerce. Therefore, it is also of interest comparing qualitatively the heating degree days with the trends in energy consumption and employment.

The previous figure shows the heating degree days together with the final energy consumption per employee. Some level of correlation between the two trends can be inferred by this figured.

Figure 112 shows the trend of employment together with final energy consumption in the tertiary sector. This and the previous graph help analyse the influence of these factors on energy consumption. It can be stated that a higher influence on per capita consumption has been exerted by weather conditions than by registered employment rates. For instance, in the period from 2000 to 2008 when the employment rates were increasing continuously; a possible negative correlation between consumption and employment should have made decrease the values of final energy consumption per employee. In contrast, this consumption augmented as happened to heating degree days (HDD), as illustrated in Figure 111.

**Figure 112: Final energy consumption and employment rates in the tertiary sector in the EU-28, 2000-2014. Source: Eurostat**



The following table shows an overview of the final energy consumption in the tertiary sector with a breakdown by Member States.

**Table 33: Final tertiary energy consumption in the EU-28 Member States. Source: Eurostat**

| | Final Tertiary Energy Consumption in the EU-28 MS (ktoe) | | | | | | | Growth Rate |
|---|---|---|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2000-2014 (% year) |
| **EU28** | **121,243.9** | **143,665.8** | **157,660.1** | **147,394.9** | **149,944.5** | **150,879.7** | **141,223.1** | **16.48%** |
| **BE** | 3,476.1 | 4,151.6 | 5,034.9 | 4,422.5 | 4,535.5 | 4,893.2 | 4,258.5 | 22.51% |
| **BG** | 648.0 | 824.2 | 988.8 | 1,047.2 | 1,022.6 | 965.2 | 926.2 | 42.93% |
| **CZ** | 2,972.5 | 3,104.9 | 3,192.5 | 3,080.2 | 2,991.0 | 3,014.3 | 2,798.6 | -5.85% |
| **DK** | 1,843.2 | 2,002.1 | 2,128.2 | 1,947.9 | 1,978.5 | 1,974.9 | 1,824.5 | -1.01% |
| **DE** | 25,793.1 | 33,192.8 | 35,355.5 | 31,909.5 | 33,249.6 | 34,488.5 | 33,042.9 | 28.11% |
| **EE** | 288.8 | 389.4 | 424.3 | 402.3 | 423.8 | 418.1 | 457.9 | 58.55% |
| **IE** | 1,366.8 | 1,643.5 | 1,522.5 | 1,330.5 | 1,333.2 | 1,304.6 | 1,236.5 | -9.53% |
| **EL** | 1,311.4 | 1,945.9 | 1,953.6 | 1,869.2 | 1,939.0 | 1,818.7 | 1,711.9 | 30.54% |
| **ES** | 6,709.6 | 8,414.6 | 9,797.1 | 10,202.9 | 10,045.5 | 9,614.6 | 8,845.1 | 31.83% |
| **FR** | 18,161.1 | 20,557.3 | 22,961.7 | 21,553.3 | 22,660.8 | 23,072.8 | 21,032.7 | 15.81% |
| **HR** | 492.0 | 692.2 | 775.8 | 762.8 | 733.1 | 712.0 | 710.8 | 44.47% |
| **IT** | 11,542.2 | 15,053.3 | 16,978.7 | 15,751.4 | 15,930.5 | 15,846.5 | 14,666.7 | 27.07% |
| **CY** | 107.6 | 160.6 | 248.4 | 236.5 | 221.8 | 199.2 | 199.8 | 85.69% |
| **LV** | 472.5 | 594.5 | 597.8 | 556.7 | 623.3 | 600.4 | 608.9 | 28.87% |
| **LT** | 463.5 | 562.3 | 603.1 | 586.8 | 613.6 | 596.9 | 593.8 | 28.11% |
| **LU** | 386.4 | 395.0 | 447.3 | 405.3 | 415.9 | 431.0 | 394.2 | 2.02% |
| **HU** | 3,026.6 | 3,510.6 | 3,135.2 | 3,143.6 | 2,763.0 | 2,443.9 | 2,241.7 | -25.93% |
| **MT** | 43.3 | 48.4 | 101.9 | 95.8 | 105.4 | 115.8 | 122.9 | 183.83% |
| **NL** | 6,241.0 | 6,931.8 | 7,803.3 | 6,937.4 | 7,175.4 | 7,194.2 | 6,326.5 | 1.37% |
| **AT** | 2,548.6 | 3,327.5 | 3,288.5 | 2,999.4 | 2,924.2 | 2,918.4 | 2,825.4 | 10.86% |
| **PL** | 4,964.8 | 6,413.2 | 8,824.9 | 8,418.0 | 8,350.4 | 8,071.2 | 7,801.0 | 57.13% |
| **PT** | 1,396.2 | 2,194.6 | 1,878.1 | 1,850.9 | 1,838.1 | 1,784.9 | 1,905.0 | 36.44% |
| **RO** | 673.3 | 1,669.9 | 1,880.5 | 1,774.0 | 1,763.2 | 1,785.1 | 1,768.4 | 162.65% |
| **SI** | 526.6 | 475.3 | 532.6 | 531.5 | 453.3 | 467.8 | 427.2 | -18.88% |
| **SK** | 2,200.4 | 1,751.1 | 2,105.7 | 1,602.9 | 1,451.6 | 1,710.9 | 1,307.5 | -40.58% |
| **FI** | 2,323.9 | 2,618.3 | 3,078.1 | 2,844.2 | 3,007.8 | 2,886.0 | 2,875.2 | 23.72% |
| **SE** | 4,404.8 | 4,297.1 | 4,549.9 | 4,024.6 | 4,085.3 | 3,961.5 | 4,419.5 | 0.33% |
| **UK** | 16,859.7 | 16,743.9 | 17,470.7 | 17,107.6 | 17,309.0 | 17,589.0 | 15,893.9 | -5.73% |

## 5.2 Electricity consumption trends in the tertiary sector

In 2014, 29.81% of the total final electrical energy consumption of the EU-28 was generated by the service sector, which achieved the second highest share after the industry sector (36.86%), see Figure 21. When focussing on the tertiary sector energy mix, electricity accounted for 49.12% in the same year, representing the highest share among the different energy types.

The total final electricity consumption increased by 27.51% during the 15-years period from 2000 to 2014. In 2014, the EU-28 electricity consumption reached 806.7 TWh, 86.3% of which was consumed by EU-15 areas. A continuous increase with an average growth rate above 3% per year can be observed between 2000 and 2010 in the EU-28. Since 2011 a decreasing trend has been registered leading to a drop by 4.64% in 2014 in comparison to year 2010 when a maximum of 845.9 TWh was reached. In 2011, a fall by 2.61% occurred due to the reduction in the consumption of EU-15 areas (-3.23%), while NMS-13 increased their consumption by 1.38% in the same period.

The overall raise in the final tertiary electricity consumption has been more relevant in the NMS-13 areas than in the EU-15. NMS-13 have indeed undergone a raise by 48.76%, whereas EU-15 areas increased their electricity consumption by 24.69%.

**Figure 113: Final tertiary electricity consumption in the EU-28, 2000-2014. Source: Eurostat**

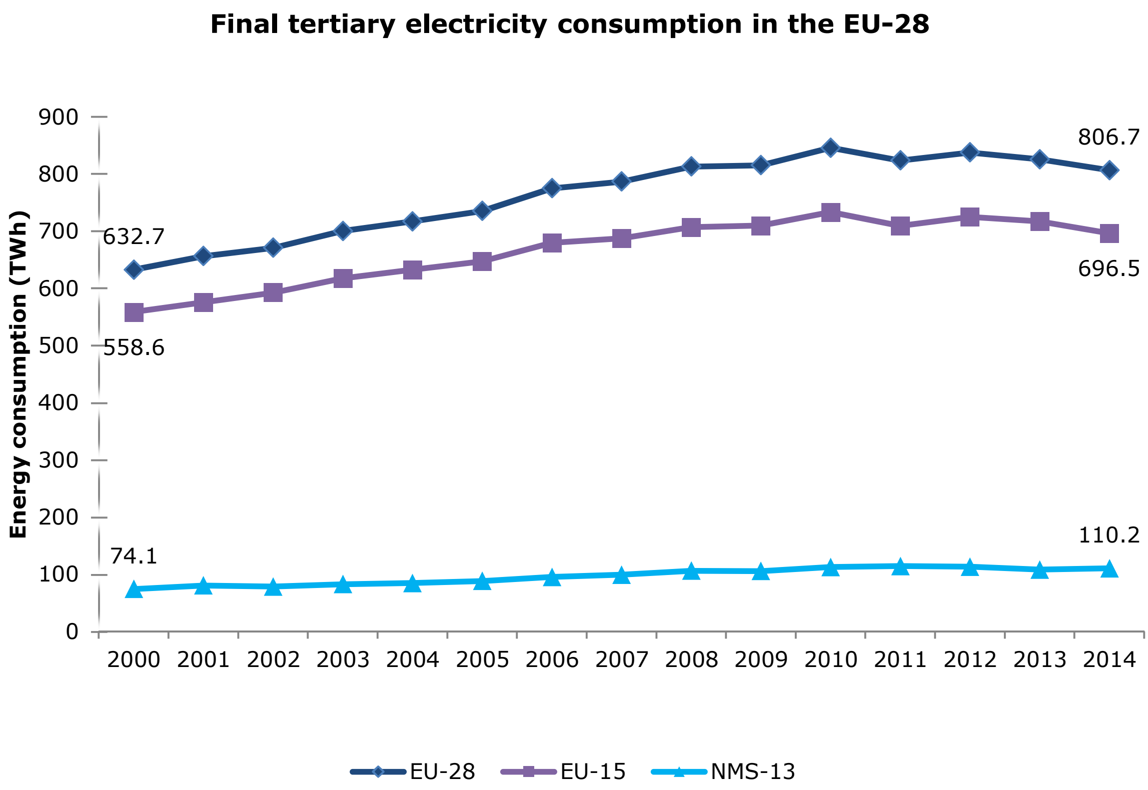
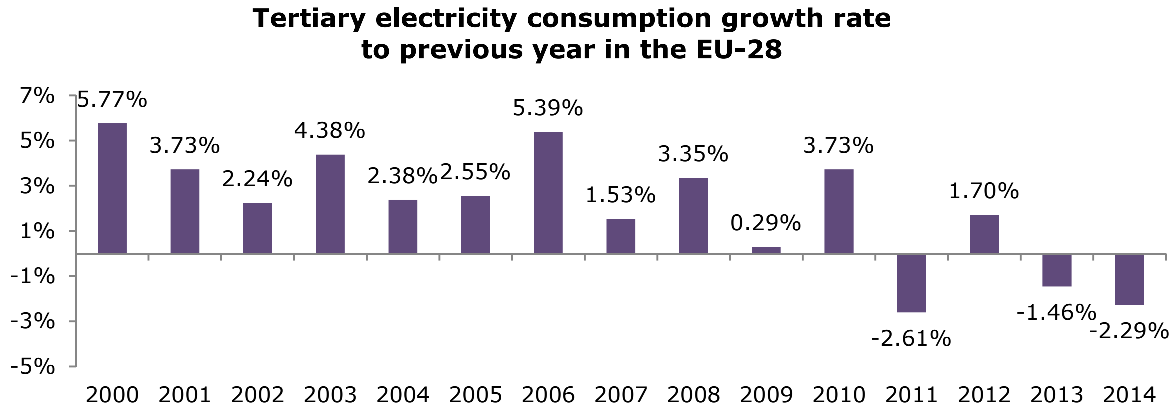
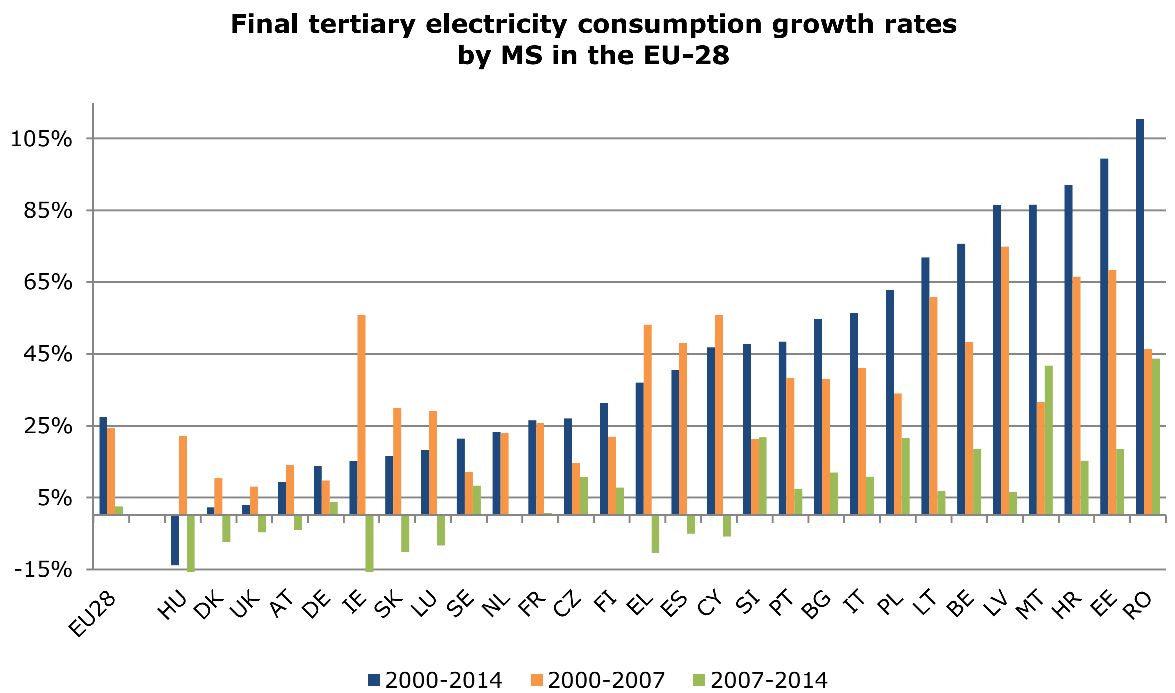


**Figure 114: Tertiary electricity consumption annual growth rates in the EU-28, 2000-2014. Source: Eurostat**




As already mentioned, the final tertiary electricity consumption has increased by 27.5% in the period 2000-2014. Looking at the growth rates of the different Member States, it is observed that twelve MSs have registered a growth rate below the EU-28 average (Figure 115). During the previously mentioned time period, the MSs with the highest growth rates have been Romania (110.5%), Estonia (99.4%) and Croatia (92.0%). In contrast, the MSs with the lowest growth rates have been Hungary (-13.9%), Denmark (2.3%) and the United Kingdom (3.0%). All the MSs show a positive growth rate in the period from 2000 to 2007. The highest growth rates were found in Latvia (75.0%), Estonia (68.3%) and Croatia (66.5%) during this latter time period. In the period from 2007 to 2014, ten EU-28 countries have reversed their growth rate trend and turned them into negative ones. The highest growth rates occurred in Romania (43.8%), Malta (41.8%) and Slovenia (21.8%); while the lowest growth rates took place in Hungary (-29.6%), Ireland (-26.1%) and Greece (-10.5%).

**Figure 115: Final tertiary electricity consumption growth rates by MS in the EU-28; 2000-2014, 2000-2007 and 2007-2014. Source: Eurostat**

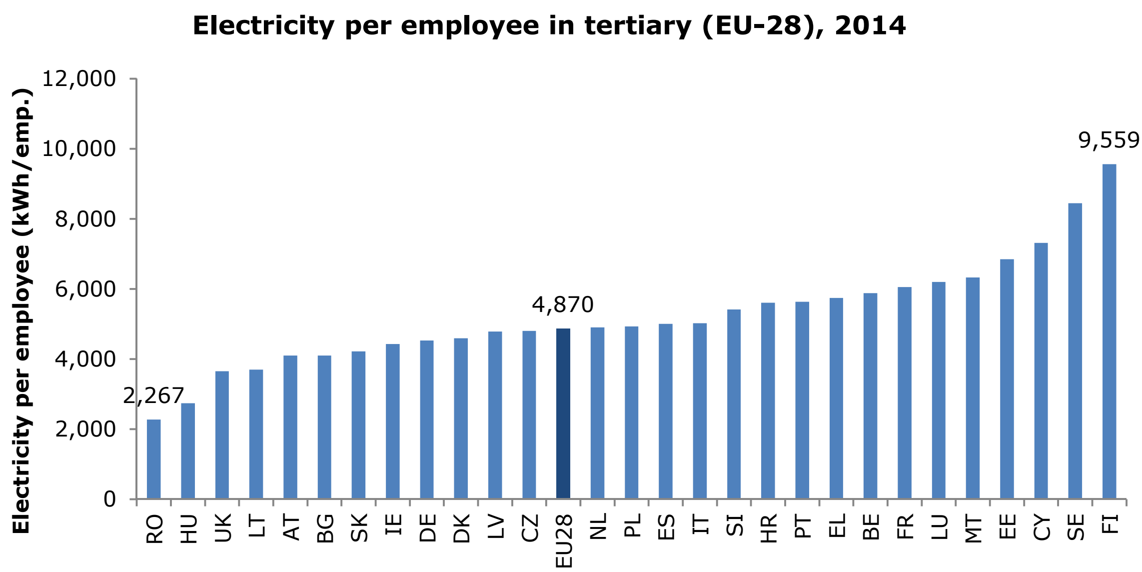


The average annual electricity consumption per employee was 4,870 kWh/emp in the EU-28 in 2014. Sixteen Member States had above EU-28 average electricity consumption per employee as illustrated in Figure 116. The MSs with the highest consumptions per employee were Finland (9,559 kWh/emp), Sweden (8,444 kWh/emp) and Cyprus (7,310 kWh/emp). On the other hand, the countries with the lowest electricity consumptions per employee were Romania (2,267 kWh/emp), Hungary (2,740 kWh/emp) and the United Kingdom (3,654 kWh/emp).

Weather and climatic conditions cannot explain the large per capita electricity consumption differences observed e.g. between Finland and Lithuania. The climatic conditions may not explain this difference as both countries are ranked as first and fifth respectively in the value of Mean Heating Degree days (see Figure 53). Neither, the difference may be explained by referring to only GDP influence, as again, United Kingdom and Finland have e.g. similar values of GDP per capita (see Figure 37). Other factors that might have caused these differences might be the installation of more energy efficient technologies in the tertiary sector, cultural and social habits, energy consumption patterns of different energy types, structural differences in the national economies and/or the combination thereof.

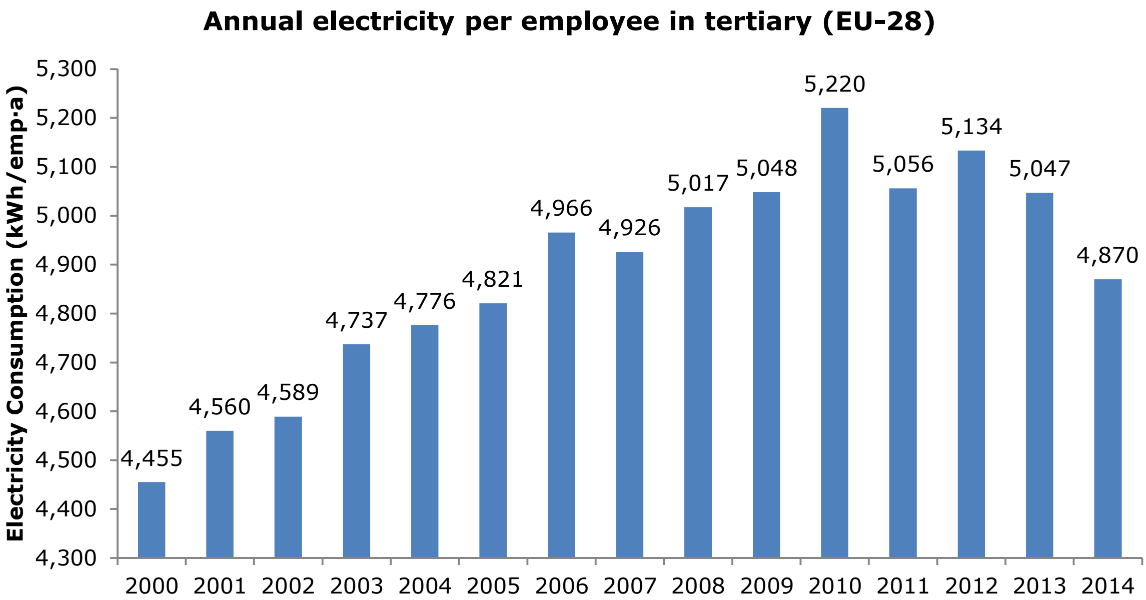
For instance, analysing the general energy consumption values per employee of Sweden and Finland, it is observed that these countries rely more on electricity than on gas as energy type (see Figure 121). While other States, such as Lithuania or Latvia, have below average EU-28 electricity and gas consumption per employee and a high percentage of citizens served by District Heating; indicating a more balanced energy mix in those countries.

**Figure 116: Annual electricity consumption per employee in the tertiary sector in the EU-28, 2014. Source: Eurostat**




The average European electricity consumption per employee has risen by 9.3% in the period from 2000 to 2014. An overall growing trend has been experienced as showed in the following figure. A maximum in the analysed time series was registered in 2010, when the electricity consumption per employee reached 5,220 kWh/emp. The highest values of electricity consumptions per employee have been registered in the period from 2008-2013. In 2014, a fall by 3.5% was registered and led electricity consumption per employee to a value of 4,870 kWh/emp.

**Figure 117: Annual electricity consumption per employee in the EU-28 tertiary sector, 2000-2014. Source: Eurostat**




The following table shows an overview of the final electrical energy consumption in the tertiary sector with a breakdown by Member States.

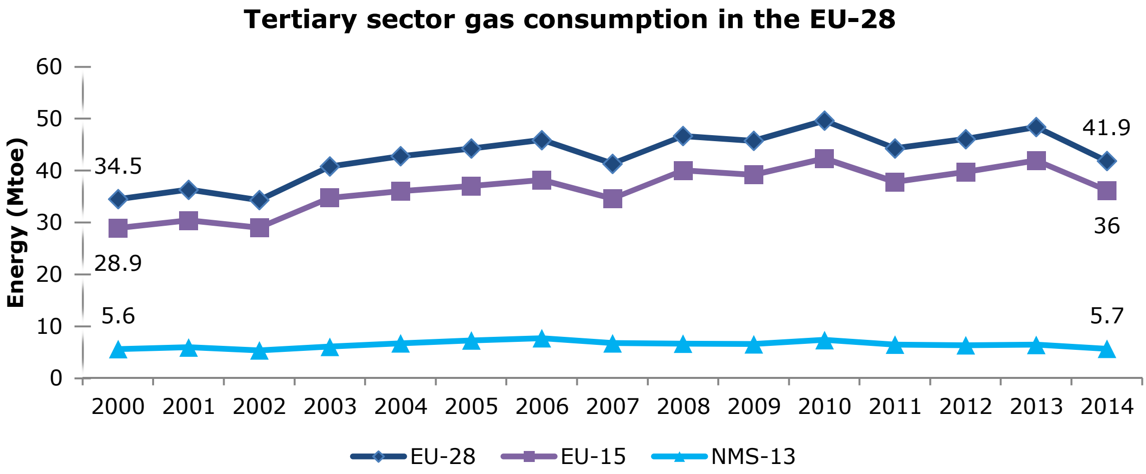
**Table 34: Final tertiary electricity consumption in the EU-28 Member States. Source: Eurostat**

| | Final tertiary electricity energy consumption in the EU-28 (GWh) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2000-2014 (% year) |
| **EU28** | **632.653** | **735.310** | **845.920** | **823.808** | **837.838** | **825.579** | **806.701** | **27,51%** |
| **BE** | 12.236 | 12.703 | 22.182 | 21.653 | 21.954 | 22.261 | 21.501 | 75,72% |
| **BG** | 5.062 | 6.143 | 8.101 | 8.437 | 8.170 | 7.954 | 7.831 | 54,70% |
| **CZ** | 11.559 | 12.530 | 14.620 | 14.413 | 14.506 | 14.353 | 14.680 | 27,00% |
| **DK** | 9.954 | 10.472 | 10.835 | 10.656 | 10.481 | 10.348 | 10.178 | 2,25% |
| **DE** | 125.453 | 137.235 | 154.075 | 146.990 | 150.511 | 150.947 | 142.868 | 13,88% |
| **EE** | 1.401 | 1.929 | 2.511 | 2.378 | 2.536 | 2.530 | 2.795 | 99,50% |
| **IE** | 5.590 | 8.465 | 7.166 | 6.501 | 6.279 | 6.366 | 6.439 | 15,19% |
| **EL** | 12.260 | 16.479 | 18.000 | 16.839 | 18.470 | 17.008 | 16.802 | 37,05% |
| **ES** | 50.023 | 63.823 | 83.892 | 81.300 | 80.212 | 75.569 | 70.309 | 40,55% |
| **FR** | 104.012 | 122.827 | 142.168 | 134.049 | 139.394 | 138.022 | 131.610 | 26,53% |
| **HR** | 2.926 | 4.413 | 5.398 | 5.534 | 5.535 | 5.395 | 5.619 | 92,04% |
| **IT** | 56.595 | 73.875 | 85.619 | 86.912 | 90.279 | 88.982 | 88.489 | 56,35% |
| **CY** | 1.251 | 1.786 | 2.256 | 2.138 | 2.000 | 1.786 | 1.838 | 46,92% |
| **LV** | 1.546 | 2.142 | 2.420 | 2.487 | 2.798 | 2.703 | 2.883 | 86,48% |
| **LT** | 1.872 | 2.686 | 2.839 | 2.953 | 3.114 | 3.130 | 3.218 | 71,90% |
| **LU** | 1.647 | 1.750 | 1.998 | 1.897 | 1.959 | 2.013 | 1.948 | 18,28% |
| **HU** | 8.880 | 9.931 | 11.355 | 11.466 | 11.517 | 7.507 | 7.645 | -13,91% |
| **MT** | 504 | 563 | 817 | 849 | 901 | 908 | 940 | 86,51% |
| **NL** | 28.796 | 33.698 | 36.766 | 36.911 | 36.106 | 36.238 | 35.506 | 23,30% |
| **AT** | 11.586 | 10.989 | 11.953 | 12.051 | 12.636 | 13.265 | 12.671 | 9,36% |
| **PL** | 27.756 | 33.357 | 43.669 | 44.190 | 44.378 | 43.130 | 45.214 | 62,90% |
| **PT** | 11.288 | 14.407 | 16.397 | 16.270 | 16.007 | 15.707 | 16.756 | 48,44% |
| **RO** | 3.908 | 4.000 | 7.581 | 7.869 | 7.897 | 7.961 | 8.223 | 110,41% |
| **SI** | 2.126 | 2.421 | 3.066 | 3.261 | 3.168 | 3.218 | 3.141 | 47,74% |
| **SK** | 5.268 | 6.151 | 8.014 | 8.232 | 6.450 | 7.549 | 6.145 | 16,65% |
| **FI** | 13.286 | 15.522 | 17.845 | 17.262 | 17.856 | 17.504 | 17.458 | 31,40% |
| **SE** | 25.383 | 26.135 | 27.187 | 24.636 | 25.741 | 25.504 | 30.826 | 21,44% |
| **UK** | 90.485 | 98.878 | 97.190 | 95.674 | 96.983 | 97.721 | 93.168 | 2,97% |

## 5.3 Gas consumption trends in the tertiary sector

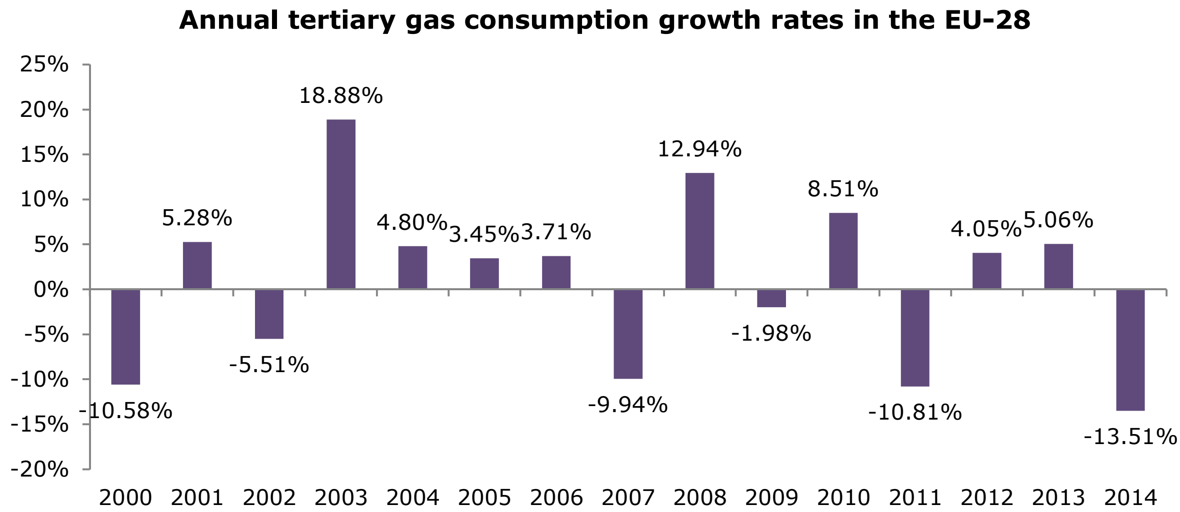
In 2014, 18.26% of the total final gas energy consumption of the EU-28 was generated in the service sector, this being the third highest share after those of the residential sector (40.20%) and the industry sector (38.05%), see Figure 25. When focussing on the tertiary sector energy mix, gas accounted for 29.64% of total final consumption in 2014, representing the second highest share among the different energy types after electricity.

**Figure 118: Final tertiary gas consumption in the EU-28, 2000-2014. Source: Eurostat**




The final tertiary gas consumption in the EU-28 has grown by 21.3% in the period between 2000 and 2014, mainly due to the influence of the EU-15 areas where it has grown by 25.2%. NMS-13 areas have raised their tertiary gas consumption by only 1.1%. In 2014, the EU-28 tertiary gas consumption reached 41.9 Mtoe, out of which 86.5% was consumed by EU-15. The tertiary gas consumption of the NMS-13 was 5.7 Mtoe (Figure 118). From 2000 to 2010 there has been a continuous increase in the consumption (leading to an overall increase of 43.9%) with the exceptions of 2002, 2007 and 2009. The maximum consumption was reached in 2010 (49.6 Mtoe). After an annual decrease by -10.8% occurred in 2011, there has been a rise by 9.3% in the period 2011-2013. In 2014, the tertiary gas consumption has been reduced by -13.5% in comparison to 2013 and has approximately returned to the levels of 2007.

**Figure 119: Annual tertiary gas consumption growth rates in the EU-28, 2000-2014. Source: Eurostat**




There are notable differences across the EU-28 Member States regarding the final tertiary gas consumption growth rates during the period between 2000 and 2014. It can be observed that countries such as Greece, Bulgaria or Estonia have experienced a very large increase in their gas consumptions in this sector in this period. This may be the result of a gradual development of gas networks and a consequent boost in the consumption of this fuel type by those States. Individual case studies and further research would however be needed in order to explain these growth rates. Eleven Member States have registered a below European average growth rate (21.3%) for the same period. The recent financial and economic crisis has had less impact on total EU-28 gas consumption after 2007 compared to other economic sectors, although it has totally reversed the tendencies in countries such as Austria (passed from an increase of 37.3% between 2000-2007 to a decrease of 35.8% in 2007-2014) or Denmark (passed from 43.52% in 2000-2007 to -34.14% in 2007-2014) as illustrated in the following figure.

**Figure 120: Final tertiary gas consumption growth rates by MS in the EU-28; 2000-2014, 2000-2007 and 2007-2014. Source: Eurostat**

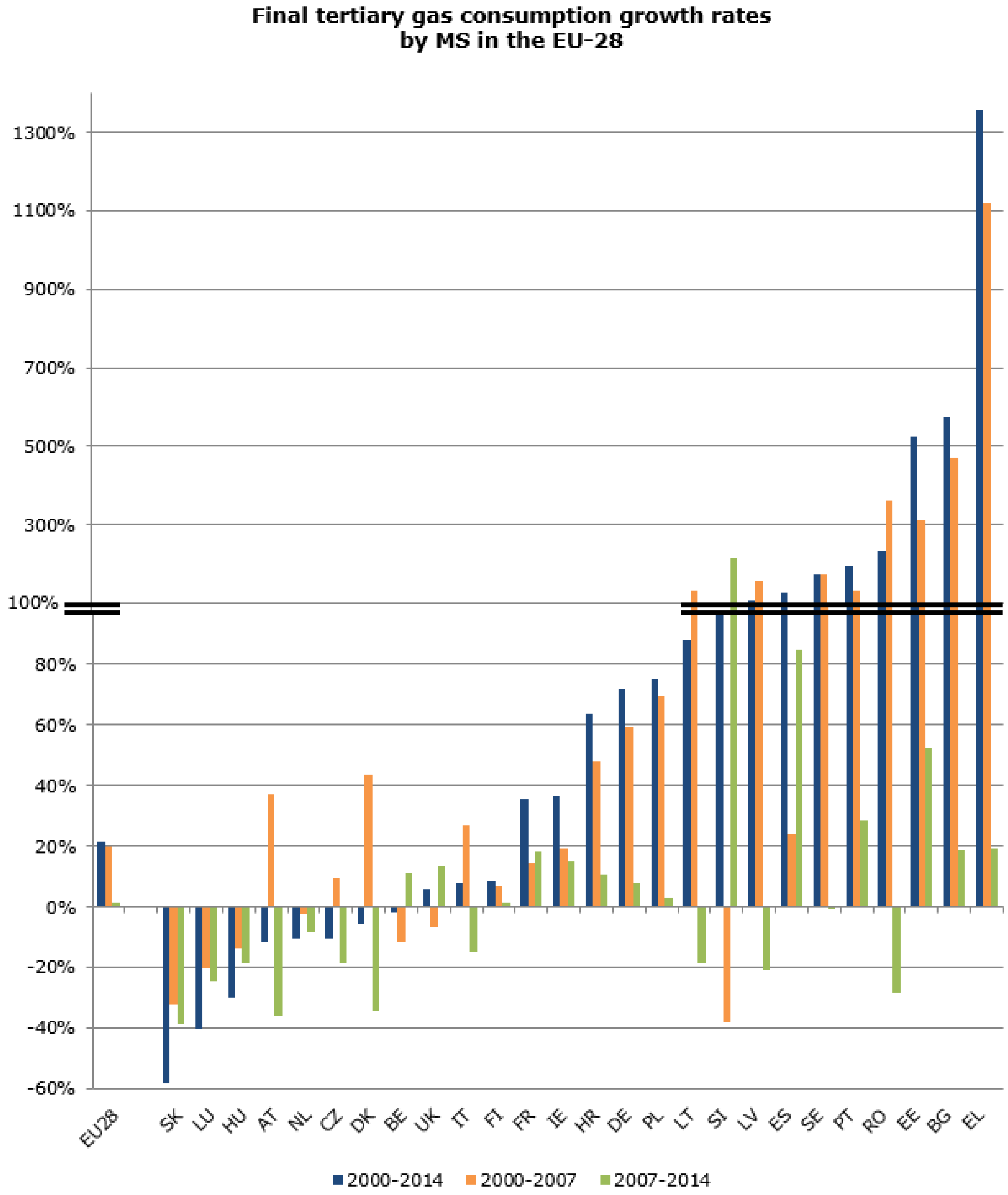
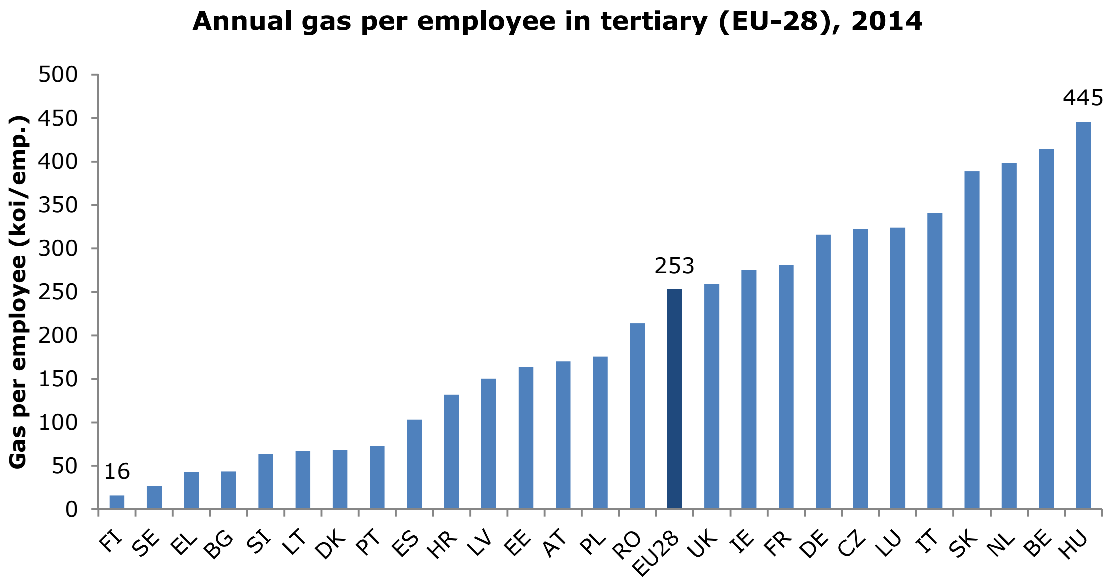
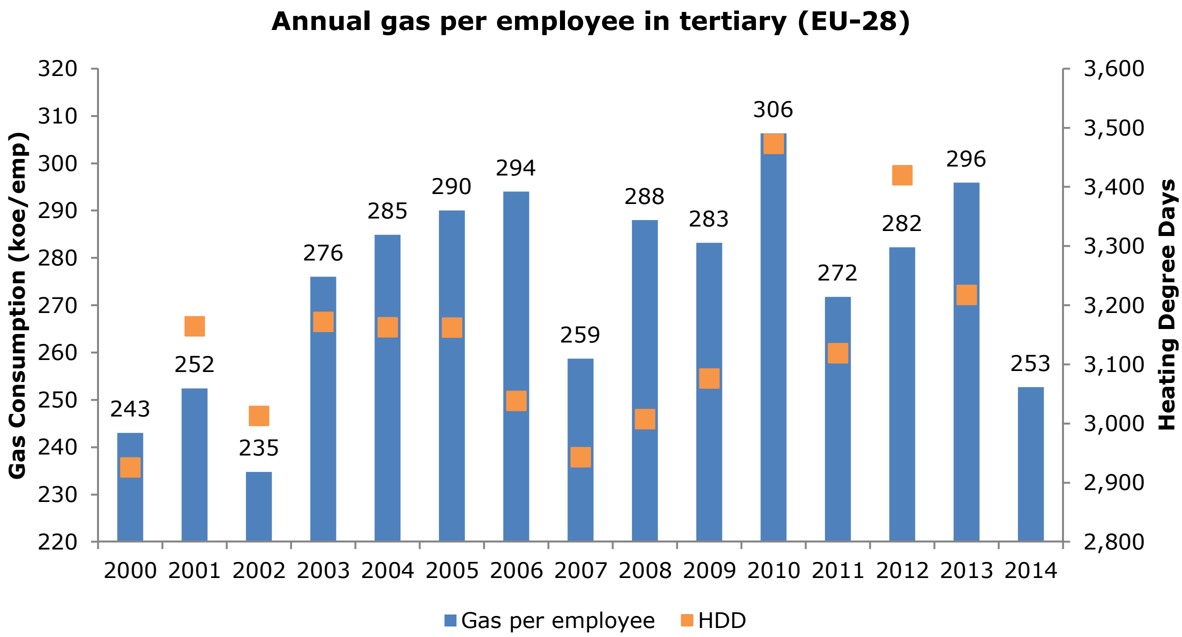


**Figure 121: Annual final gas consumption per employee in the tertiary sector in the EU-28 Member States, 2014. Source: Eurostat[114]**




The average gas consumption per employee in the EU-28 in the tertiary sector was 253 koe/emp in the year 2014. There are notable differences among the EU-28 Member States. The European country with the lowest gas consumption per employee was Finland which registered 16 koe/emp, followed by Sweden (27 koe/emp) and Greece (43 kow/emp). On the other hand, the Member State with the highest consumption was Hungary 445 koe/emp. Second was Belgium (414 koe/emp) and third the Netherlands (399 koe/emp). Eleven countries registered consumption levels above EU-28 level as illustrated in the figure below.

**Figure 122: Annual final gas consumption per employee in the tertiary sector in the EU-28, 2000-2014. Source: Eurostat**




114 Data for Cyprus and Malta equal zero.

Unlike electricity usage which can be used for other purposes, gas usage has heating as major application. Therefore, the qualitative correlation between gas consumption per employee in the tertiary sector and the weather conditions (heating degree days) is a matter of higher interest in this case. Figure 122 shows degree days and gas consumption per employee in the EU-28 for the 15-years period from 2000 to 2014. During this period, the gas consumption per employee in the EU-28 has raised by 4.1% (from 243 koe/emp in 2000 to 253 koe/emp in 2014). The maximum value was achieved in 2010 (306 koe/emp) when the highest HDD value (3,473) was also achieved.

The following table shows an overview of the final gas energy consumption in the tertiary sector with a breakdown by Member States.

**Table 35: Final tertiary gas consumption in the EU-28 Member States. Source: Eurostat**

| Final tertiary gas energy consumption, EU-28 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **(ktoe)** | **2000** | **2005** | **2010** | **2011** | **2012** | **2013** | **2014** | **2000-2014 (% year)** |
| **EU28** | **34,506.9** | **44,242.9** | **49,640.1** | **44,274.8** | **46,069.7** | **48,399.5** | **41,858.3** | **21.3%** |
| **BE** | 1,545.3 | 1,770.9 | 1,953.3 | 1,562.4 | 1,695.5 | 1,930.0 | 1,515.5 | -1.9% |
| **BG** | 12.3 | 43.6 | 80.1 | 82.6 | 81.7 | 78.0 | 83.2 | 576.4% |
| **CZ** | 1,103.7 | 1,273.6 | 1,378.3 | 1,289.8 | 1,188.1 | 1,210.1 | 987.6 | -10.5% |
| **DK** | 160.4 | 221.3 | 227.6 | 177.8 | 198.4 | 205.2 | 151.6 | -5.5% |
| **DE** | 5,806.5 | 9,228.1 | 9,953.1 | 8,961.6 | 9,135.4 | 10,696.8 | 9,969.7 | 71.7% |
| **EE** | 10.7 | 46.2 | 29.7 | 31.0 | 34.9 | 43.3 | 66.8 | 524.3% |
| **IE** | 292.7 | 297.9 | 439.3 | 365.6 | 400.2 | 406.0 | 400.5 | 36.8% |
| **EL** | 8.6 | 73.8 | 139.0 | 164.8 | 138.0 | 124.7 | 125.3 | 1357.0% |
| **ES** | 632.4 | 706.4 | 1,064.6 | 1,755.6 | 1,617.7 | 1,497.2 | 1,450.5 | 129.4% |
| **FR** | 4,518.3 | 5,579.0 | 6,691.1 | 5,615.7 | 6,764.4 | 7,213.4 | 6,111.6 | 35.3% |
| **HR** | 80.9 | 124.4 | 157.7 | 141.9 | 132.3 | 136.1 | 132.5 | 63.8% |
| **IT** | 5,571.8 | 7,434.4 | 8,613.8 | 7,254.5 | 7,276.4 | 7,259.0 | 6,012.1 | 7.9% |
| **LV** | 44.2 | 93.7 | 115.6 | 104.4 | 98.0 | 83.6 | 90.6 | 105.0% |
| **LT** | 31.1 | 50.6 | 66.4 | 60.1 | 63.3 | 63.2 | 58.4 | 87.8% |
| **LU** | 169.7 | 122.7 | 154.1 | 115.6 | 134.1 | 129.7 | 101.8 | -40.0% |
| **HU** | 1,773.1 | 2,280.9 | 1,715.2 | 1,725.8 | 1,387.1 | 1,407.9 | 1,243.1 | -29.9% |
| **NL** | 3,227.3 | 3,523.1 | 4,035.1 | 3,221.7 | 3,633.4 | 3,646.4 | 2,887.5 | -10.5% |
| **AT** | 597.0 | 917.4 | 742.2 | 631.3 | 575.3 | 581.7 | 526.4 | -11.8% |
| **PL** | 921.3 | 1,634.0 | 1,993.2 | 1,870.1 | 1,932.3 | 1,827.4 | 1,610.6 | 74.8% |
| **PT** | 73.0 | 136.3 | 196.3 | 217.6 | 217.9 | 218.9 | 215.9 | 195.8% |
| **RO** | 234.6 | 781.6 | 935.6 | 756.0 | 764.0 | 784.6 | 775.8 | 230.7% |
| **SI** | 18.7 | 25.5 | 23.6 | 39.4 | 13.2 | 31.8 | 36.7 | 96.3% |
| **SK** | 1,360.1 | 900.6 | 843.0 | 356.8 | 644.2 | 771.9 | 567.3 | -58.3% |
| **FI** | 27.0 | 31.5 | 30.6 | 37.1 | 33.5 | 34.8 | 29.3 | 8.5% |
| **SE** | 35.9 | 95.2 | 107.1 | 96.4 | 123.8 | 108.1 | 98.5 | 174.4% |
| **UK** | 6,250.3 | 6,849.9 | 7,954.7 | 7,639.3 | 7,786.5 | 7,909.6 | 6,609.7 | 5.8% |

**Data for CY and MT equal zero.**

## 5.4 Overview – Tertiary sector

The tertiary sector represented about 74% of the EU-28 GDP in the year 2014. Tertiary sector is related to activities such as professional, scientific and technical services, public administration, wholesale, retail, etc. These activities which have caused an employment increase by 3,409 thousand units across the EU-28 during the period from 2010 to 2014.

In 2014, the tertiary sector accounted for 13.31% of total European final energy consumption. The final energy consumption of the sector has grown by 16.5% (from 121 Mtoe to 141 Mtoe) in the 15-years period from 2000 to 2014. A similar increase has been followed by EU-15 and NMS-13 areas which have grown by 16.19% and 18.27% respectively. The sector registered a final energy consumption of 141.2 Mtoe in 2014, out of which 85.9% (121.2 Mtoe) was generated by EU-15 areas. The maximum consumption occurred in the year 2010 (157.7 Mtoe). Annual consumption falls around 6.5% as registered in 2011 and 2014 have led the final tertiary energy consumption to 2007 levels.

Very different growth rates have been registered across the EU-28 Member States. In the period from 2000 to 2014, the MSs with highest reduction rate of final tertiary energy consumption are Slovakia (-40.58%), Hungary (-25.93%) and Slovenia (-18.88%). The Member States with the highest growth rates in the tertiary sector are Malta (183.83%), Romania (162.65%) and Cyprus (85.69%), all of them belonging to NMS-13.

Compared to the period 2000-2007, a significant change in the growth rates occurred during 2000-2007 in countries such as Romania where from a growth rate of 200% in the period 2000-2007, a decrease of 12.44% was registered during 2007-2014 period, Ireland, Greece, Latvia and Austria. In general terms, the growth rates variations between these two time periods are not as significant as the variations occurred in other economic sectors. This can be the result of an on-going tertiarization process at European level.

The energy mix in the final energy consumption in the EU-28 in the tertiary sector in 2014 was mainly made by three energy types which accounted for above 90% of the total. Electricity achieved the highest share (49.12%), followed by gas (29.64%) and petroleum products (10.82%). A reduction by 7.87% in the share of petroleum products is one of the main occurred changes in comparison with the scenario of year 2000. Electricity (+4.25%) and gas (+1.18%) have instead acquired larger shares as happened also for derived heat, renewables and solid fuels.

Weather and climate conditions as well as economic growth and employment growth can be energy consumption influencing factors in the tertiary sector. Comfort conditions (e.g. temperature or humidity levels) are other important influencing factors in the tertiary sector as it includes the public sector, professional, scientific and technical activities, services and commerce. In general terms, the electricity consumption per employee show a correlation with the values of HDD. With regard to the employment creation during the period 2000-2014, the sector has increased by 16.7% (by creating about 23.6 million of new employees). Despite this favourable trend, there is a clear impact on the employment creation rates by the financial and economic crisis. It is indeed observed that the period 2000-2010 registered a 14.1% growth rate whereas the period 2010-2014 registered an increase by only 2.2%.

The total final energy consumption per employee is a very interesting to consider in the tertiary sector. In 2014, its average European value was 0.85 toe/emp. Across the EU-28 Member States, the highest values were registered in Finland (1.57 toe/emp.), Luxembourg (1.25 toe/emp.), and Sweden (1.21 toe/emp.); while the lowest values were in Bulgaria and Romania (0.49 toe/emp.), Greece (0.58 toe/emp.) and the United Kingdom (0.62 toe/emp.)

The total final electricity consumption in the service sector accounted for 29.81% of the total final electricity of the EU-28 in 2014. This sector was the second highest consumer after the industry sector (36.86%). Regarding the tertiary sector energy mix, electricity accounted for 49.12% of the total final energy consumption in the same year, confirming electricity as the main consumed fuel type.

The final electricity consumption trend in the service sector shows an increase in the consumption by 27.51% (from 632.7 TWh to 806.7 TWh) during the 15-year period from 2000 to 2014. The raise in the consumption has been more relevant in the NMS-13 (48.76%) countries than in the EU-15 (24.69%).

Concerning the growth rates of the different Member States, it is observed that twelve MSs have showed growth rates below the average EU-28 growth rate (+27.51%) during the period 2000-2014. The MSs with highest growth rates have been Romania (110. 5%), Estonia (99.4%) and Croatia (92.0%). The lowest growth rates have been registered in Hungary (-13.9%), Denmark (2.3%) and the United Kingdom (3.0%); these last two values might be the result of energy efficiency actions. To be noted that all the MSs show a positive growth rate in the period from 2000 to 2007. Nevertheless, this trend changed in the period from 2007 to 2014 during which ten EU-28 countries have reversed their growth rates turning them into negative ones.

The electricity consumption per employee in the EU-28 for the year 2014 was 4,870 kWh/emp. Sixteen Member States had above average electricity consumption per employee. The highest consumption per employee were registered in Finland (9,559 kWh/emp), followed by Sweden (8,444 kWh/emp) and Cyprus (7,310 kWh/emp); whereas the countries with lowest electricity consumption per employee were Romania (2,267 kWh/emp), Hungary (2,740 kWh/emp) and the United Kingdom (3,654 kWh/emp) in the same year. The average European electricity consumption per employee has increased by 9.3% in the period from 2000 to 2014. The maximum registered value occurred in 2010 (5,220 kWh/emp). The highest electricity consumptions per employee have been registered in the period 2008-2013. In 2014, electricity consumption per employee was 4,870 kWh/emp; representing a drop by 3.5% in comparison to year 2013.

The final gas consumption in the service sector accounted for 18.26% of the total final gas consumption of the EU-28 in 2014. This sector was the third highest gas consumer after the residential sector (40.20%) and the industry sector (38.05%). Regarding the tertiary sector energy mix, gas accounted for 29.64% of the total final energy consumption in the same year, representing the second highest share among the different energy types after electricity.

The final gas consumption trend in the service sector shows an increase in the consumption by 21.3% (from 34.5 to 41.9 Mtoe) during the 15-years period from 2000 to 2014. The raise in the consumption have been mainly due to the EU-15 areas which have increased their consumption by 25.2%. NMS-13 areas have instead only raised their tertiary gas consumption by 1.1%.

Per employee gas consumption in the EU-28 was 253 koe/emp in the year 2014. In the same year the Member States with the highest gas consumption per employee were Hungary (445 koe/emp), Belgium (414 koe/emp), and the Netherlands (399 koe/emp). On the other hand, the European countries with the lowest gas consumption were Finland (16 koe/emp), Sweden (27 koe/emp) and Greece (43 koe/emp).

Gas as energy fuel has its major application in heating applications. Therefore it is of interest to analyse gas consumption correlation with the weather conditions (Heating Degree Days). Per employee gas consumption has raised by 4.1% (from 243 koe/emp to 253 koe/emp) in the EU-28 for the 15-years period from 2000 to 2014. The maximum value (306 koe/emp) during the analysed period was achieved in 2010. This year corresponded to the year with the highest HDD value (3,473). A positive correlation can qualitatively established between the number heating degree days and the energy consumptions values in the various years.

From 2000 to 2010, there was a continuous increase in the annual consumption with the exceptions of 2002, 2007 and 2009. During this period gas consumption has totally increased by 43.9%. In 2014, the tertiary gas consumption has instead been reduced by -13.5% compared to the previous year so approximately returning to 2007 levels.

There are notable differences across the EU-28 Member States regarding the final tertiary gas consumption growth rates during the period comprised from 2000 to 2014. Member States such as Greece, Bulgaria or Estonia which have registered the highest growth rates during this 15-years period have experienced an extensive increase (>500%) in their gas consumptions in this sector. These values are most probably due to the introduction and development of gas networks and installations. Eleven Member States have registered below European average growth rate (21.3%) for the same period. The impact of the financial and economic crisis (after 2007) on total EU-28 gas consumption has been less relevant compared to other economic sectors, although it has entirely reversed the tendencies in countries such as Austria (passed from an increase of 37.3% to a decrease of -35.8%) or Denmark (passed from 43.52% to -34.14%) during the time periods 2000-2007 and 2007-2014.

# 6. Energy Consumption Trends and Environmental Performances of the Transport Sector

This chapter covers the energy consumption trends in the transport sector including a breakdown into subsectors such as rail, road, international and domestic aviation and domestic navigation. Complementing the analysis of energy consumption, an insight of road sector, passenger and freight transport and carbon dioxide emissions is given.

## 6.1 Final energy consumption and energy mix of the transport sector

The transport sector accounted for 33.22% of total final energy consumption in the year 2014 (Figure 6), confirming transportation as the main consuming sector.

The final energy consumption in the EU-28 transport sector has grown by 2.2% in the 15-years period from 2000 to 2014. This increase has not been followed in the same way by both EU-15 and NMS-13 areas. EU-15 areas have reduced its consumption by 2.3%, whereas NMS-13 have increased by 47.5% their final energy demand. In 2014, the final energy consumption reached 352.5 Mtoe, out of which 87.1% (307.0 Mtoe) was accounted by EU-15 areas and the remainder 12.9% (45.5 Mtoe) was consumed in the NMS-13. The maximum consumption of this period took place in the year 2007 when the EU-28 consumption reached 383.0 Mtoe, while the minimum during the analysed period corresponds to year 2000 (344.9 Mtoe). There is a reversing trend as before and after the year 2007 as illustrated in Figure 123 and Figure 124. From the period 2000 to 2007, there was an increasing trend which set positive growth rates (average growth rate of +1.4% per year) for all the years. In contrast, from 2007 onwards there has been undergone a fall in the final energy consumption with an average reduction of 1.2% per year. In 2014, the final energy consumption in the transport sector grew by 1.4%; value which breaks the existing decreasing trend underwent until 2013. This break was expected as per the end of the economic recession.

**Figure 123: Final energy consumption in the transport sector in the EU-28, 2000-2014. Source: Eurostat**

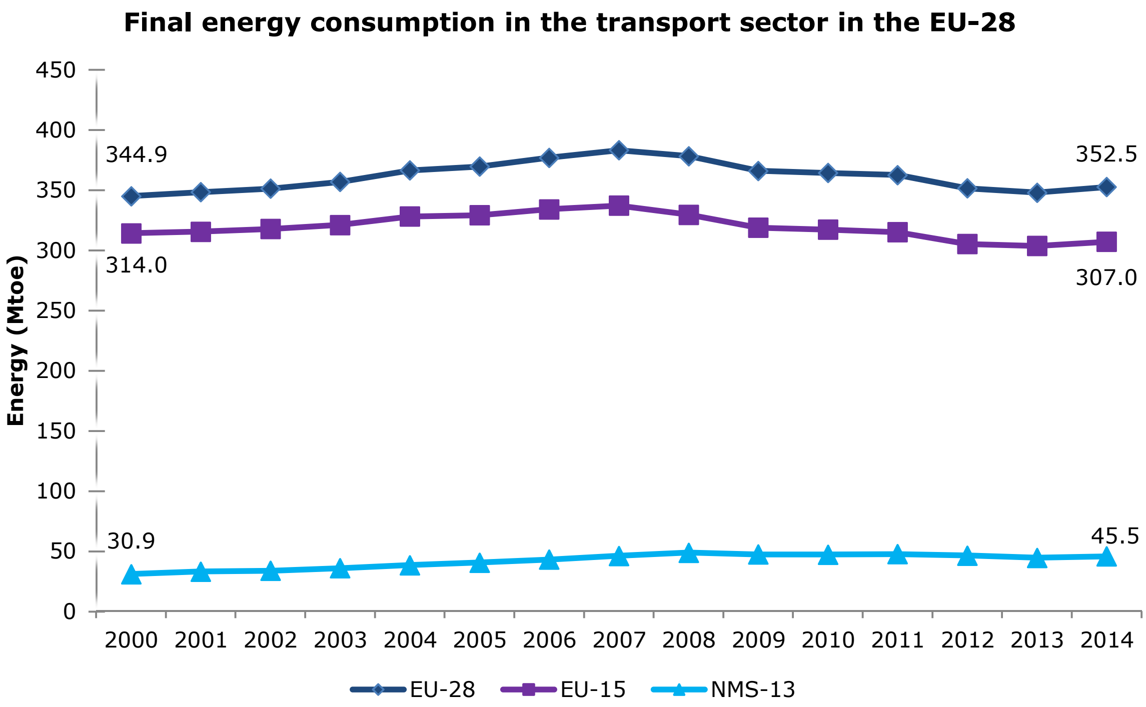
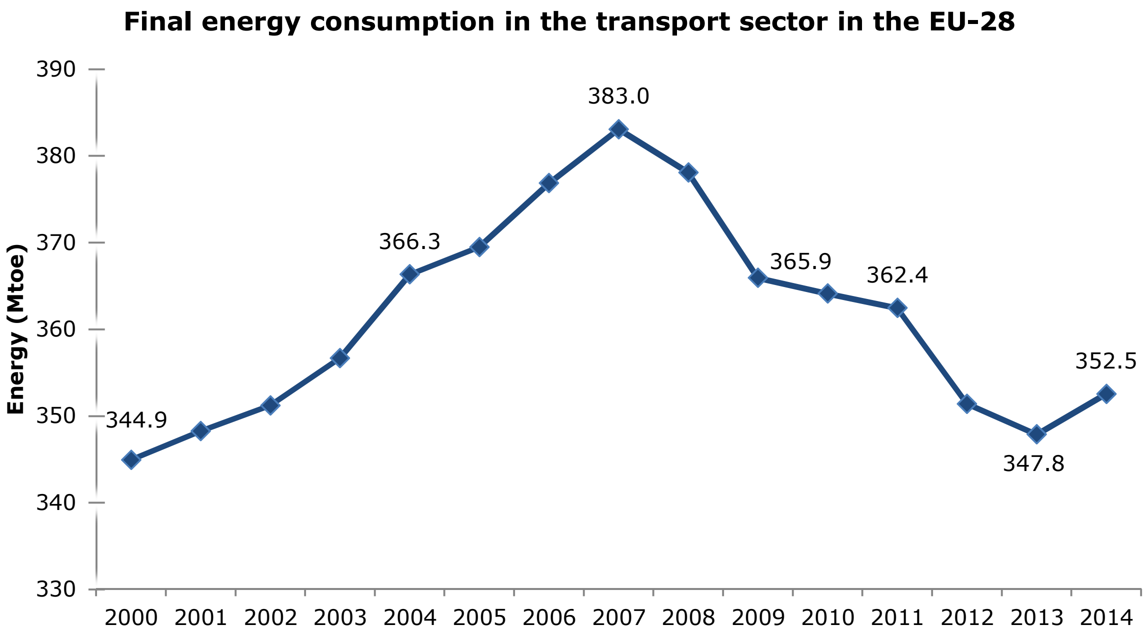


**Figure 124: Final energy consumption in the transport sector in the EU-28, 2000-2014 (detailed). Source: Eurostat**




From the period from 2000 to 2007, the highest growth rate between two consecutive years of the series occurred in 2004 when there was an increase by 2.7 in comparison to the previous year. In contrast, 2009 registered the lowest growth rate (-3.2%) in comparison to the previous year. The reduction of the energy consumption in the transport level may be explained, among others, by the impact of the financial and economic crisis which peaked between 2007 and 2008.

**Figure 125: Annual energy consumption growth rates in the EU-28 transport sector, 2000-2014. Source: Eurostat**

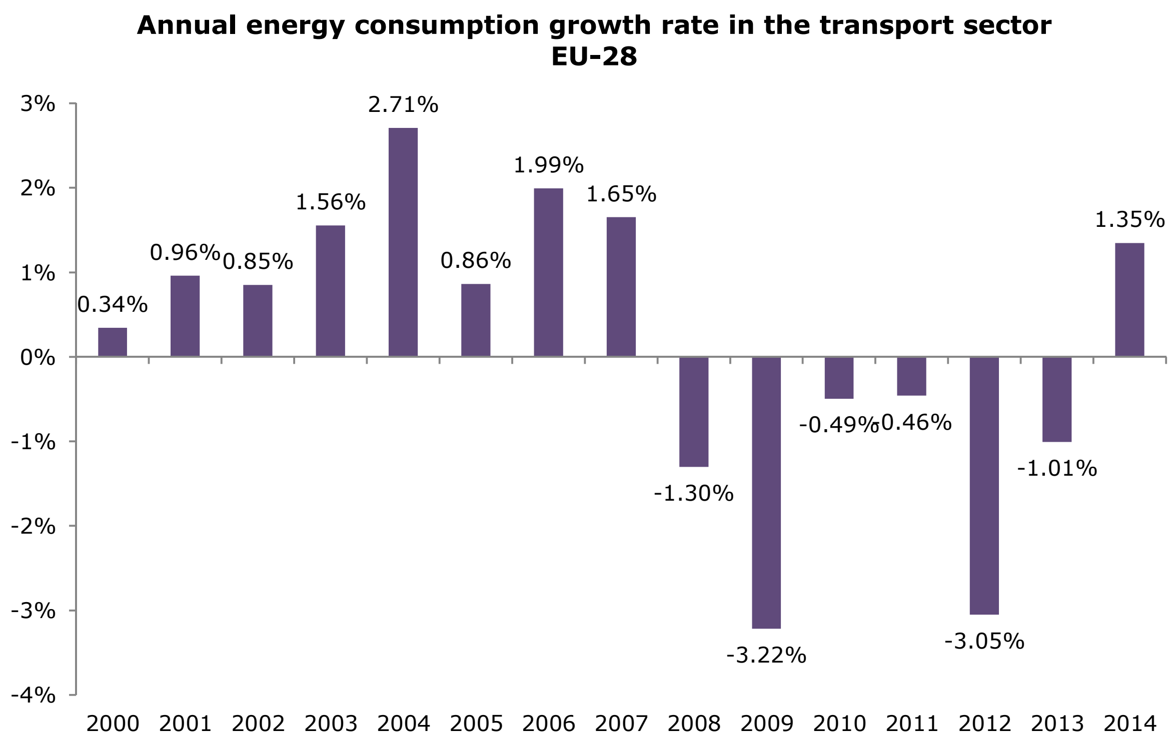
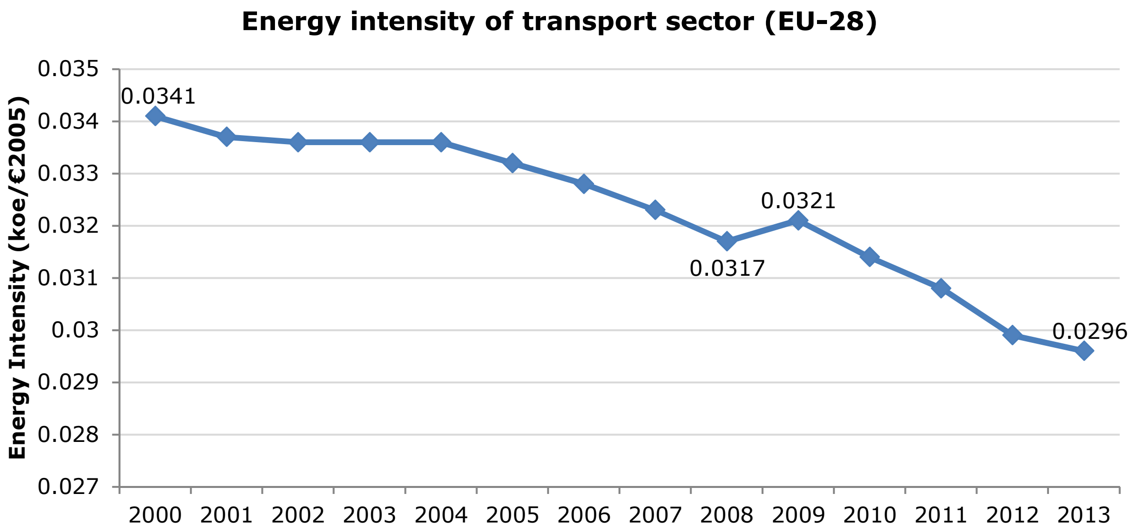


**Figure 126: Energy intensity of transport sector in the EU-28, 2000-2013. Source: Odyssee**

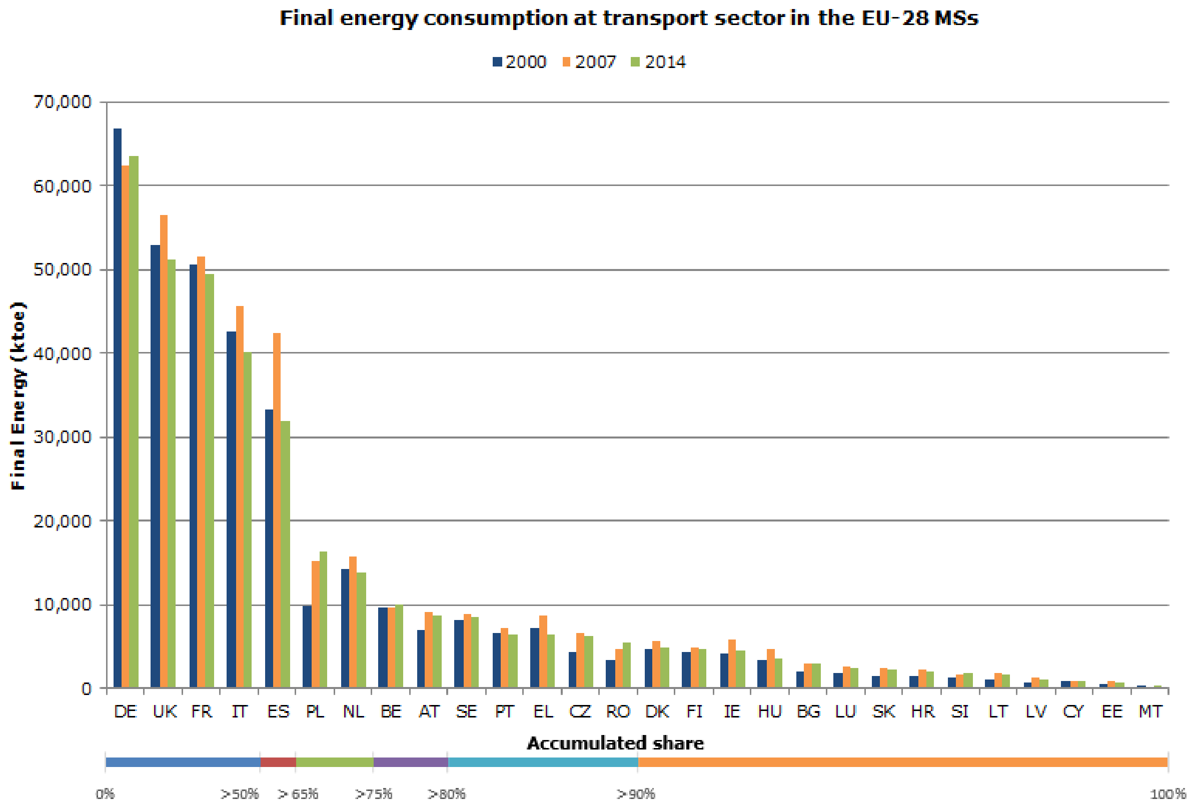



During the period from 2000 to 2013, the energy intensity in the transport sector has decreased by 13.2% until registering the value of 0.0296 koe/€2005 in 2013. The lowering trend along the whole period was interrupted in 2009 by a rise of 1.3% as per the consequence of the impact of the financial and economic crisis in the GDP values.

In 2014, the Member State with the highest consumption at transport sector was Germany (63.5 Mtoe), followed by the United Kingdom (51.1 Mtoe) and France (49.5 Mtoe). Back in 2000, all three countries occupied the same positions in the ranking of the most final energy consumers for transportation.

The mentioned three Member States together Italy accounted for more than 55% of the final energy consumption in the sector. Whether Spain is added, the share reaches more than 65% of the final energy consumption. Fourteen Member States accumulated more than 90% of the final energy consumption in 2014 (see figure below).

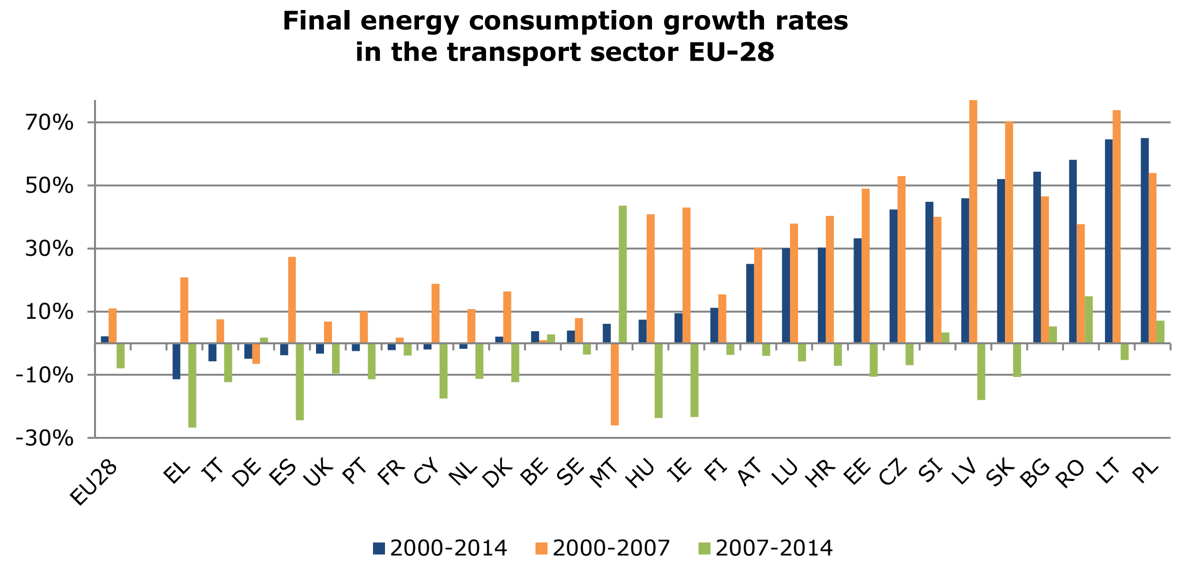
**Figure 127: Final energy consumption and accumulated share at transport sector in the EU-28 Member States, 2000, 2007 and 2014. Source: Eurostat**




The evolution and changes along the 15-years period from 2000 to 2014 in the different European States can be better analysed by the growth rates changes in their final energy consumption. The States with the highest growth rates in the final energy consumption in the transport sector between 2000 and 2014 have been Poland (65.0%), Lithuania (64.7%) and Romania (58.2%), while the Member States with the lowest growth rates were Greece (-11.4%), Italy (-5.7%) and Germany (-5.0%). Ten EU-28 countries registered below average European values in the same period (< 2.2%).

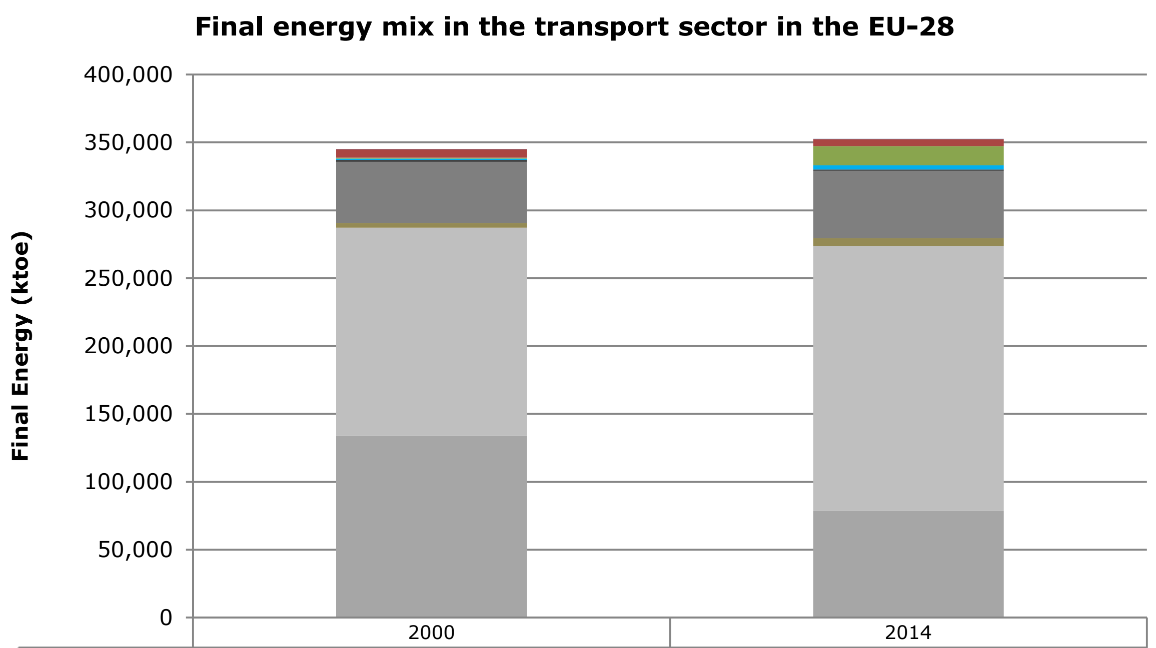
In the period 2000-2007, all the Member States with the exception of Germany and Malta registered increased in their final energy consumption. The average European growth rate was 11.1% during the same period. The trends were significantly different in the period from 2007 to 2014 when seven Member States recorded a positive growth rate (see Figure 128). This latest sub-period reflects the energy consumption decline produced by the financial and economic crisis (after 2007) which can be clearly observed in the overall European final energy consumption trend.

**Figure 128: Final energy consumption growth rates at transport sector in the EU-28 Member States; 2000-2014, 2000-2007 and 2007-2014. Source: Eurostat**




The final energy mix in the transport sector in mainly provided by petroleum products. Petroleum products represented 93.63% (330,058 ktoe) in 2014. This represents a reduction in the share in comparison to 2000 (97.75%; 337,138 ktoe).

**Figure 129: Final energy mix in the transport sector in the EU-28 (absolute numbers), 2000 and 2014. Source: Eurostat**

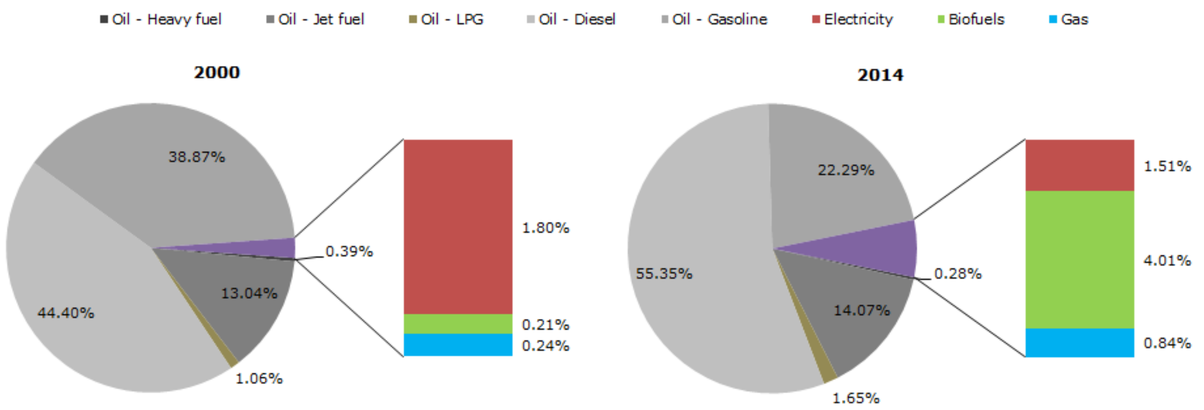



| | 2000 | 2014 |
|---|---|---|
| Solid fuels | 9.8 | 8.6 |
| Electricity | 6,222.0 | 5,337.7 |
| Biofuels | 709.3 | 14,141.3 |
| Gas | 813.5 | 2,955.8 |
| Oil - Heavy fuel | 1,349.1 | 984.2 |
| Oil - Jet fuel | 44,976.5 | 49,589.1 |
| Oil - LPG | 3,652.6 | 5,812.5 |
| Oil - Diesel | 153,117.4 | 195,107.4 |
| Oil - Gasoline | 134,042.7 | 78,564.8 |

Among the petroleum products stand out: diesel and gasoline. In 2014, oil-diesel accounted for 55.4% (195,107 ktoe) and gasoline for 22.3% (78,565 ktoe). The remaining shares were completed by jet fuel (14.1%; 49,589 ktoe), biofuels (4.0%; 14,141 ktoe), LPG (1.7%; 5,813 ktoe), electricity (1.5%; 5,338 ktoe), gas (0.84%; 2,956 ktoe), and heavy fuel (0.28%; 984.2 ktoe). Solid fuels represented a negligible share in the final energy mix (0.002%; 8.6 ktoe).

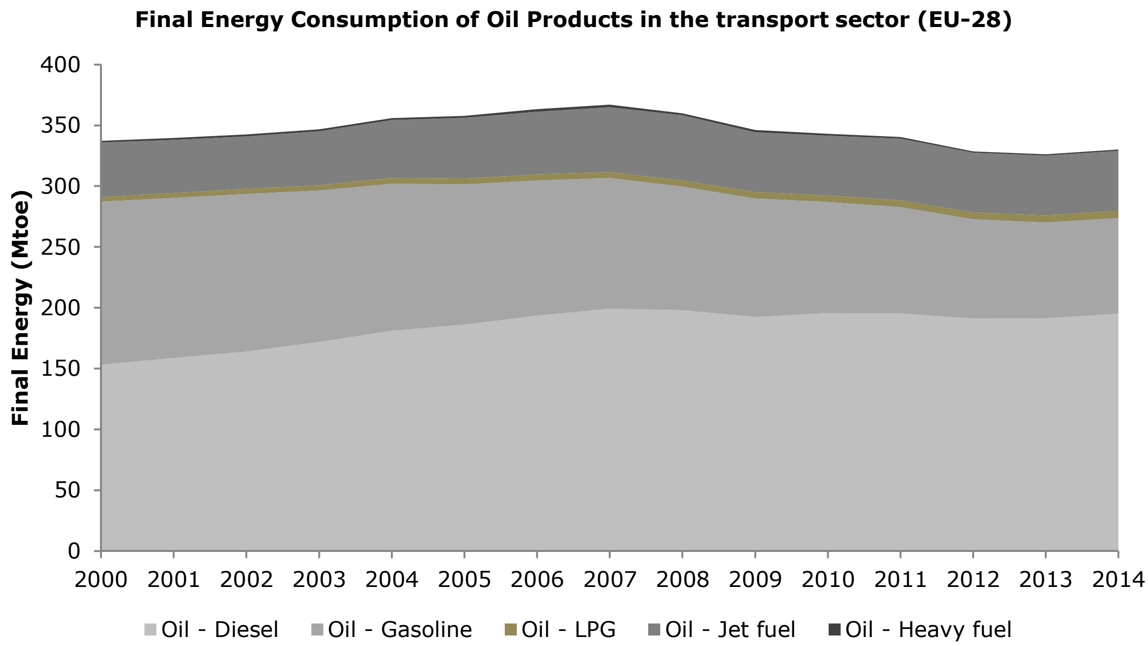
A reduction in the gasoline share by 16.6% (55.5 Mtoe), together with increases by 11.0% (42.0 Mtoe) and 3.8% (13.4 Mtoe) in the shares of diesel and biofuels respectively constituted the most significant changes in the final energy mix in comparison to year 2000 scenario.

**Figure 130: Final energy mix in the transport sector in the EU-28 (shares), 2000 and 2014. Source: Eurostat**



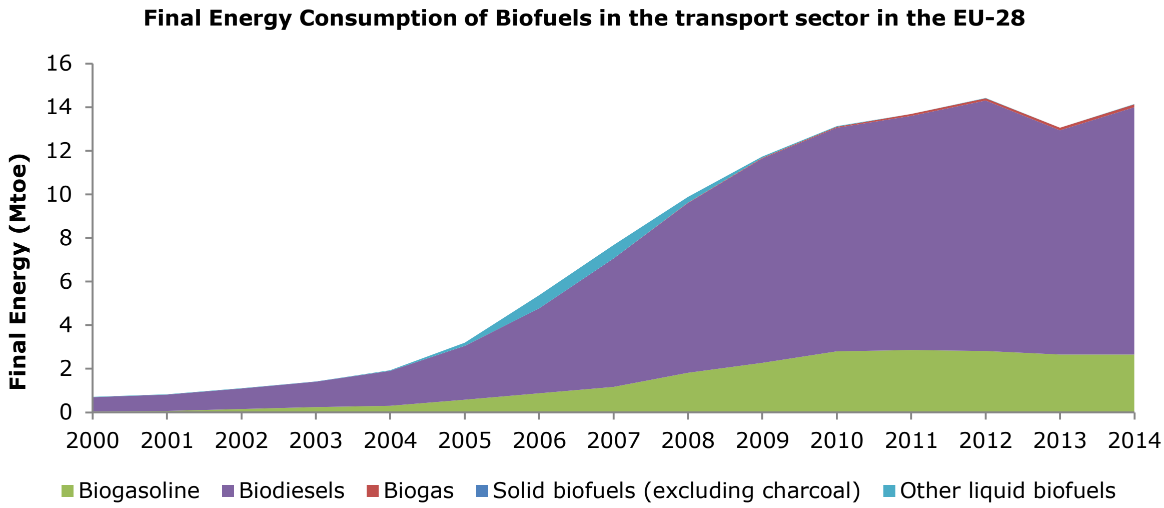

From 2000 to 2014, the petroleum products consumption has drop by 2.1% (7.1 Mtoe). During this period the diesel has gradually increased its presence; diesel's consumption has increased by 59.1%, while gasoline has declined by 41.4%. Heavy fuel has registered a significant fall by 27.1% (-364.9 ktoe) in the same period. The changes in the petroleum products consumption have occurred gradually during the analysed 15-years period as illustrated in Figure 131.

**Figure 131: Final energy consumption of oil products in the EU-28 transport sector, 2000-2014. Source: Eurostat**



Despite petroleum products are the main fuel type in the transport sector, the renewable energies (biofuels) increase in the energy mix is a fact to consider as the production of transport fuels from biomass, in either liquid or gaseous form, holds the promise of a low net fossil-energy requirement and low life-cycle greenhouse gas (GHG) emissions [51].

**Figure 132: Final energy consumption of biofuels in the EU-28 transport sector, 2000-2014. Source: Eurostat**




The biofuels have highly developed during the period from 2000 to 2014. The increase in the consumption took place especially between 2005 and 2010 when the consumption rose by four times (from 3,199 ktoe to 13,137 ktoe); increase directly bound to the growth of biodiesels. Biodiesels represent the highest consumed renewable fuel type (see Figure 132). Biogasoline is the second highest consumed biofuel; its growth started after 2004 and since 2010 the energy consumption of this fuel type has remained stable. The biogas started being consumed in 2008 (19.1 ktoe). Since then, an increase by 602% has been registered until 2014. The energy consumption of other liquid biofuels[115] was observed between 2005 and 2010. In 2013, a drop by 10.5% (1.2 Mtoe) in the biodiesel occurred. In 2014 the growing trend from 2012 was recovered. In the recent years solid biofuels have had a negligible consumption (below 1 ktoe a year).

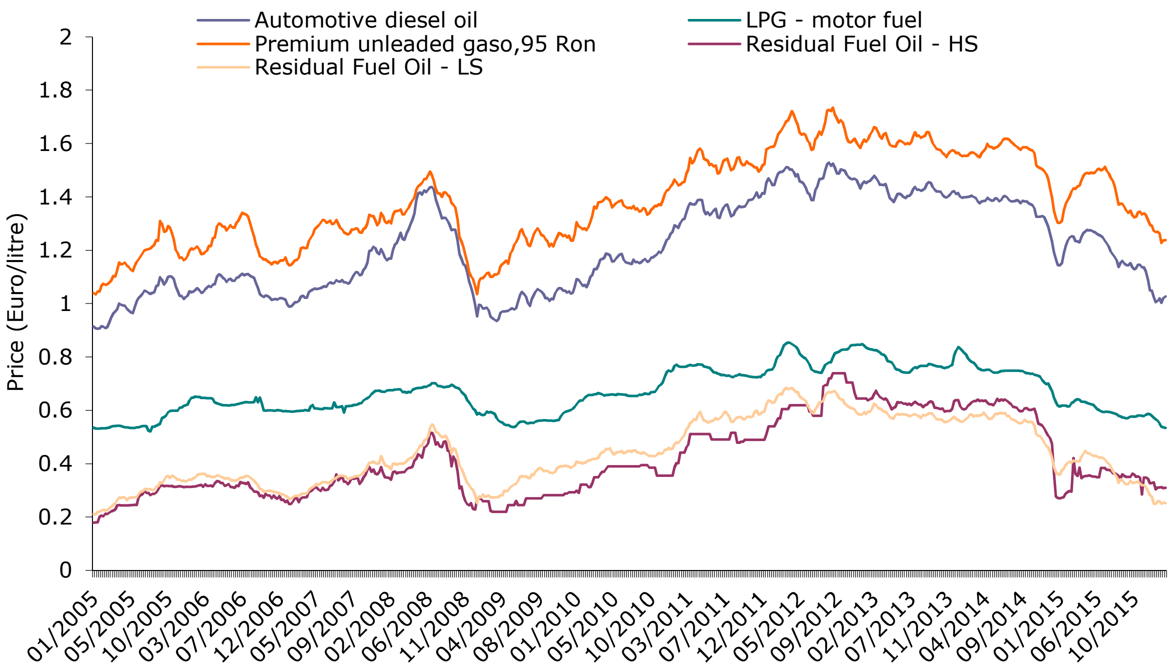
[115] This category includes liquid biofuels, used directly as fuel, not included in the definitions of biogasoline, biodiesel or bio jet kerosene and liquid biofuels consumption that cannot be reported under the right category because of missing information. Source: Eurostat

### Fuel prices

Automotive diesel oil and gasoline prices increased from 2002 onwards. From mid-2008 to mid-2009 a significant drop took place. Afterwards, the prices continued rising until September-October 2012 where the maximum of the period 2000-2014 were registered (gasoline 95 Ron: 1.678 Euro/litre; automotive diesel oil: 1.488 Euro/litre). Since then, a progressive reduction in the prices has been taking as illustrated in Figure 133. Between 4th quarter of 2014 and 1st quarter of 2015 a significant drop was registered. That drop in the consumer prices was linked to the sharp decline in the price of crude oil barrels.

The decline in oil prices was driven by a number of factors: several years of upward surprises in the production of unconventional oil; weakening global demand; a significant shift in OPEC policy; unwinding of some geopolitical risks; and an appreciation of the U.S. dollar [52], [53].

**Figure 133: Consumer prices of petroleum products inclusive of duties and taxes - Eurozone weighted average, January 2005 – February 2016. Source: EC DG-ENER**



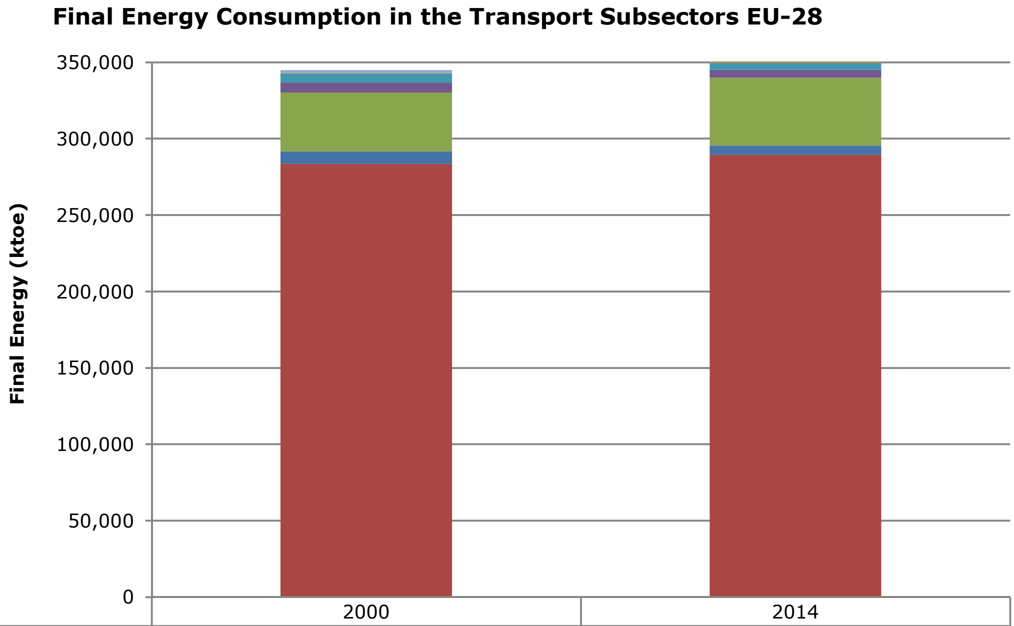

From mid-2015 to February 2016, the prices are still registering the overall lowering-prices trend. In February 2016 the average consumer prices of petroleum products in the Eurozone were: gasoline 95 Ron (1.227 Euro/litre), automotive diesel oil (1.011 Euro/litre), LPG – motor fuel (0.552 Euro/litre), residual fuel oil – HS (0.311 Euro/litre), and residual fuel oil – LS (0.250 Euro/litre).

## 6.2 Transport subsectors

In this chapter, the final energy consumption in the transport sector is broken-down into the different transport subsectors. These are the followings: road; rail; international aviation; domestic aviation; domestic navigation; pipeline transport; and other transports[116].

Energy consumption data of the all mentioned transport subsectors can be found at Eurostat site [3]. This chapter analyses the consumption trends and changes of these transport subsectors for the period 2000-2014.

**Figure 134: Final energy consumption in the EU-28 transport subsectors, 2000 and 2014. Source: Eurostat**

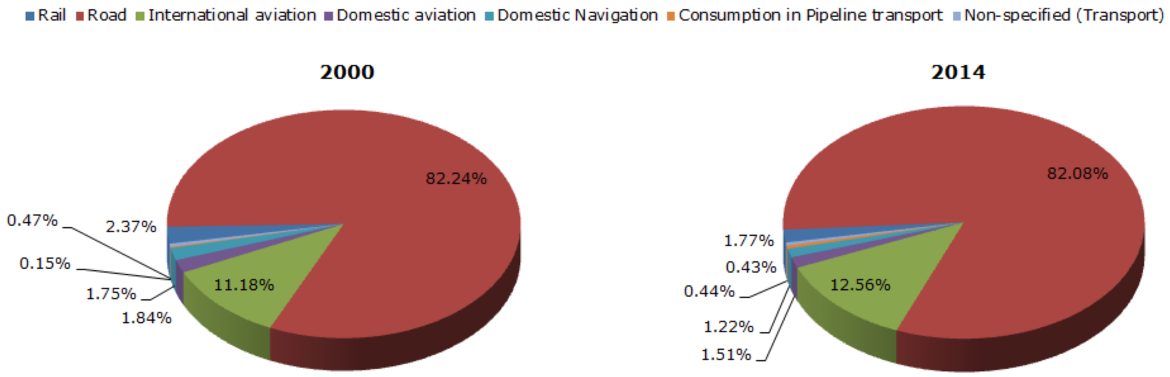



| | 2000 | 2014 |
|---|---|---|
| Non-specified (Transport) | 1,609.3 | 1,505.2 |
| Pipeline transport | 533.8 | 1,560.9 |
| Domestic Navigation | 6,031.1 | 4,299.7 |
| Domestic aviation | 6,357.3 | 5,307.2 |
| International aviation | 38,558.3 | 44,259.2 |
| Rail | 8,174.2 | 6,222.0 |
| Road | 283,629.0 | 289,347.1 |

Road transport is extensively the main energy consuming subsector. It consumed 82.08% (289.4 Mtoe) of the final energy share in 2014. In the same year, the second consuming subsector was international aviation (12.56%; 44.3 Mtoe), followed by rail (1.77%; 6.2 Mtoe), domestic aviation (1.51%; 5.3 Mtoe), domestic navigation (1.22%; 4.3 Mtoe), pipeline transport (0.44%; 1.6 Mtoe) and other non-specified transport (0.43%; 1.5 Mtoe). The most remarkable change to year 2000 scenario is the energy consumption of pipeline transport has increased by nearly times three (from 534 ktoe to 1,561 ktoe). In comparison to year 2000, road, rail, domestic navigation, domestic aviation, and non-specified transport have reduced their shares, while the rest of transport subsectors (i.e. international aviation and pipeline transport) have increased their shares as illustrated in Figure 134 and Figure 135.

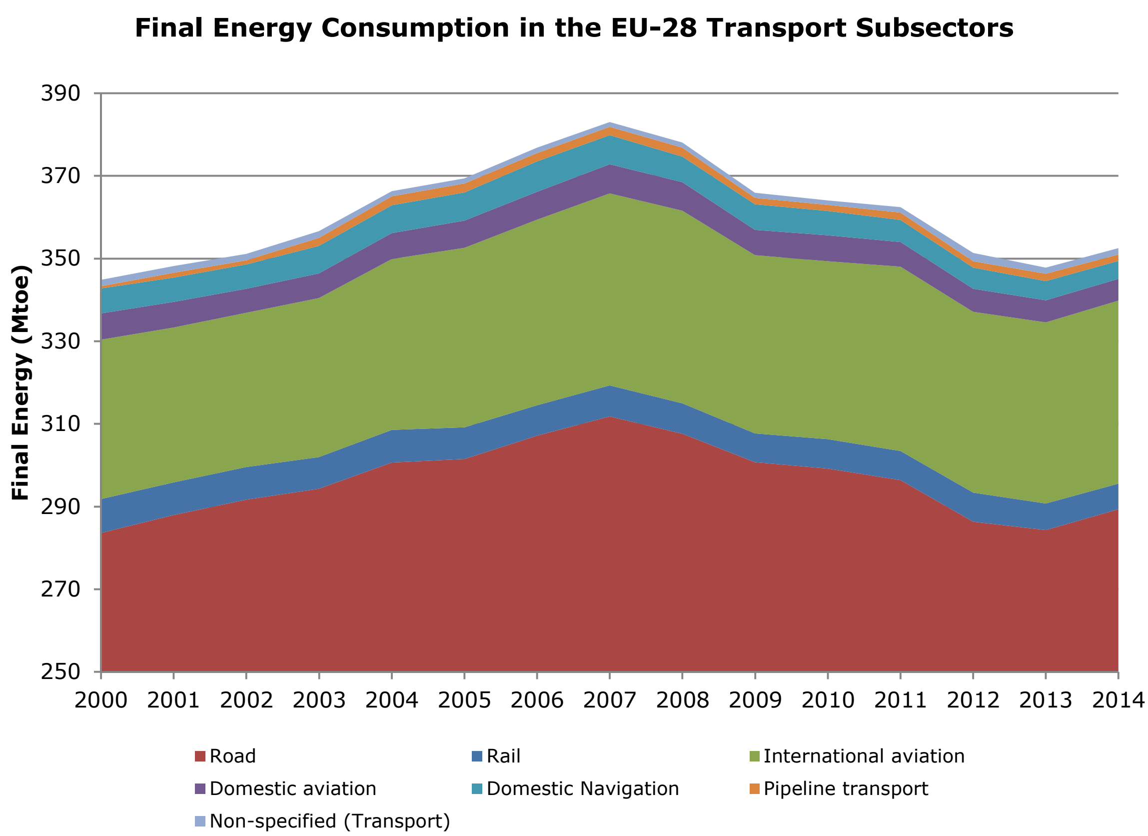
[116] It includes fuels used by airlines for their road vehicles and fuels used in ports for ships' unloaders, various types of cranes. Source: Eurostat

**Figure 135: Share of transport subsector to final energy consumption, 2000 and 2014. Source: Eurostat**




The aggregated energy consumption of the different subsectors for the period from 2000 to 2014 is shown in the following figure. During this period, the total final energy consumption in the sector has increased by 2.2%. However, this increase has not been followed by all the subsectors. Domestic navigation has declined the most (by 28.7%). Rail, domestic aviation and non-specified transport have declined their energy consumption by 23.9%, 16.5% and 6.5% respectively. In contrast, pipeline transport (by 192.4%), international aviation (by 14.8%) and road transport (by 2.0%) are the subsectors which have registered a rise in their consumption in comparison to the year 2000. Despite the annual variation in the final energy consumption, overall energy consumptions have gradually changed and no sharp changes have been observed along the 15-years period.

**Figure 136: Final energy consumption in the EU-28 transport subsectors, 2000-2014. Source: Eurostat**



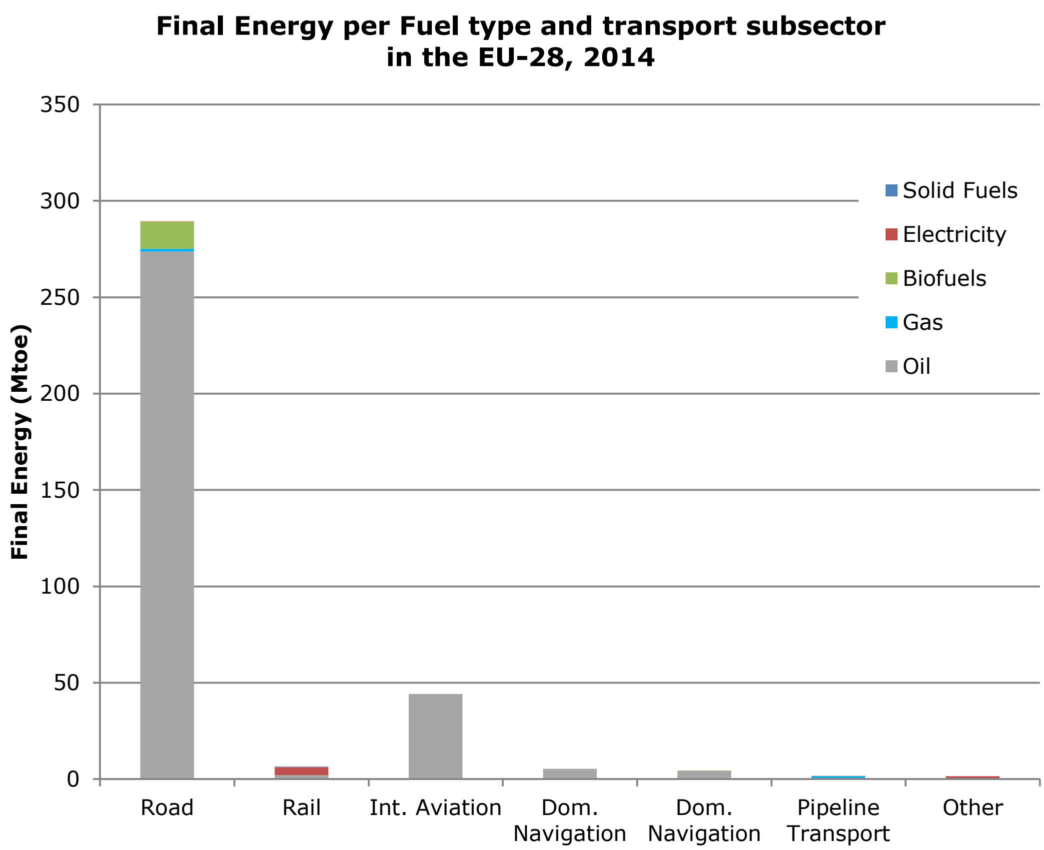
The following table shows an overview of the final energy consumption and growth rates occurred in the transport subsectors from 2000 to 2014.

**Table 36: Growth rates of energy consumption transport subsectors, 2000 and 2014. Source: Eurostat**

| | Final Energy (ktoe) | | Growth Rate (%) | Share in % | | Change of shares |
|---|---|---|---|---|---|---|
| | 2000 | 2014 | 2000-2014 | 2000 | 2014 | 2000-2014 |
| **Transport** | ***344,893*** | ***352,501*** | ***2.2%*** | | | |
| Rail | 8,174 | 6,222 | -23.9% | 2.37% | 1.77% | **-0.60%** |
| Road | 283,629 | 289,347 | 2.0% | 82.24% | 82.08% | **-0.15%** |
| International aviation | 38,558 | 44,259 | 14.8% | 11.18% | 12.56% | **1.38%** |
| Domestic aviation | 6,357 | 5,307 | -16.5% | 1.84% | 1.51% | **-0.34%** |
| Domestic Navigation | 6,031 | 4,300 | -28.7% | 1.75% | 1.22% | **-0.53%** |
| Consumption in Pipeline transport | 534 | 1,561 | 192.4% | 0.15% | 0.44% | **0.29%** |
| Other transports | 1,609 | 1,505 | -6.5% | 0.47% | 0.43% | **-0.04%** |

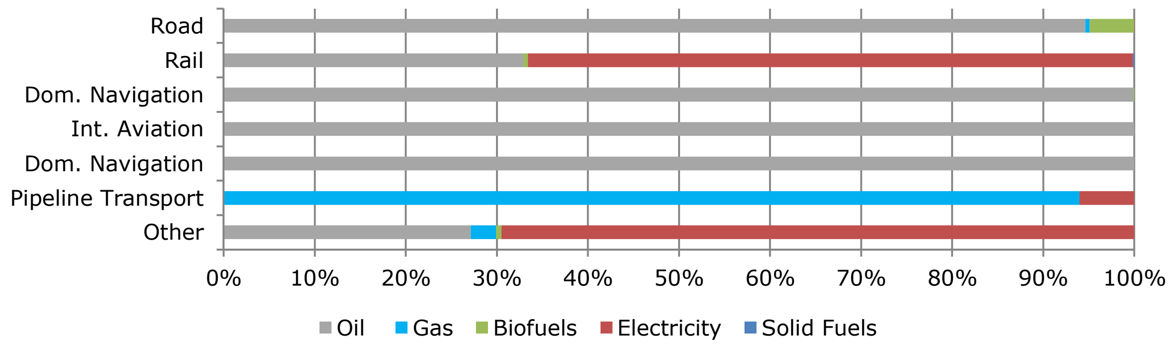
The following figures (Figure 137 and Figure 138) show the energy mix of the different subsectors for the year 2014 in both absolute numbers and percentage of the total final energy consumption per subsector. It is observed how oil (petroleum products) is the only fuel type in the aviation and navigation and it is main contributor (94.6%) in the road transport.

**Figure 137: Final energy per fuel type and transport subsector in the EU-28, 2014. Source: Eurostat**



In 2014, electricity represented the main consuming fuel in rail (66.4%) and other transports (69.5%) categories. Gas was the major fuel type used in pipeline transport (94.0%). With regard to renewable energies, biofuels occupied a share in road (4.9%), rail (0.5%) and other transports (0.6%).

**Figure 138: Share of fuel type and transport subsector in the EU-28, 2014. Source: Eurostat**



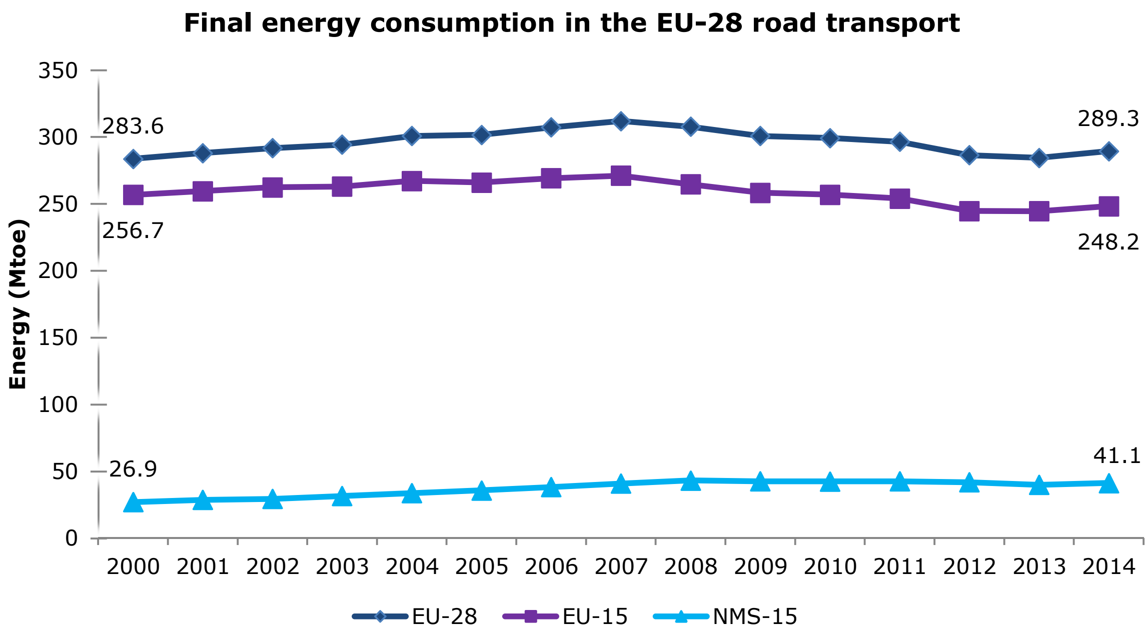

It can be observed that road transport clearly outstands among the rest subsectors in terms of final energy consumption. Thus, it can be assumed that overall transport sector trends are mainly influenced by the road transport changes.

## 6.3 Road sector

A specific analysis of the road sector energy consumption trends is undergone in this chapter. This insight is matter of interest as road sector accounted for 82% of the final energy consumption of the total energy consumed in the transport sector in 2014.

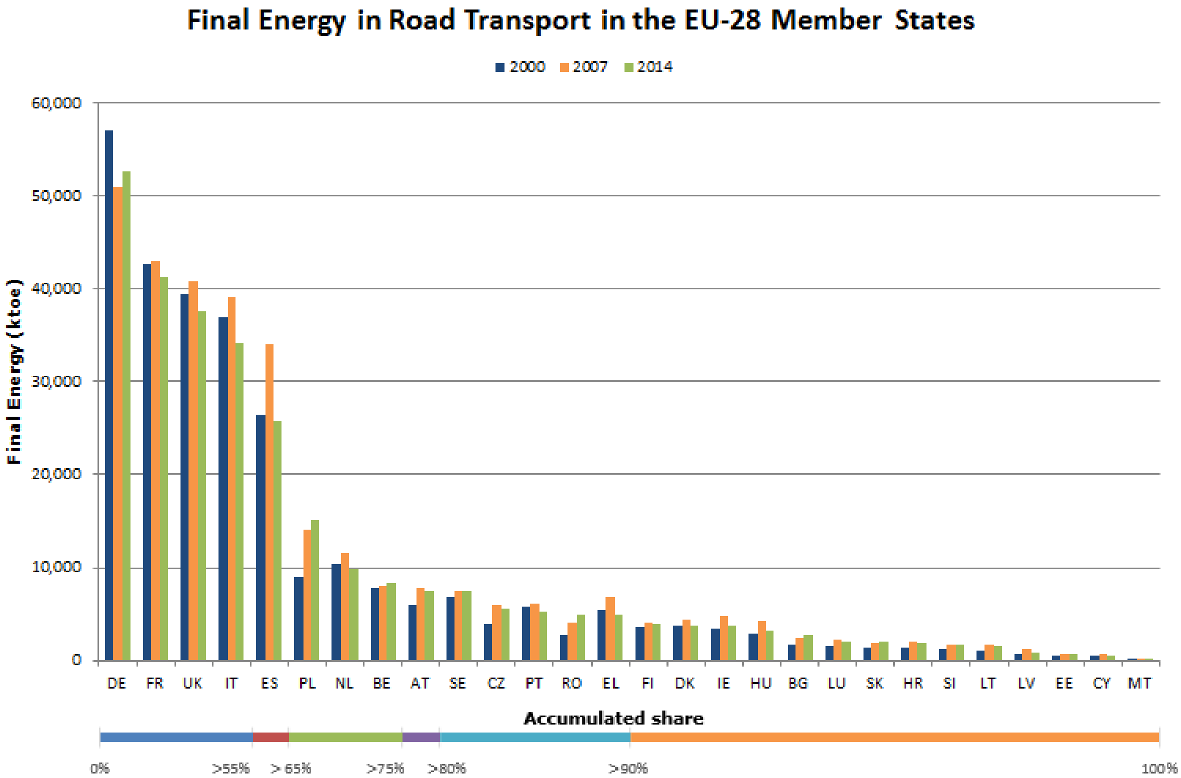
The final energy consumption in the road transport has increased by 2.0% (5.7 Mtoe) in the period from 2000 to 2014. This increase has not been registered equally in EU-15 and NMS-13 area. NMS-13 have increased their final energy consumption by 53.0%, while EU-15 have registered a drop by 3.3%. In 2014, 85.8% (248.2 Mtoe) were consumed in the EU-15 areas as illustrated in the following figure.

**Figure 139: Final energy consumption in the EU-28 road transport, 2000-2014. Source: Eurostat**



Across the EU-28 Member States there are remarkable differences in the final energy consumptions. In 2014, the countries with the highest road energy consumption numbers are Germany (52.7 Mtoe), France (41.4 Mtoe), United kingdom (37.6 Mtoe) and Italy (34.3 Mtoe). These four countries accounted for more than 55% of the total final energy consumption in the road transport. In the same year, fourteen Member States consumed more than 90% of the final energy consumption in the road transport as it can be observed in the accumulated share bar in Figure 140.

**Figure 140: Final energy consumption in road transport per Member State in the EU-28 with accumulated share (2014) of the final energy, 2000, 2007 and 2014. Source: Eurostat**




With regard to the energy mix in the road transport, petroleum products (i.e. diesel, gasoline, LPG and gas) are the major consumed fuel types. In 2014, diesel was the most consumed fuel type (65.6%), followed by gasoline (27.0%), biofuels (4.9%), LPG (2.0%), gas (0.5%) and electricity which accounted for a minor share (0.02%) of the final energy consumption.

Figure 141 shows the final energy mix for four different years (i.e. 2000, 2005, 2010 and 2014). It can be observed the gradual reduction of gasoline consumption and the increase in the final energy consumption of diesel and biofuels. Oil-LPG, gas and electricity have slightly increased their energy consumption shares.

The increase in the share of biofuels is a fact to be noted as this trend shows the development towards a more sustainable way of road transport. Biodiesels have been the main biofuel along the entire analysed period (2000-2014). Back in 2000, biodiesels were the main biofuel accounting for 89.7%, followed by biogasoline (8.21%); other liquid and solid biofuels completed the renewable energy mix. In 2014, 15 years later, the biodiesels remained as the major renewable fuel type with 80.2%. Biogasoline is the second with 18.8%. Biogas started to account in the final energy consumptions after 2008; biogas reached about 1% share of the renewable energy mix. Regarding other liquid biofuels, its share has largely reduced until registering by 0.06% in 2014. The presence of solid biofuels has totally vanished along these years in the final energy consumption of road transport as shown in Figure 142.

**Figure 141: Final energy mix in the EU-28 road transport, years 2000, 2005, 2010 and 2014. Source: Eurostat**

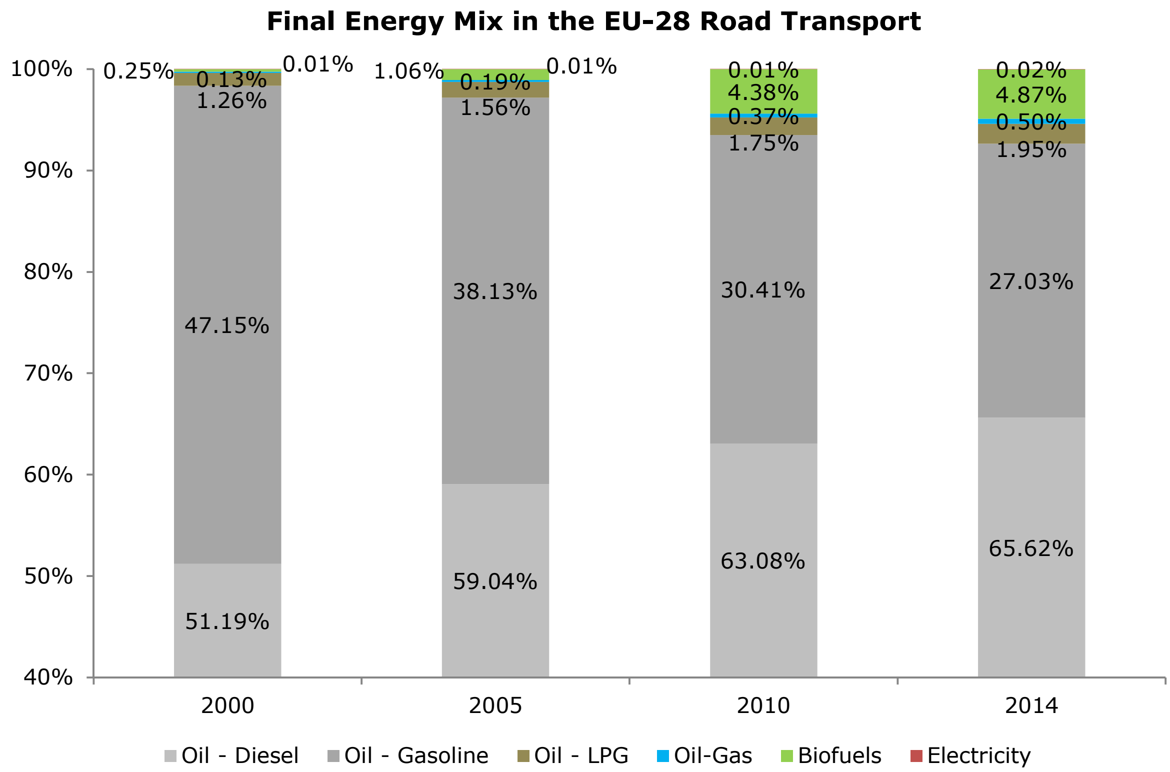
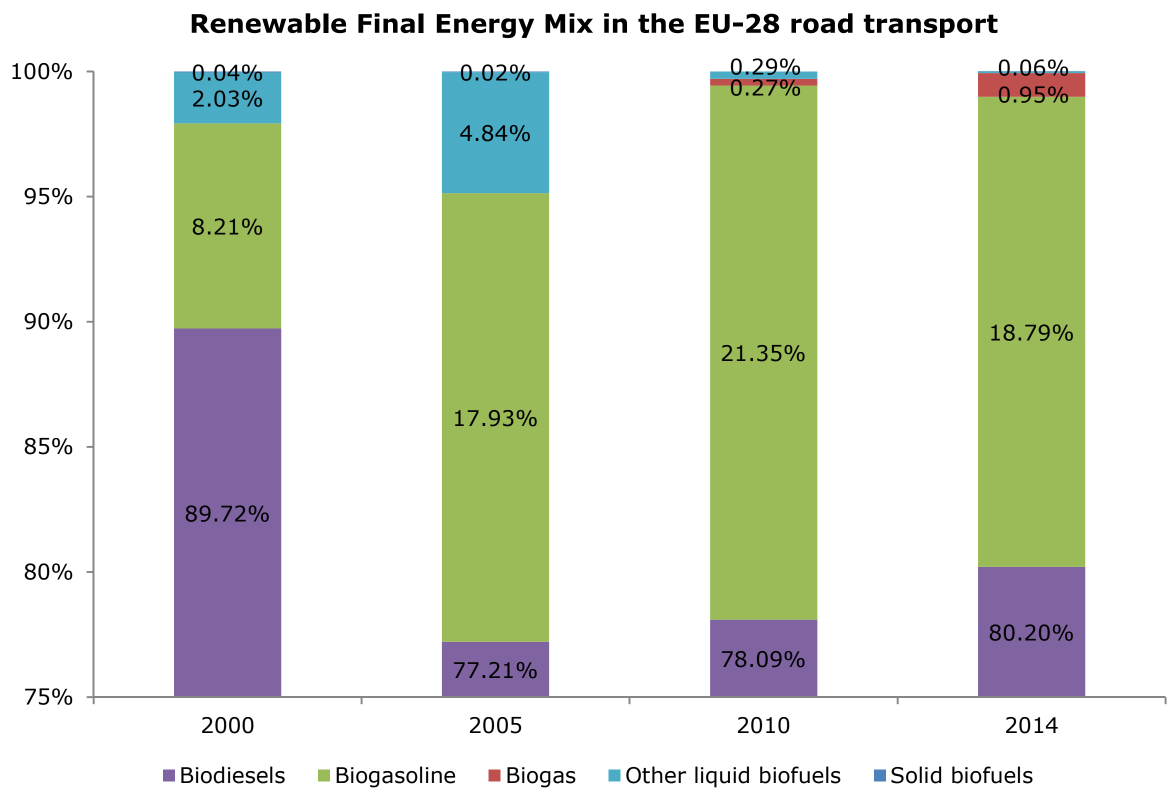



**Figure 142: Renewable final energy mix in the EU-28 road transport, years 2000, 2005, 2010 and 2014. Source: Eurostat**



Among the different vehicle types, cars outstand as the main energy consumers in the road transport. In 2013, cars accounted for 59.3% (168.5 Mtoe) of the road final energy consumption, followed by trucks and light vehicles (35.5%; 100.9 Mtoe), buses (3.9%; 11.0 Mtoe) and two wheels vehicles (1.3%; 3.6 Mtoe). There have not been remarkable differences between 2000 and 2013. Nevertheless, during this period (e.g. in 2007 when the highest energy consumption in the road transport was registered) there have been registered increases in the consumption due to car and trucks and light vehicles energy demand as illustrated in the following figure.

**Figure 143: Road energy consumption per vehicle type in the EU-28, 2000, 2007 and 2013. Source: Odyssee**

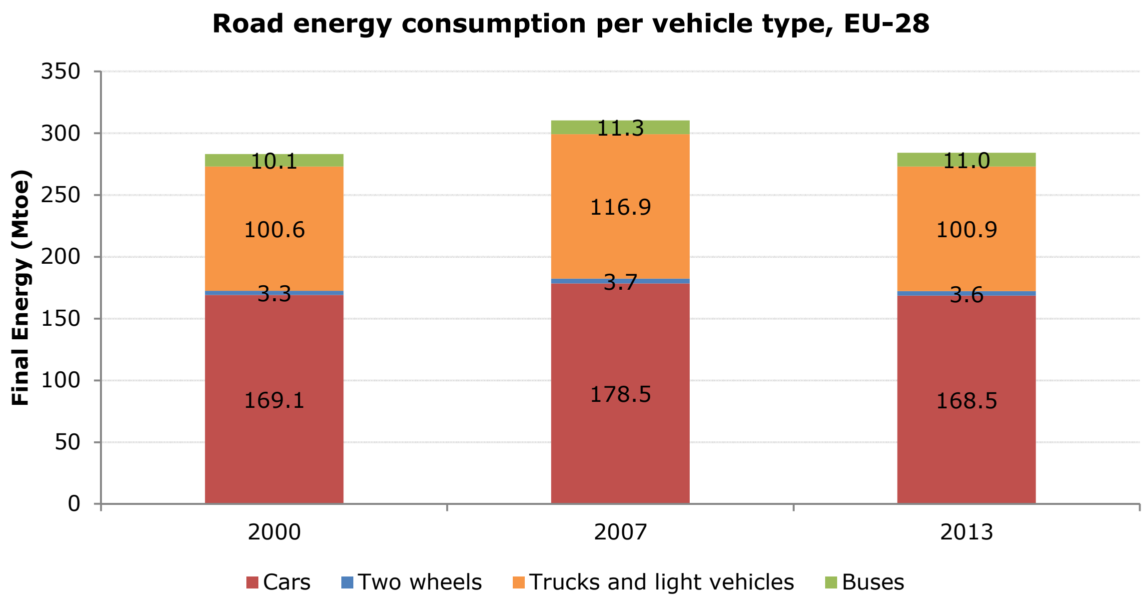
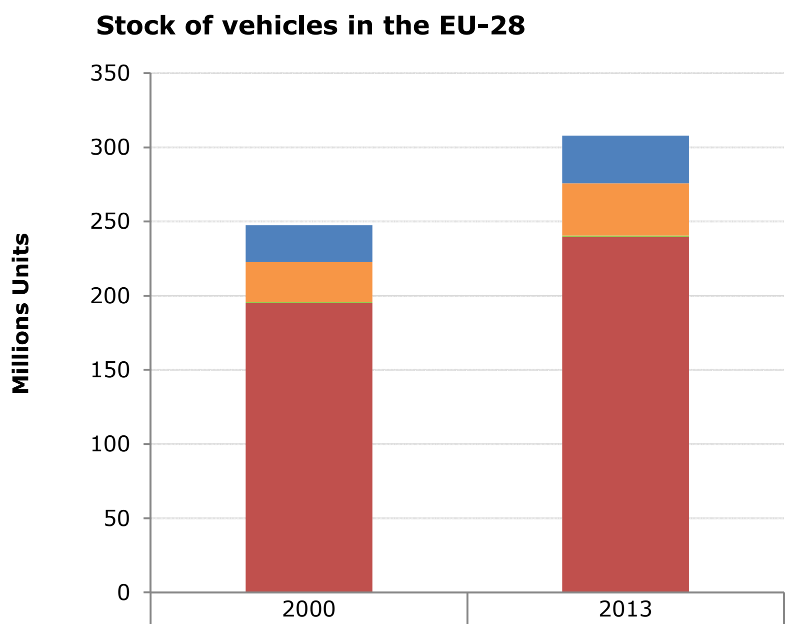


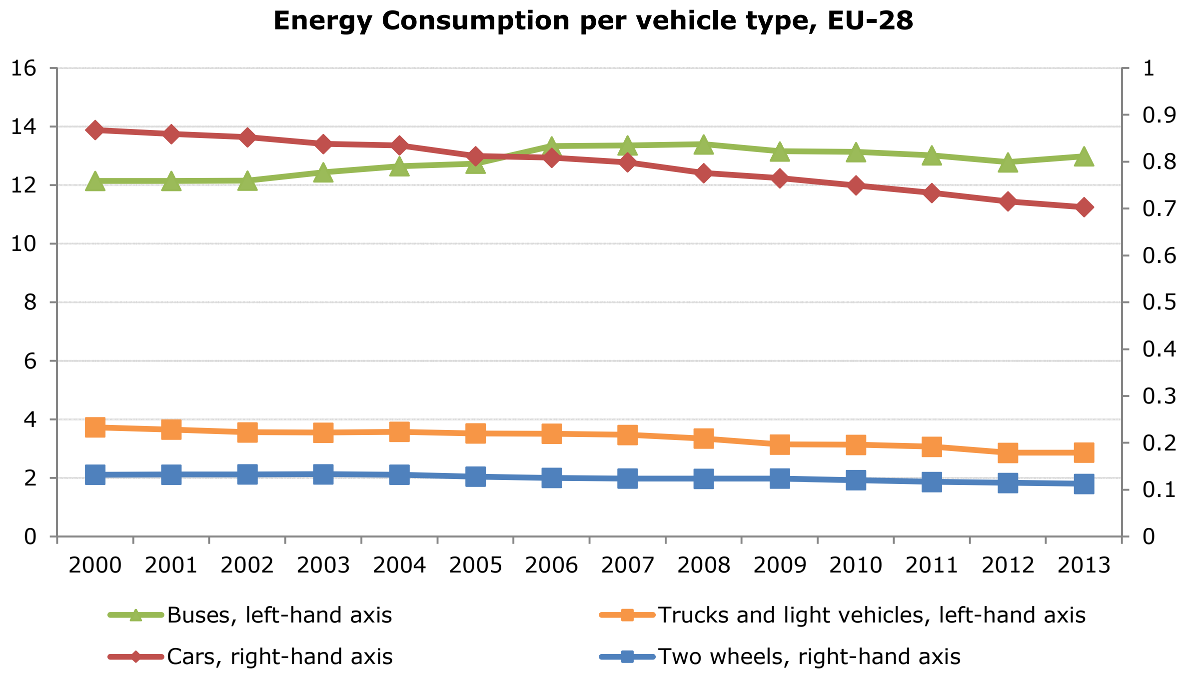

**Figure 144: Number of vehicles in the EU-28, 2000 and 2013. Source: Odyssee**




| | 2000 | 2013 |
|---|---|---|
| Two wheels | 24.699 | 32.172 |
| Trucks and light vehicles | 26.948 | 35.202 |
| Buses | 0.834 | 0.849 |
| Cars | 194.913 | 239.687 |

The stock of vehicles in the EU-28 was mainly formed cars (78% in 2013). In 2013, there were registered 239.7 million cars in Europe. Trucks and light vehicles were the second vehicle type according to stock size with over 35.2 million units, followed by two wheels vehicles (32.2 million units) and buses (849 thousand units). In comparison with the year 2000, the total stock of vehicles has increased by 60.5 million units, representing an increase by 24.5%. All the vehicle types have increased their stocks. Trucks and light vehicles are the vehicle type which has experienced the highest growth in the stock numbers with an increase by 30.6% (8.3 million units). Two wheels vehicles have enlarged in a similar range its stock (30.3%; 7.5 million units). Cars and buses have incremented their stock numbers by 23% and 1.8% respectively.

**Figure 145: Energy consumption per vehicle type (toe/veh) in the EU-28, 2000-2013. Source: Eurostat**




Buses have the largest energy consumption per vehicle. This fact may be easily understandable due to the average size of this sort of vehicles. In 2013, the average European energy consumption per buses was 12.99 toe/veh. In the same year, trucks and light vehicles consumed 2.87 toe/veh, cars 0.70 toe/veh and two wheels 0.11 toe/veh. In comparison to year 2000 scenario, cars have decreased by 19.0%, two wheels by 14.5% and trucks and light vehicles by -23.2%. In contrast, buses have registered an increase by 6.9%.

To be noted that buses are the only vehicle type that has experienced an increase in their energy consumption per unit during the period from 2000 to 2013. This might be the result of an increase in the usage of buses as transportation mode, for instance, city buses. A higher number of kilometres per year driven by bus would lead to higher energy consumption per vehicle. Also, it might be ancillary increased by the incorporation of additional built-in services to enhance the comfort of the passengers such as air-conditioning, reading-lights, display screens, or internet-related services (i.e. Wi-Fi). Most of these services are largely spread nowadays among the buses fleet in many Europeans regions in both private- and public-operated buses.

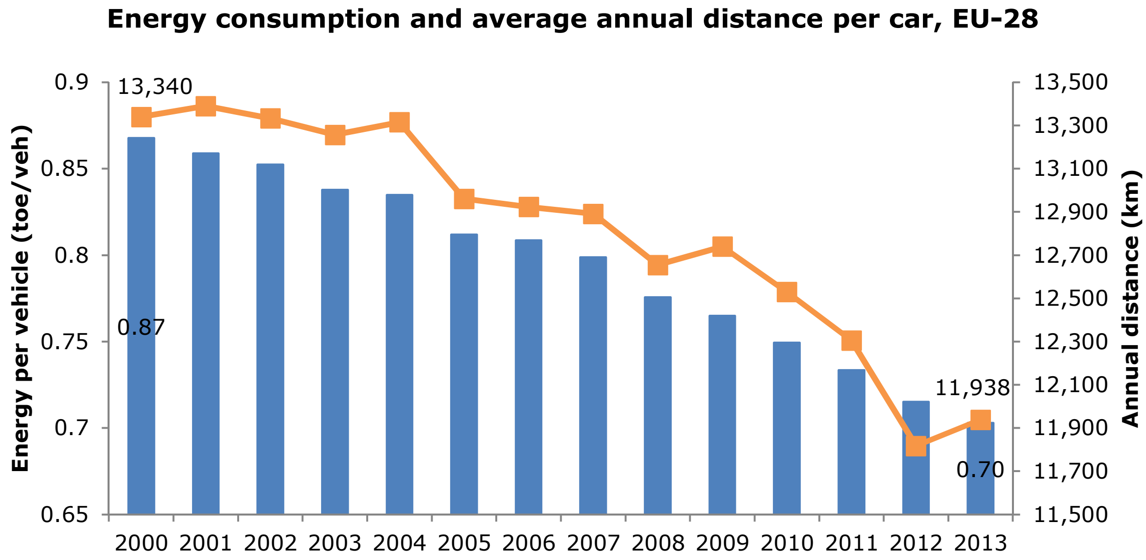
### 6.3.1 *Road sector – Cars*

Cars represented 78% of the stock of vehicles and 59.3% of the final road energy consumption in 2013. Therefore, its further analysis can provide with a better understanding of how the energy consumption in the road transport evolves and consequently how it does in the transport sector as it has been already mentioned the large amount of energy that road transportation represents within the sector.

In 2000, the average energy consumption per car in the EU-28 registered the value of 0.87 toe per vehicle. During the period from 2000 to 2013, there has been observed a gradual lowering trend which led to a drop by 19.5% in 2013.

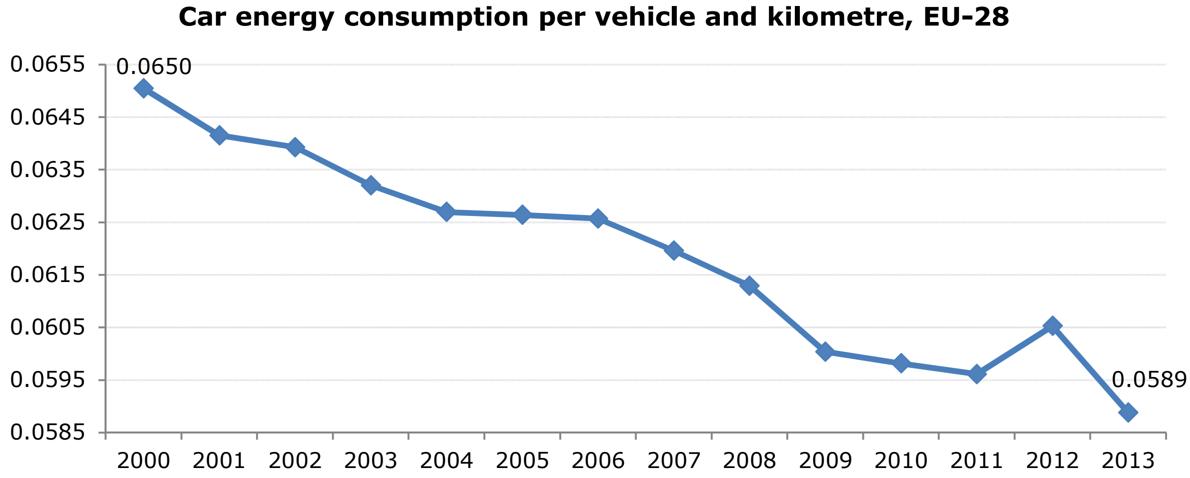
Figure 146 shows the energy consumption per car, together with the average annual distance travelled by car in the EU-28 during the same period (2000-2013). It is observed that the average annual distance travelled by car has decreased by 1,402 km along the 14-years period (from 13,340 km to 11,938 km). The minimum of the time series was registered in 2012 (11,817 km). Overall, the average annual distance per car has undergone a gradual lowering trend similar to the annual energy consumption values. Therefore, it might be possible that the decreasing in the average annual energy consumption per car is not only related to energy efficiency performance improvements in the vehicles, but also bound to a lowering trend in the usage of the vehicles in terms of distance per year. Further and more throughout research should be done regarding this topic in order to quantitatively account the possible influence of this factor.

**Figure 146: Annual energy consumption and annual distance travelled per car in the EU-28, 2000-2013. Source: Odyssee**



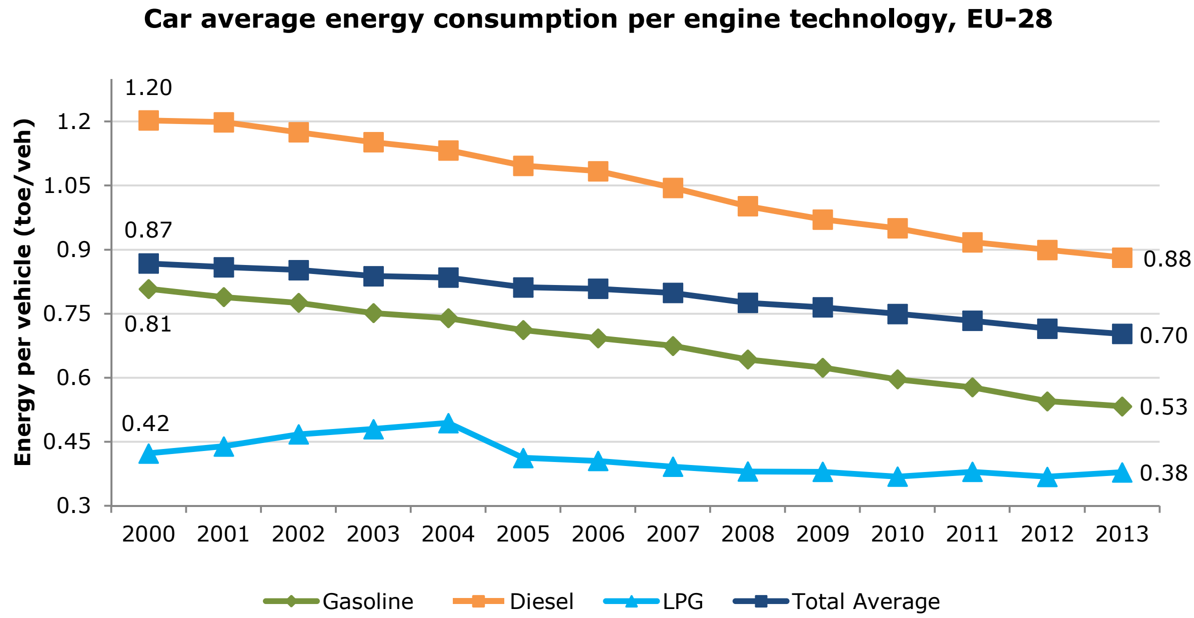

The following figure shows the total car energy consumption per stock of vehicle and per average annual distance in the EU-28. From 2000 to 2013, there has been a total reduction of 9.4% in this indicator. Indicator which considers the energy consumption based on the total travelled distance and the number of vehicles. The reduction could have been influenced by multiple factors such as: cars driving in speeds with the highest efficiency performance ratios, less traffic congestion, usage of smaller or more efficient car models.

**Figure 147: Car energy consumption per vehicle in stock and annual distance in the EU-28, 2000-2013. Source: Odyssee**




The following figure shows the energy consumption per vehicle differing by engine technology. Diesel-fuelled vehicles are the vehicles type with the highest unitary energy consumption. The total average energy consumption per vehicle reduction during the period from 2000 to 2013 (-19.5%) is the result of a reduction by 34.6% in gasoline-fuelled cars, a reduction by 26.7% in diesel fuelled cars and a reduction by 9.5% in the LPG-fuelled cars. In 2013, the average energy consumption values were around 25% below the total average for the gasoline cars and 25% above the average for diesel cars. Overall, a lowering trend has been experienced by the cars of all engine technologies due to energy efficiency performance improvements, with the exception of LPG cars from 2000 and 2004 when the energy consumption values registered an annual increased in comparison to the previous year respectively. Since 2004, LPG cars trend has followed the others.

**Figure 148: Average energy consumption per car engine technology in the EU-28, 2000-2013[117]. Source: Odyssee**

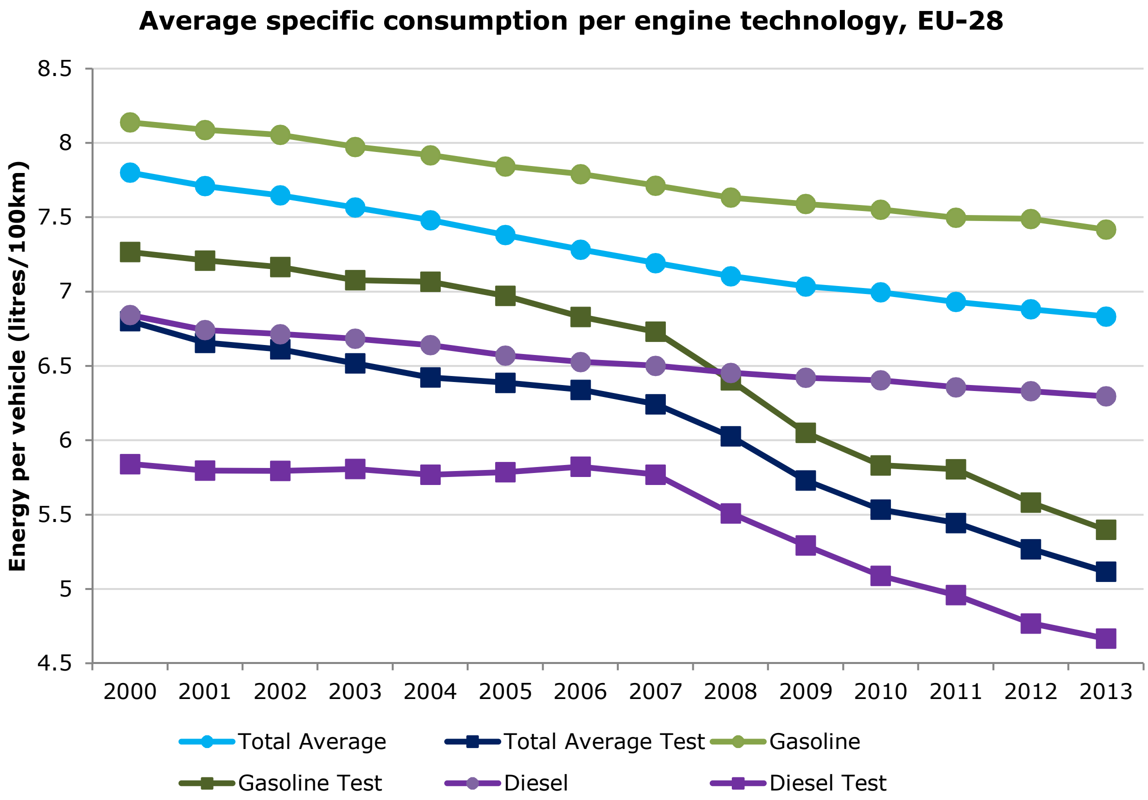



[117] The series 'Total Average' also includes the energy consumption per vehicle of biofuel-fuelled vehicles.

The average specific consumption of cars shows the consumption of one vehicle in litres per 100 km. It is calculated from the total consumption of cars, stock of cars and average distance travelled by car per year. The average consumption of new cars is calculated from fuel consumption tests[118]. Figure 149 shows that in both cases (i.e. calculated from data and from test values) and for the two main engine technologies (i.e. gasoline and diesel) there is an ongoing decline since 2000. In total, the average consumption of cars in the market has declined by 12.4%, while the consumption of new cars entering the market (tagged as 'test') is even larger at 24.8%. Comparing the average specific consumptions per engine technology, gasoline-fuelled cars consumed more fuel than any other engine technology. In the period from 2000 to 2013, gasoline and diesel cars already in the market have registered a reduction by 8.9% (from 8.1 litres/100 km in 2000 to 7.4 litres/100 km in 2013) and 8.0% (from 6.8 litres/100 km in 2000 to 6.3 litres/100 km in 2013) respectively. In the same period, the new cars gasoline- and diesel-fuelled entering into the market have also registered reductions in their specific consumption values. New gasoline cars have reduced by 25.7% their specific fuel consumption (from 7.3 litres/100 km in 2000 to 5.4 litres/100 km in 2013). New diesel cars have reduced by 20.1% their specific fuel consumption (from 5.8 litres/100 km in 2000 to 4.7 litres/100 km in 2013).

To be that noted that after 2007 the rate of decline in the consumption of new cars increased. These observed lowering trends in the average specific consumption values might be the result of the automotive industry to the policy implementations regarding the $CO_2$ emissions of light-duty vehicles.

**Figure 149: Average specific consumption per car engine technology in the EU-28, 2000-2013. Source: Odyssee**



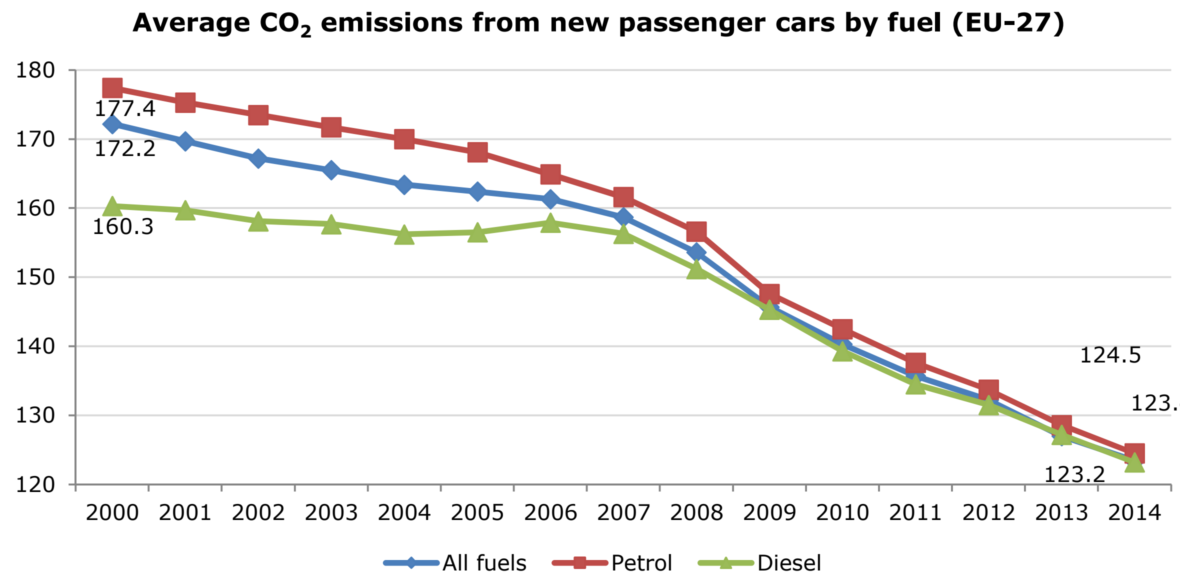

118 Definition of energy efficiency indicators in Odyssee database.

In March 2014, the European Regulation No 333/2014 amended the Regulation No 443/2009 which defined the emission performance standards for new passenger cars to reduce $CO_2$ emissions from light-duty vehicles.

The Regulation No 333/2014 sets a target of 95 g $CO_2$/km for the average emissions of the new car fleet from 2020 onwards as measured in accordance with Regulation No 715/2007 (Euro 5 and Euro 6 emission standards) and the annex XII to Regulation No 692/2008.

The following figure shows the average carbon dioxide emissions of new passenger cars for the period from 2000 to 2014. The EU average carbon dioxide emissions was 123.4 g $CO_2$/km in 2014; it represents a drop by 28.3% in comparison with the year 2000. It is observed that in there are not remarkable differences in the average $CO_2$ emissions of petrol and diesel fuelled passenger cars in the recent years (from 2009 onwards). Passenger cars fuelled by gasoline (petrol) registered an average $CO_2$ emissions of 123.2 g $CO_2$/km in 2014; while passenger cars diesel-fuelled registered 1.3 g $CO_2$/km more (124.5 g $CO_2$/km) in the same year. Those registers represent reductions by 29.8% and by 23.1% for petrol- and diesel-fuelled vehicles respectively.

**Figure 150: European average $CO_2$ emissions per kilometre of new passenger cars, 2000-2014. Source: EEA**




Across the EU-28 Member States, Latvia (147.1 g $CO_2$/km), Estonia (146.9 g $CO_2$/km) and Bulgaria (141.7 g $CO_2$/km) were the countries with the highest average emissions of the new car fleet in 2013. In contrast, the Netherlands (109.1 g $CO_2$/km), Greece (111.9 g $CO_2$/km) and Portugal (112.2 g $CO_2$/km) registered the lowest average emissions of new cars in the same year (see Figure 151).

Across the EU-28 Member States in 2013, the countries the highest percentage of petrol (gasoline) fuelled passenger cars were Cyprus (88%), the Netherlands (80%) and Finland (77%). The States with the highest presence of diesel-fuelled passenger cars were Luxembourg (65%), Belgium (63%) and Austria (56%). Lithuania (16.9%), Poland (16.5%), Italy (7.0%) and Sweden (5.9%) were the European countries where alternative-fuelled engines have reached largest shares (see Figure 152).[119]

[119] A type of motor energy other than the conventional fuels, petrol and diesel. Alternative fuels include electricity, LPG, natural gas (NGL or CNG), alcohols, mixtures of alcohols with other fuels, hydrogen, bio-fuels (such as biodiesel), etc. (this list is not exhaustive). Alternative fuels do not include unleaded petrol, reformulated petrol or city (low-sulphur) diesel.

**Figure 151: Average $CO_2$ emissions per kilometre of new passenger cars in the EU-27, 2013. Source: EEA**

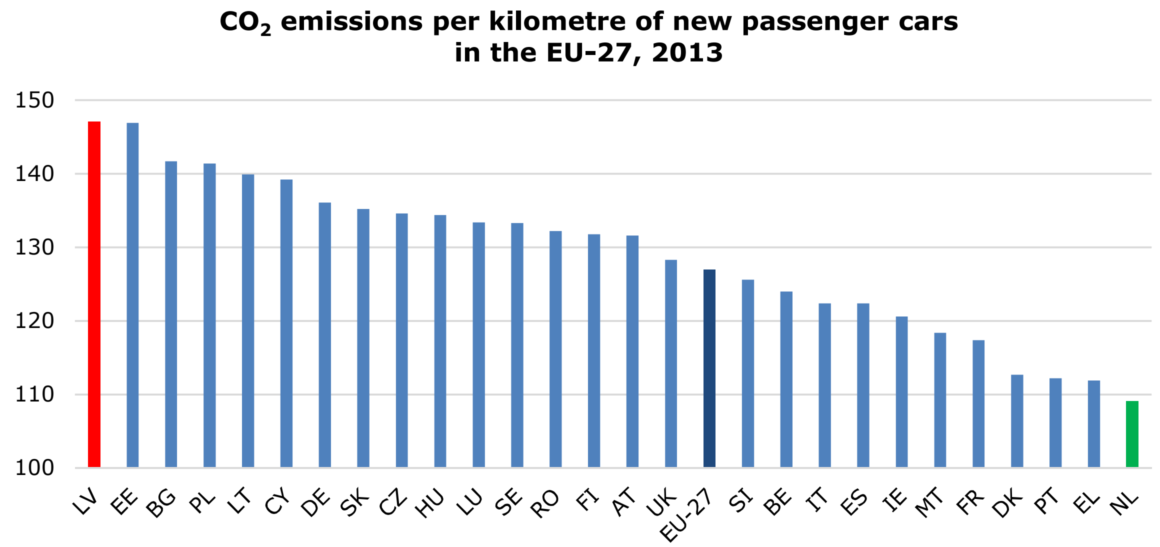
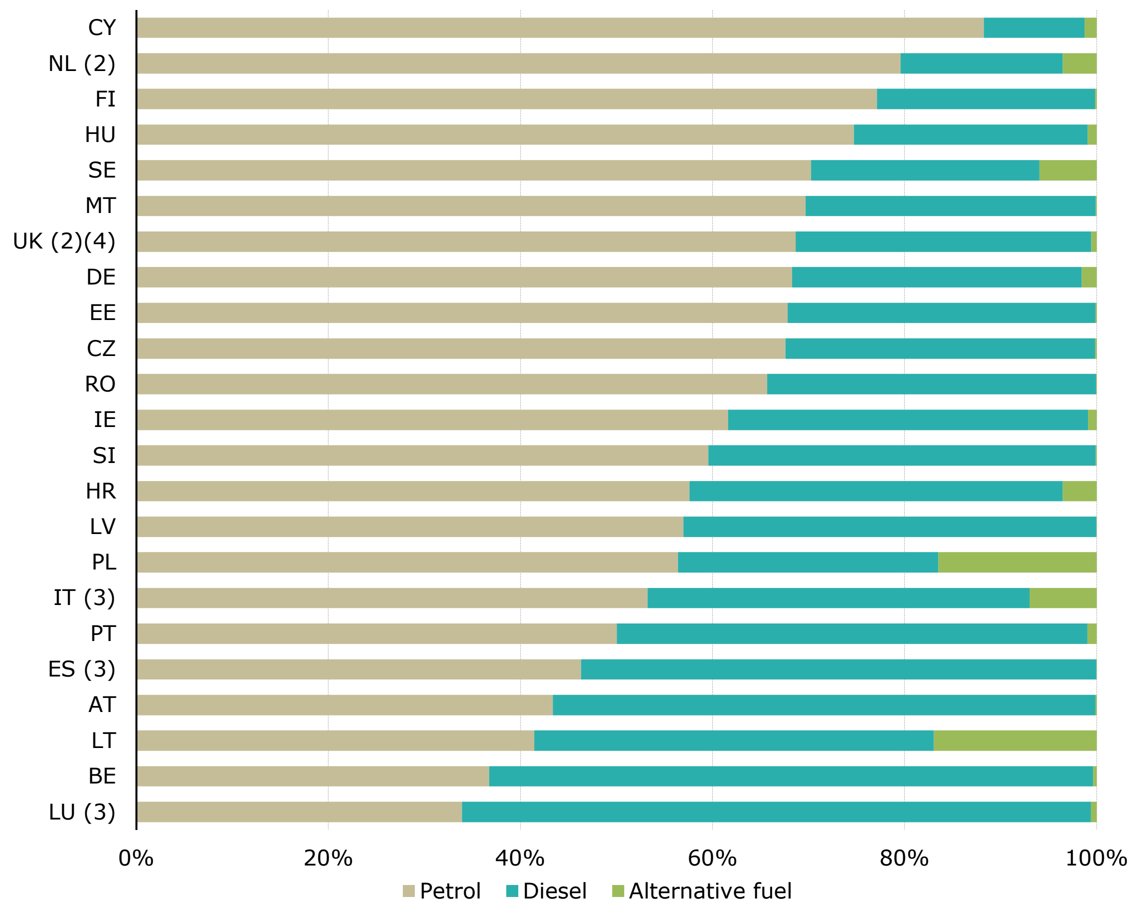



**Figure 152: Passenger cars by type of engine fuel, 2013 (% of all passenger cars)[120]. Source: Eurostat**

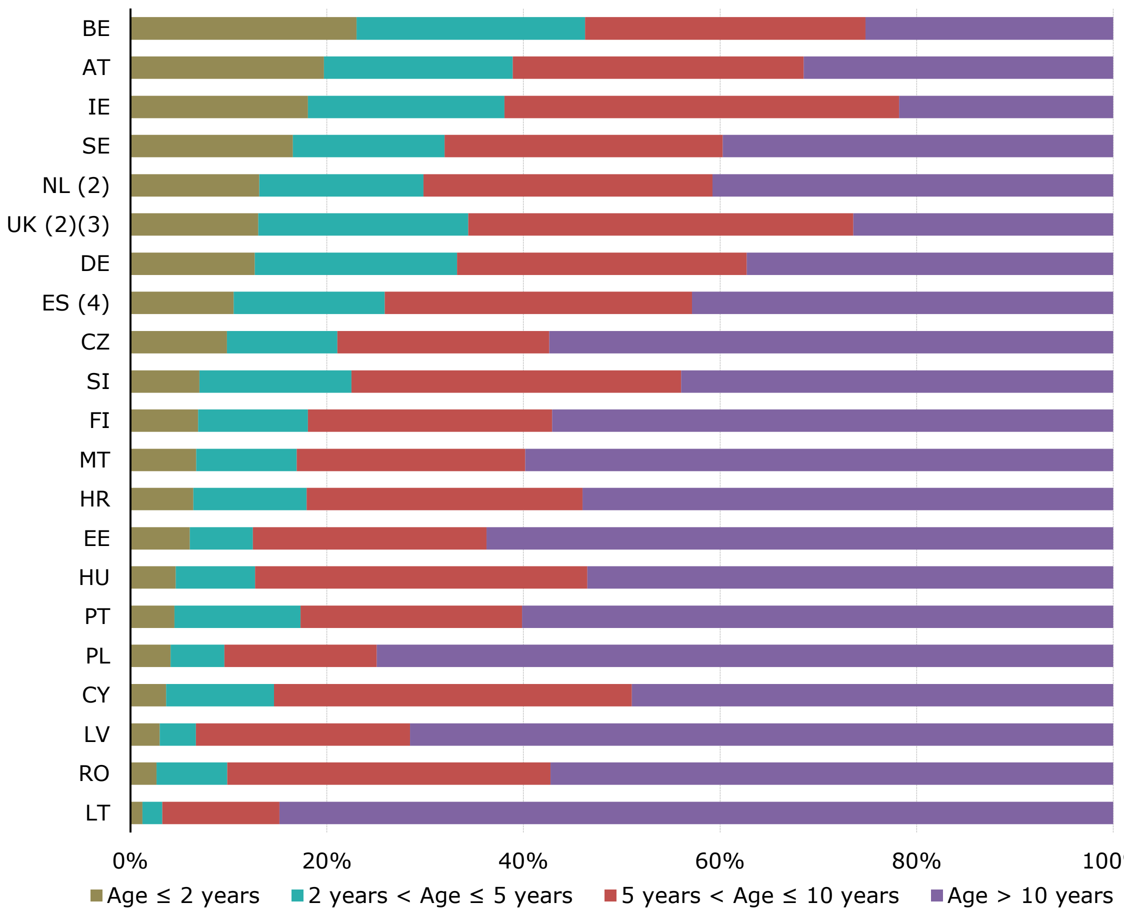



120 (1) BG, DK, EL, FR and SK: Data not available; (2) 2011 data; (3) 2012 data; (4) Great Britain only.

The age of the vehicles fleet is matter of interest in order to better understand the energy consumptions and emissions in a short term future. According to the trends of energy consumption per vehicle which follow a decreasing figure year after year, the lower age of the vehicles, the lower energy consumptions per vehicles. In 2013, the EU-28 Member State with the newest fleet of passenger cars was Belgium with 23% of its passenger cars below or equal 2 years old, followed by Austria (20%) and Ireland (18%). In contrast, the oldest fleet of passenger cars (older than 10 years) were registered in Lithuania (85%), Poland (75%) and Latvia (72%) in the same year as illustrated in Figure 153. The highest share of passenger cars between 2 and 5 years is again found in Belgium (23%), the United Kingdom and Germany (21%), and Ireland (20%). And the passenger cars between 5 and 10 years are majorly registered in Ireland (40%), United Kingdom (39%) and Cyprus (36%).

Overall, Ireland, Belgium and the United Kingdom have the newest fleet of passenger cars (these MSs have the lowest share of above 10 years old passenger cars). Despite this positive fact that, as already mentioned, could lead to lower energy consumption in the road transport in the short-term or mid-term future, there are multiple factors to consider regarding the rest of characteristics of the vehicles which could instead not cause any energy savings. Also, this scenario could completely change if a slow renovation rate of the fleet of vehicles would occur as the newer cars would age turning into old cars and the old cards would be replaced by new models in the countries with the oldest car fleet.

**Figure 153: Passenger cars by age, 2013 (% of all passenger cars)[121]. Source: Eurostat**

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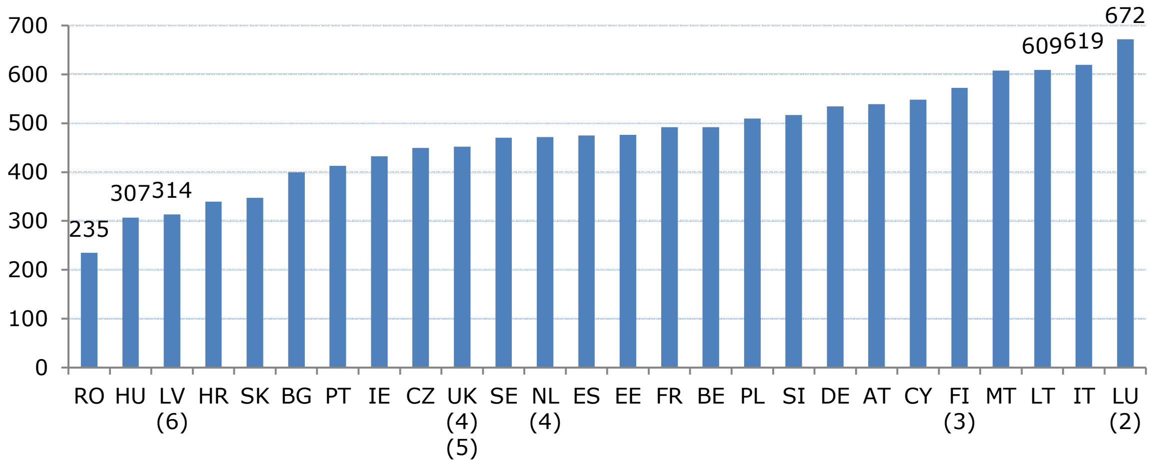
121 (1) BG, DK, EL, FR, IT, LU and SK: Data not available; (2) 2011 data; (3) Great Britain only; (4) 2012 data.

The Member State with the highest number of passenger cars per 1,000 inhabitants was Luxembourg (672 cars) in 2013; the second State was Italy (619 cars) and the third Lithuania (609 cars). In contrast, the lowest number of passenger cars per thousand inhabitants were registered in Romania (235 cars), Hungary (307 cars) and Latvia (314 cars) for the same year as illustrated in the following figure.

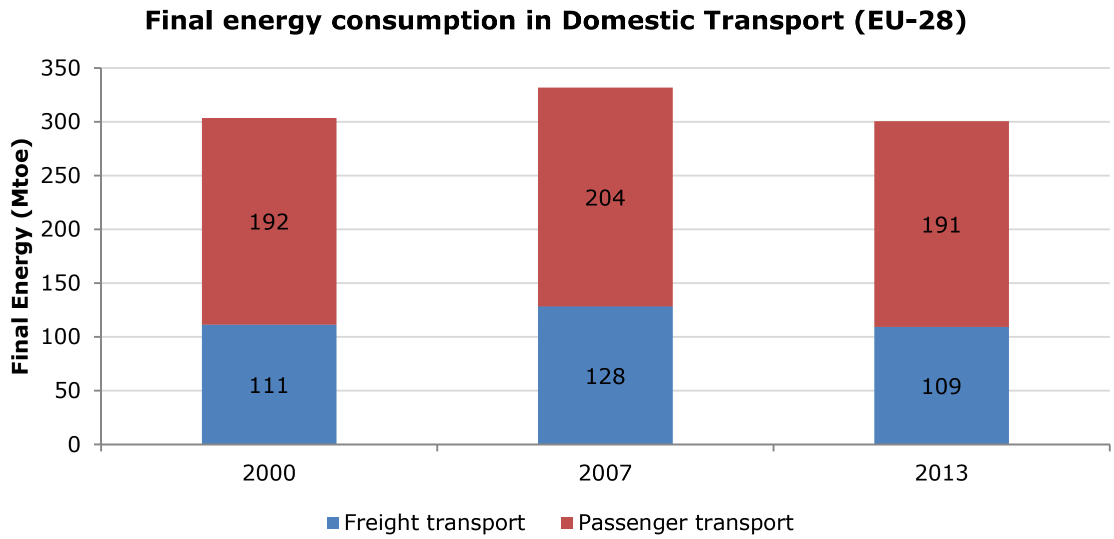
**Figure 154: Number of passenger cars per 1,000 inhabitants, 2013[122]. Source: Eurostat**




## 6.4 Passenger and freight transport

Most of the energy used in the transport sector is for domestic transportation, which can be divided into passenger and freight transport. Passenger transport accounted for the 63.7% of the domestic transport and freight transport for 36.3% in 2013. Overall, the figures of domestic transport have slightly declined between 2000 and 2013 (from 303 Mtoe to 300 Mtoe respectively), representing a drop by 1%.

**Figure 155: Final energy consumption by passenger and freight domestic transport in the EU-28, 2000, 2007 and 2013. Source: Odyssee**

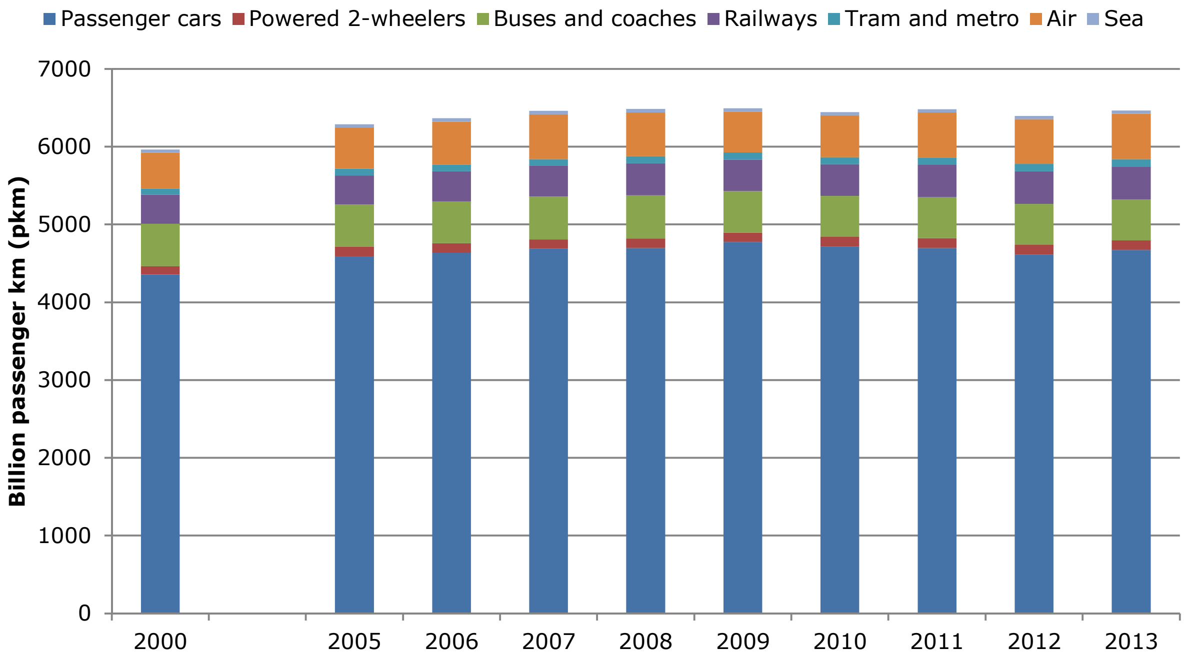



122 (1) Denmark and Greece: Data not available; (2) 2012 data; (3) Including Åland; (4) 2011 data; (5) Great Britain only; (6) Vehicles with no technical inspection for 5 years are excluded.

### *6.4.1 Passenger traffic*

The passenger transport volume has risen by 8.4% in the period from 2000 to 2013. In 2013, the value registered 6,464 billion pkm. The maximum passenger volume during the period was observed in 2009 (6,493 billion pkm).

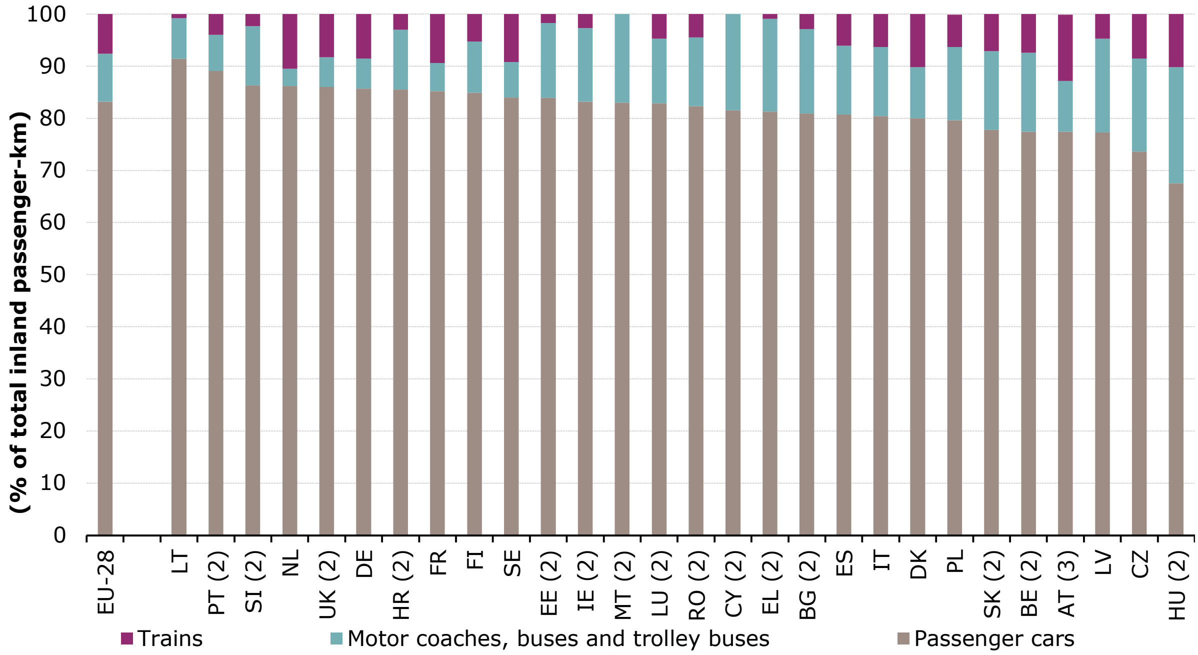
**Figure 156: Passenger transport volume and modal split in the EU-28, 2000 and 2005-2013. Source: EC DG-MOVE**




Distinguishing by conveyance, passenger cars are the transportation with the highest volume of passengers. Passenger cars registered 4,672 billion pkm (83.2% of the total) in 2013 which corresponds to an increase by 7.3% in comparison with 2000. Between the years 2000 and 2013 and regarding the rest of conveyances, air transport has increased by 26.7%, tram and metro by 21.8%, powered 2-wheelers by 15.7% and railways by 14%. In contrast, sea transportation and buses and coaches have dropped by 7.1% and by 4.0% the volume of passengers during the same period (see Figure 156).

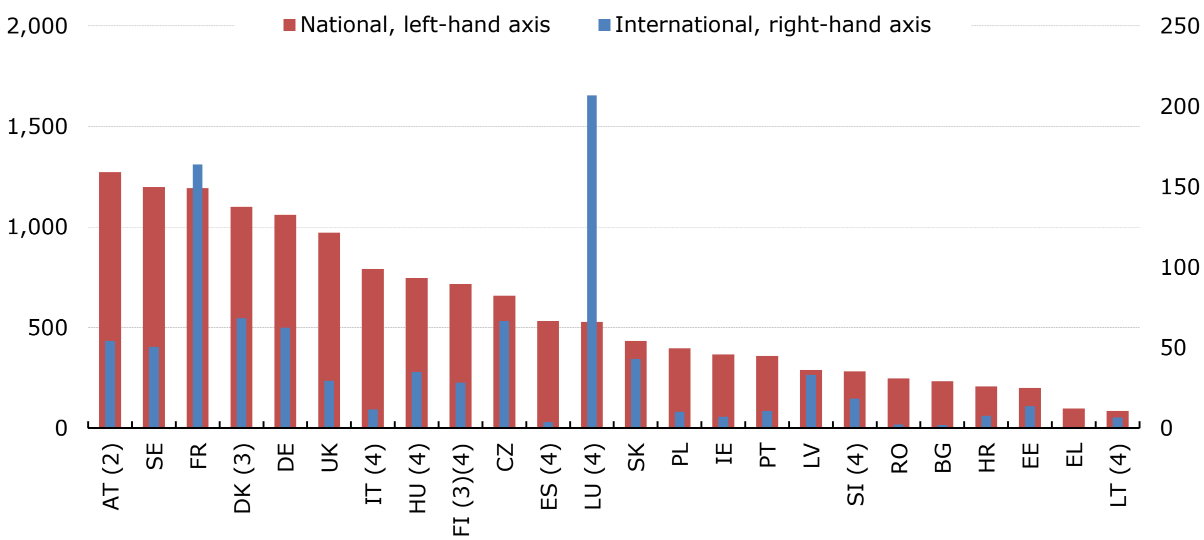
Analysing the inland passenger transport in the EU-28 Member States, it can be observed that Lithuania was the European country the highest volume of passenger cars (91.4%) in 2013, followed by Portugal (89.1%) and Slovenia (86.3%). In contrast, Hungary (67.5%), Czech Republic (73.6%) and Latvia (77.3%) were the Member States with the lowest percentage of inland passenger transport in the same year. Sixteen Member States registered below European average passenger cars' percentage in 2013 (< 83.2%). The relative importance of motor coaches, buses and trolley buses exceeded one fifth of inland passenger transport in Hungary (22.3%), followed by Cyprus (18.5%) and Latvia (18.0%). This share was between 10.0% and 20.0% in 17 other Member States while the lowest share for motor coaches, buses and trolley buses was registered in the Netherlands (3.3%). Regarding to railways, the highest share of trains transport were recorded in Austria (12.7%), the Netherlands (10.5%) and Denmark and Hungary (10.2%). According to the data, Hungary seemed to have the most balanced inland passenger transport among the EU-28 MSs accounting passenger cars, trains and motor coaches, buses and trolley buses in 2013.

**Figure 157: Modal split of inland passenger transport in the EU-28, 2013[123]. Source: Eurostat**




In 2014, Austria registered the highest passenger volume in rail transport at national level with the value 1,273 passenger-km per inhabitant. The second was Sweden (1,199) and the third France (1,193). In terms of international rail travel, only Luxembourg (207) and France (164) reported averages of more than 100 passenger-kilometres per inhabitant in 2014 as illustrated in Figure 158.

**Figure 158: Rail passenger transport (passenger-km per inhabitant) in the EU-28, 2014[124]. Source: Eurostat**

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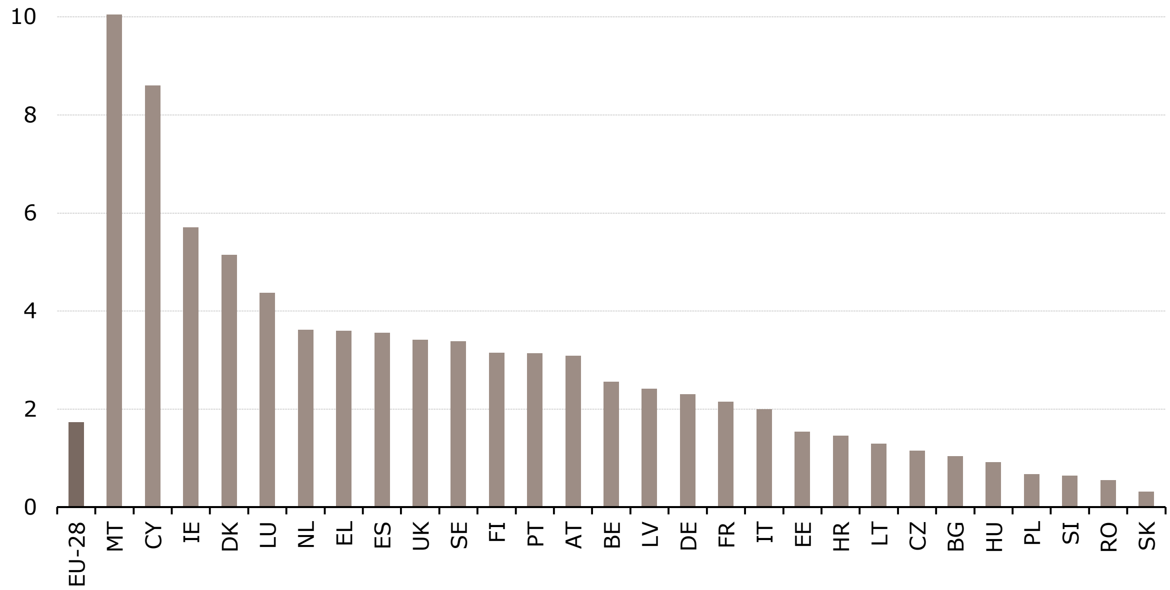
[123] Note: (1) Excluding powered two-wheelers. Cyprus and Malta: railways not applicable; (2) Includes estimates or provisional data; (3) The railway in Liechtenstein is owned and operated by the Austrian ÖBB and included in their statistics.

[124] Note: (1) Cyprus and Malta: not applicable. Belgium and the Netherlands: not available; (2) The railway in Liechtenstein is owned and operated by the Austrian ÖBB and included in their statistics; (3) Data from 2013; (4) Provisional.

With regard to air passenger transport, Malta was the Member State with the highest rate of passengers per inhabitant in the year 2014 with 10.0 passengers per inhabitant; the second was Cyprus (8.6). Eighteen countries registered higher values than the average European rate for 2014 which was 1.7 passengers per inhabitant (see Figure 159).

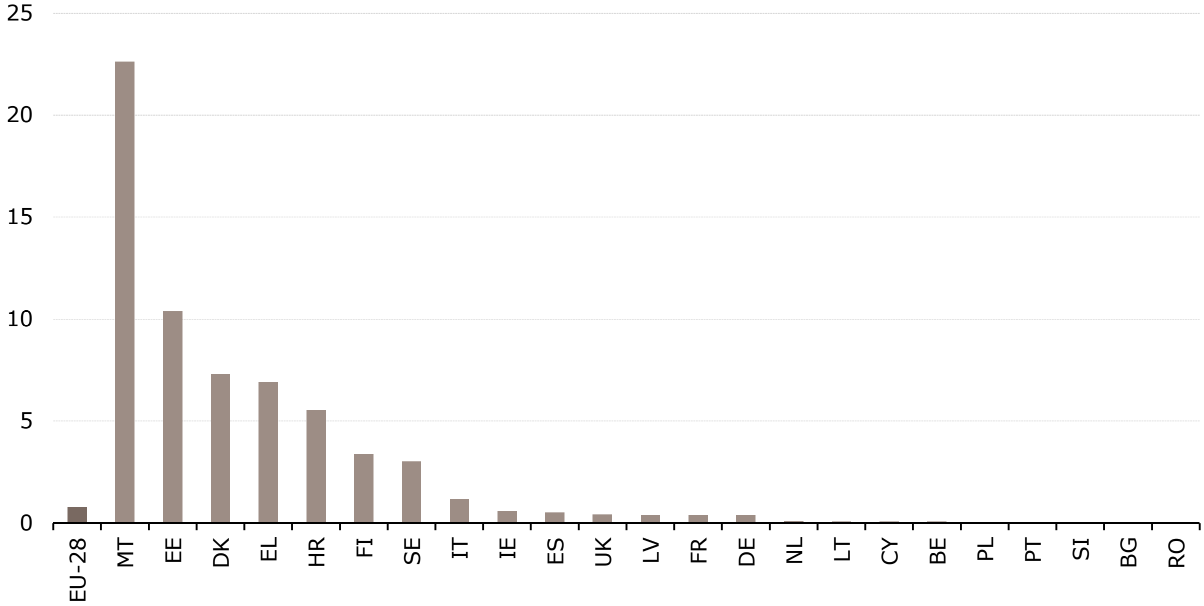
**Figure 159: Air passenger transport (passengers per inhabitant) in the EU-28, 2014[125]. Source: Eurostat**




The average EU-28 number of passengers per inhabitant in sea transport was 0.8 passengers per inhabitant in 2014. Eight Member States registered higher values than the European record. In the same year, the importance of maritime passenger transport was particularly high in Malta (22.6), followed by Estonia (10.4), Denmark (7.3), Greece (6.9) and Croatia (5.6).

[125] Total passengers carried (arrivals and departures for national and international); aggregates exclude the double-counting impact of passengers flying between countries belonging to the same aggregate. If both the port of embarkation and disembarkation report data to Eurostat, then these passengers are counted twice.

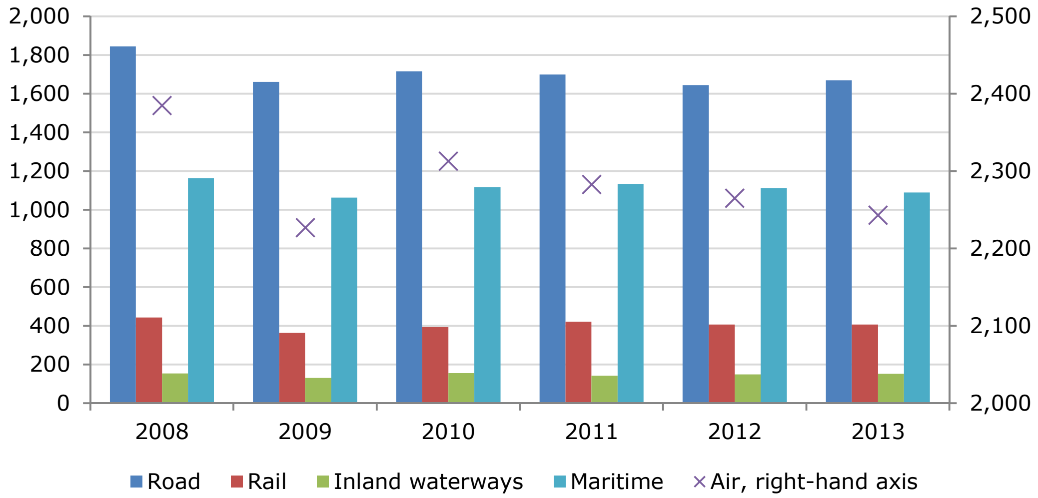
**Figure 160: Sea passenger transport (passengers per inhabitant) in the EU-28 Member States, 2014[126]. Source: Eurostat**




### 6.4.2 Freight traffic

Total inland freight transport in the EU-28 was estimated to be over 2,200 billion tonne-kilometres (tkm) in 2013. In the period from 2008 to 2013, the total freight traffic has declined by 8% (288.1 billion tkm). Road is the mode of transport which most have dropped during these years (by 9.5%). Inland waterways is the mode of transport with the lowest decrease (by 1.1%). Overall, a remarkable drop was registered in all the transport modes in the year 2009 as illustrated in Figure 161.

**Figure 161: Freight transport traffic (billion tkm) breakdown into conveyances in the EU-28, 2008-2014[127]. Source: Eurostat**

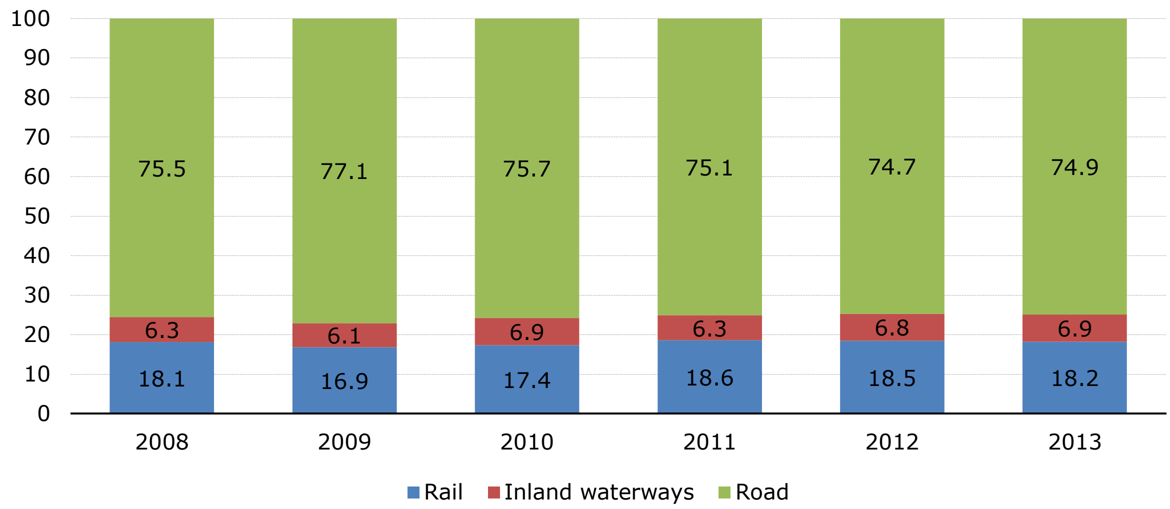



[126] Figures refer to the number of passengers 'handled in ports' (the sum of passengers embarked and then disembarked in ports). If both the port of embarkation and disembarkation report data to Eurostat, then these passengers are counted twice. EU-28, France: 2013. The Czech Republic, Luxembourg, Hungary, Austria and Slovakia: not applicable.

[127] Air and maritime cover only intra-EU transport (transport to/from countries of the EU) and exclude extra-EU transport.

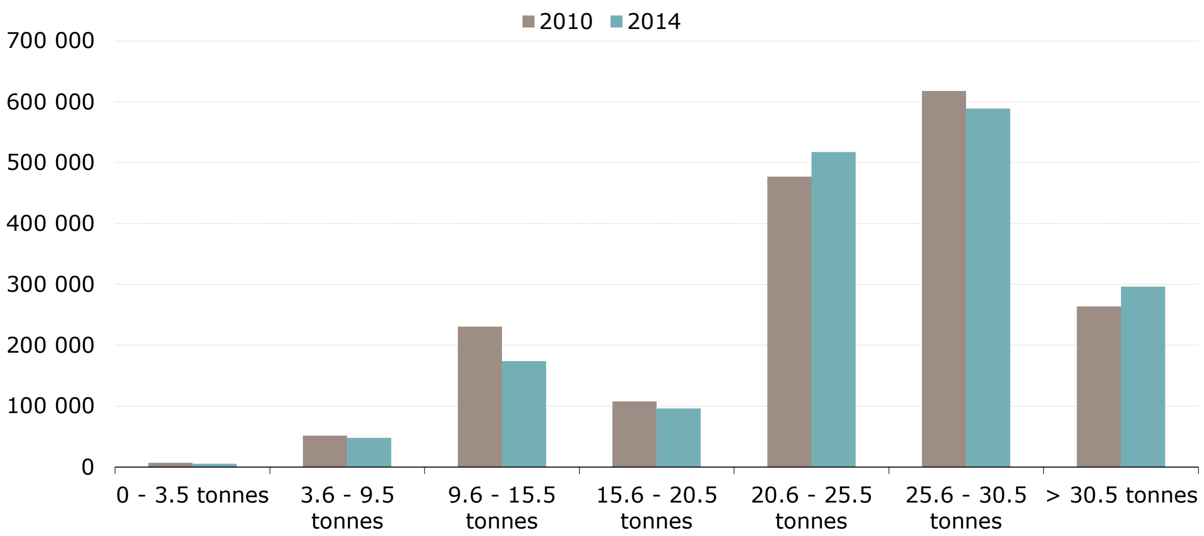
Analysing the inland transport modes, road registered 75% of the freight traffic in 2013, confirming this mode of transport as the major freight transport. Rail was the second freight transport with highest presence in the EU-28 freight traffic (18%). During the period from 2008 to 2013, the shares of the different inland transport modes have not experienced significant changes.

**Figure 162: Freight transport in the EU-28: modal split of inland transport modes (% of total tonne-kilometres), 2008-2013[128]. Source: Eurostat**




Transportation of loads between 25.6-30.5 tonnes was the most frequent in the European road conveyance in the year 2014 (588,867 Mtkm). Road transport with capacity between 9.6-15.5 tonnes has reduced the most (-24.6%) during the period 2010-2014. The presence of freight traffic between 20.6-25.5 tonnes and above 30.5 tonnes has augmented (8.5% and 12.3% respectively) in comparison with the year 2010.

**Figure 163: Evolution of EU-28 road transport by load capacity, 2010 and 2014 (million tonne-kilometres). Source: Eurostat**

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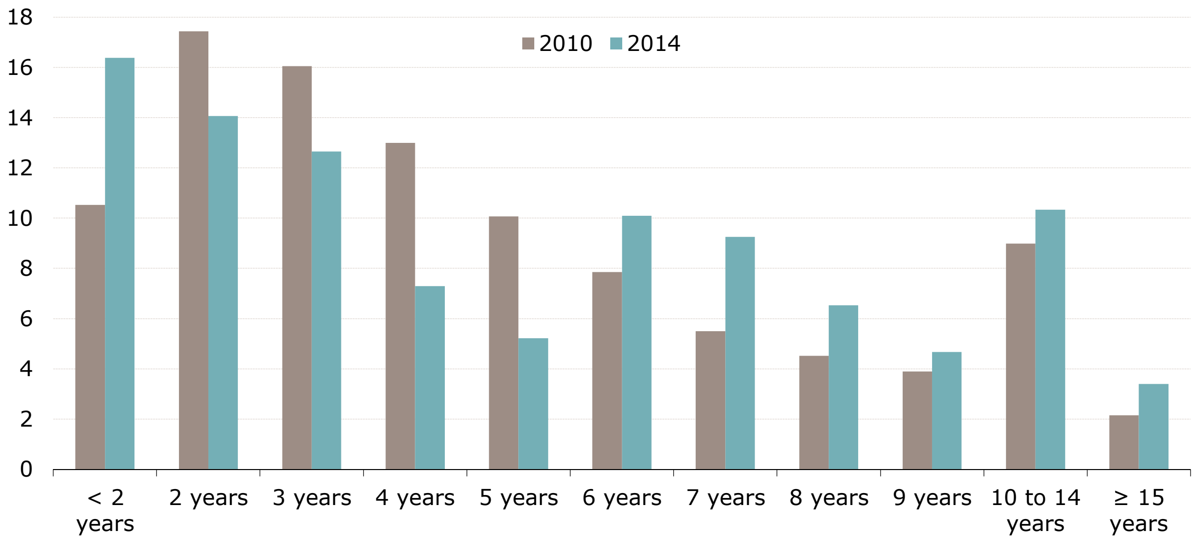
128 Note: EU aggregates contain estimated data for rail for 2012-2013 (BE, LU), inland waterways for 2008 (BG, RO) and exclude road freight transport for MT (negligible).

The total road transport traffic declined by 1.7% during the last 5 years, from 1,755 billion tkm in 2010 to 1,725 billion tkm in 2014.

**Figure 164: Road goods transport in the EU-28 by age of vehicle, 2010 and 2014 (% of total tonne-kilometres). Source: Eurostat**




Regarding the fleet's age of the road goods transport, it is observed that over 50% of the vehicles fleet had 4 years or below in 2014. In the same year, the vehicles of age below 2 years were the majority (16.4%). There is a decreasing presence of vehicles as the age of the vehicles rises. This trend is interrupted for vehicles of 6 years old; vehicles that might correspond to the newest ones from the year 2010 which have experienced a gradual aging. In comparison to the year 2010, the share of good transport of age below 2 years has increased by 5.9%. Overall, the fleet of vehicles up to 3 years of age have remained nearly the same (44.0% in 2010 vs 43.1% in 2014). Nevertheless, a general gradual aging of the fleet has been registered as vehicles up to 5 years old accounted for 67.1% in 2010, whereas accounted for 55.6% in 2014.

Analysing the age in road goods transport across the EU-28 Member States, it is found that the vehicles between 2 and 5 years were the majority in 2014. In 2014, the average EU-28 shares of goods transport vehicles by age were: less than 2 years (15.2%); between 2 and 5 years (38.0%); between 6 and 9 years (30.5%); between 10 and 14 years (11.7%) and 15 years and over (4.5%). With 31.6% of its fleet with less than 2 years, Denmark was the European country with the newest fleet of vehicles dedicated to goods transport; it doubles the European average value for that year. Whether the all goods transport vehicles up to 5 years old are accounted, then Germany was the State with the newest vehicles' fleet with a share of 73.3%; closely followed by Luxembourg (69.6%), Denmark (69.2%) and Sweden (69.1%). Ireland registered the highest share of vehicles between 6 and 9 years (54.6%). And Greece had the oldest fleet of goods transport vehicles in 2014, 61.3% of the vehicles were older than 10 years. Distinguishing by age ranges Greece was, also, the European country with the oldest fleet of vehicles dedicated to road goods transport in the range between 10 and 14 years and in the range of 15 and over years (35.7% and 25.5% respectively).

**Figure 165: Share of age categories in road goods transport, 2014 (% in vehicle-kilometres). Source: Eurostat**

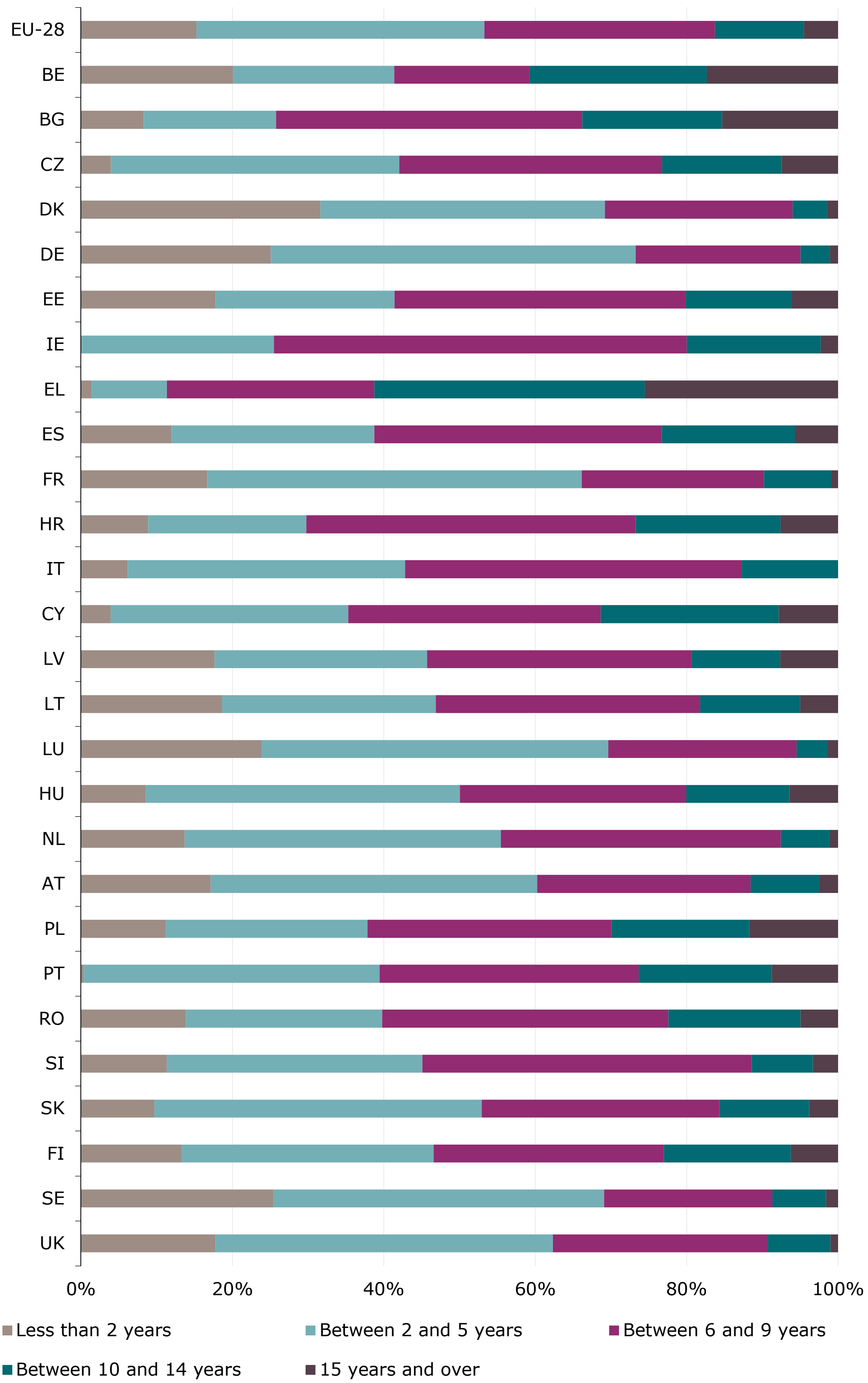
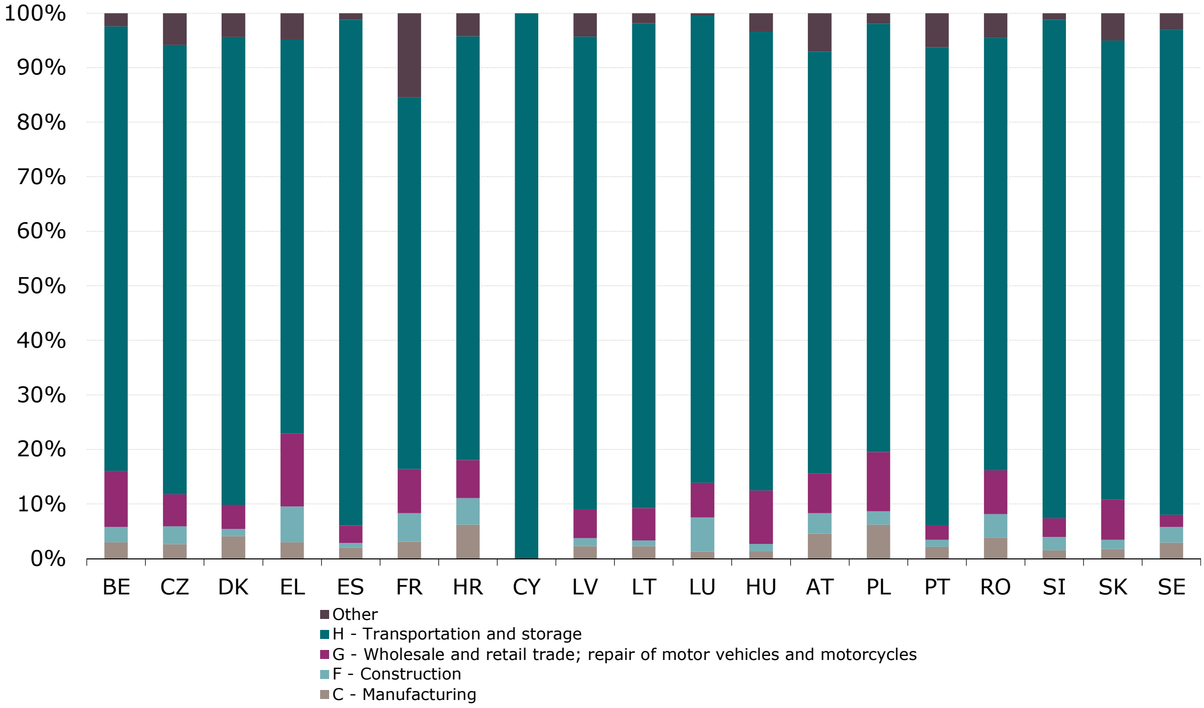


**Figure 166: Road freight transport by economic activity, 2014 (million tonne-kilometres). Source: Eurostat**

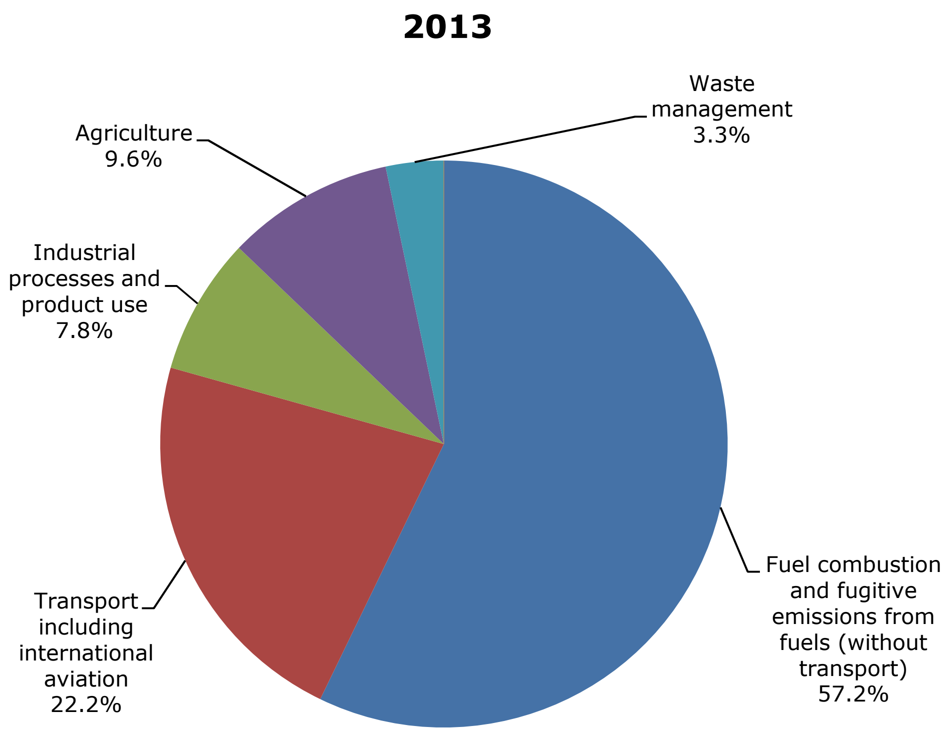



Transportation and storage of goods was the main economic activity related to freight traffic in the EU-28 in 2014. In the State with the least share this activity even accounted for a large representative share (France; 68.2%), while it was estimated to be 100% in Cyprus. On average, the second main economic activity was wholesale and retail trade and repair of motor vehicles and motorcycles which registered their highest shares in Greece (13.4%), Poland (10.9%) and Belgium (10.3%). The highest shares of road freight transport related manufacturing activities were registered in Poland and Croatia (6.2%), Austria (4.6%) Denmark (4.1%). Road freight transport related to construction found their highest records in Greece (6.6%), Luxembourg (6.3%) and France (5.2%).

## 6.5 Carbon Dioxide ($CO_2$) Emissions

Among the economic sectors analysed in this report, the transport sector is the major contributor to carbon dioxide emissions after the emissions derived from fuel combustions which mainly take place in the energy sector. In 2013, the transport sector was responsible of 22.2% of the $CO_2$ equivalent emissions[129].

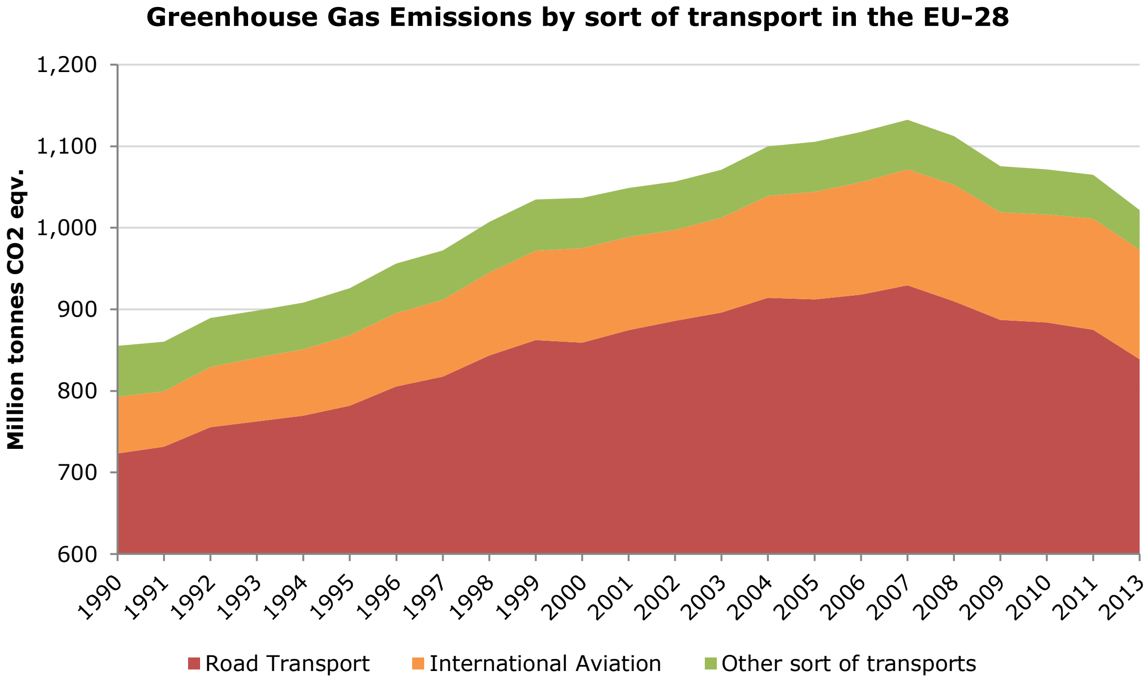
**Figure 167: Greenhouse gas emissions by source sector in the EU-28, 2013 (percentage of total). Source: EEA**




With regard to the greenhouse gas emissions, it is of relevance to follow the trend-line since 1990 as the European targets (the cut of 40% in greenhouse gas emissions) are set according to levels of this year. The following figure shows the aggregated emissions produced in the transport sector by sort of transport. Since 1990, the emissions associated to road transport have been the main share, accounting for circa 95% in 2013. International aviation sector registered its maximum value during 2008 (142.8 Mtoe). Other transports category, which is formed by domestic aviation, domestic navigation, rail, non-specified and pipeline transport, have been responsible of 5-8% of the emissions per year in the transport sector along the period from 1990 to 2013.

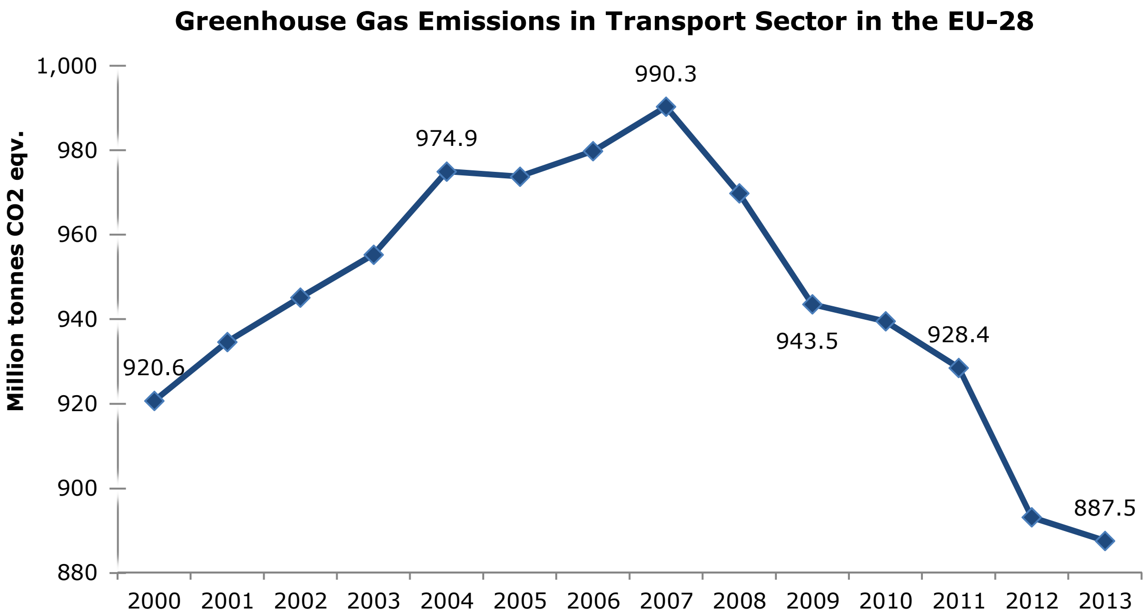
[129] The air pollutants are quantified in CO2 equivalent emissions which carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6), in a specific sector.

**Figure 168: Greenhouse gas emissions by sort of transport in the EU-28, 1990-2013. Source: EEA**




Overall, the greenhouse gas emissions in the transport sector have followed the trend of the energy consumption in the sector as per its direct causation. From 2000 to 2013 the CO2 equivalent emissions have declined by 3.6% (33.1 $MtCO_2e$). The maximum in the time series took place in 2007 when the value of 990.3 $MtCO_2e$ was reached, year which coincides with the maximum in the final energy consumption in the sector. Since 2007, a total reduction by 10.4% has been registered. In 2013, the minimum value for the analysed period (2000-2013) was recorded (887.5 $MtCO_2e$), returning to similar levels of years 1997-1998.

**Figure 169: Greenhouse gas emissions in transport sector in the EU-28. Source: EEA**

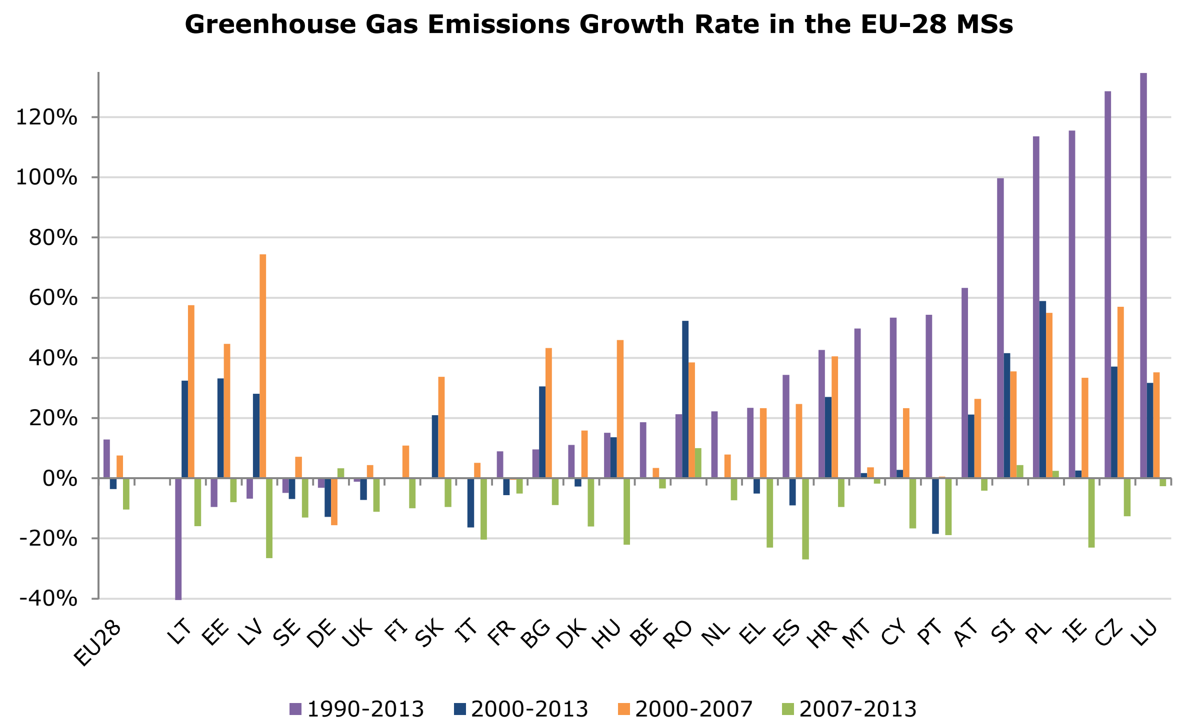


The following table shows an overview of the greenhouse gas emissions values in the transport sector and their subsectors, together with the growth rates in the two different periods, i.e. 1990-2013 and 2000-2013.

**Table 37: Greenhouse Gas Emissions in the EU-28 transport sector. Source: EEA**

| | | **Total Transport** | Road Transport | International Aviation | Other Transports |
|---|---|---|---|---|---|
| Greenhouse Gas Emissions (kilotonnes of CO2 equivalent) | 1990 | ***785,891*** | 723,149 | 69,514 | 62,742 |
| | 2013 | ***887,484*** | 838,921 | 134,247 | 48,564 |
| | 2012 | ***893,043*** | 842,193 | 134,360 | 50,850 |
| | 2011 | ***928,431*** | 874,939 | 136,263 | 53,491 |
| | 2010 | ***939,458*** | 883,788 | 132,229 | 55,670 |
| | 2005 | ***973,705*** | 912,210 | 131,733 | 61,494 |
| | 2000 | ***920,627*** | 859,214 | 115,860 | 61,413 |
| Growth Rates (%) | 1990-2013 | ***12.9%*** | **16.0%** | **93.1%** | **-22.6%** |
| | 2000-2013 | ***-3.6%*** | **-2.4%** | **15.9%** | **-20.9%** |

**Figure 170: Greenhouse gas emissions growth rate in the EU-28 Member States; 1990-2013, 2000-2013, 2000-2007 and 2007-2013. Source: EEA**

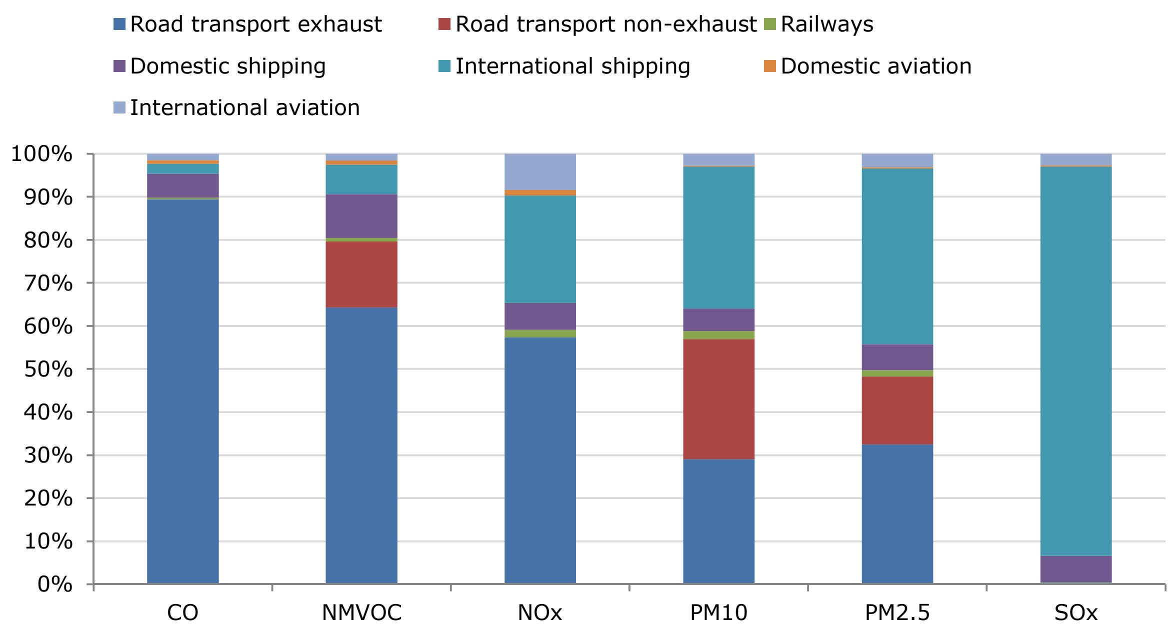



Across the EU-28 Member States, the countries with the highest reduction rates during the period from 2000 to 2013 have been Portugal (-18.5%), Italy (-16.4%), Germany (-12.8%), Spain (-9.0%) and the United Kingdom (-7.2%). In contrast, the States with the highest increase of greenhouse gas emissions during the same period have been Poland (58.9%), Romania (52.3%), Slovenia (41.5%), Czech Republic (37.1%) and Estonia (33.2%). Eight Member States have registered higher reduction rates of emissions than the average European level (< -3.6%) for that period. To be noted that Germany was the only State that registered a reduction of $CO_2$ emissions in the period from 2000 to 2007. From 2007 to 2013, only four countries registered an increase in the emissions, these are: Romania (10.0%), Slovenia (4.4%), Germany (3.3%) and Poland

(2.5%). The reduction rates in the period 2007-2013 might indicate the consequences of the impact produced by the financial and economic crisis in the sectors such as freight transportation. Whether the GHG emissions growth rate changes are analysed for the period from 1990 to 2013 it observed that the EU-28 GHG emissions have increased by 12.9%, whereas Lithuania (-40.5%), Estonia (-9.6%) and Latvia (-6.7%) are the European States with the highest reduction rates. The MSs with the highest increases registered during that period are Luxembourg (134.7%), Czech Republic (128.6%) and Ireland (115.5%).

Distinguishing by air pollutants and transport subsectors, road transport was main responsible CO (89.4%), NMVOC (64.3%) and NOx (57.4%) emissions in 2013. In the same year, international shipping was the main responsible of SOx emissions (90.4%), PM2.5 (40.8%) and PM10 (33%). Road transport would also be the main polluter of PM10 and PM2.5 if road transport non-exhaust emissions (from fuel evaporation, tyre and brake wear emissions) were accounted (57.0% and 48.3% respectively). NOx was the most emitted pollutant in international and domestic aviation, while PM10 was the most emitted pollutant in railways and NMVOC in domestic shipping as illustrated in the following figure.

**Figure 171: Contribution of the transport sector to emissions of the main air pollutants in the EEA-32, 2013. Source: European Environment Agency**



## 6.6 Overview – Transport sector

The transport sector accounted for 33.22% of total final energy consumption in the year 2014, confirming transportation as the main consuming sector. The final energy consumption in the sector has grown by 2.2% at European level between 2000 and 2014. The increase in the final energy consumption has been the result of a reduction by 2.3% in the EU-15 areas and increase by 47.5% from NMS-13 areas.

The maximum consumption during this period (2000-2014) was registered in the year 2007 (383.0 Mtoe), while the minimum during the analysed period corresponds to year 2000 (344.9 Mtoe). There is a reversing (growing to falling) trend before and after the year 2007 as a consequence of the financial and economic crisis.

In 2014, the final energy consumption in the transport sector grew by 1.4% (up to 352.5 Mtoe; out of which 87.1% was consumed by EU-15 areas) breaking the existing decreasing trend underwent until 2013.

The energy intensity in the transport sector has decreased by 13.2% during the period from 2000 to 2013, registering the value of 0.0296 koe/€2005 in 2013. The lowering trend along the whole period was interrupted in 2009 by a rise of 1.3% as per the consequence crisis in the GDP values.

There are significant differences of final energy consumption in the transport sector among the Member States as fourteen States accumulated more than 90% of the final energy consumption in 2014. Germany (63.5 Mtoe), United Kingdom (51.1 Mtoe), France (49.5 Mtoe) and Italy (40.1 Mtoe) are the highest final energy consumers of the sectors; they accounted for more than 55% of the final energy consumption in the sector in 2014.

Between 2000 and 2014, Poland (65.0%), Lithuania (64.7%) and Romania (58.2%) are the EU-28 MSs with the highest growth rates in the final energy consumption in the transport sector. In contrast, Greece (-11.4%), Italy (-5.7%) and Germany (-5.0%) registered the lowest growth rates. Ten EU-28 countries (i.e. Greece, Italy, Germany, Spain, United Kingdom, Portugal, France, Cyprus, the Netherlands, and Denmark) registered below average European values in the same period (< 2.2%).

In the period 2000-2007, all the Member States with the exception of Germany and Malta registered increased in their final energy consumption. The average European growth rate in that period was 11.1%. The trends were significantly different in the period from 2007 to 2014 when seven Member States recorded a positive growth rate. The period 2007-2014 reflects the energy consumption decline produced by the financial and economic crisis (after 2007) which is clearly observed in the overall European final energy consumption trend.

The energy mix in the transport sector in mainly formed by petroleum products. Petroleum products represented 93.63% (330,058 ktoe) in 2014; this represents a small reduction in the share in comparison to 2000 (97.75%).

Diesel and gasoline consumption stand out among the petroleum products. In 2014, oil-diesel accounted for 55.4% (195,107 ktoe) and gasoline for 22.3% (78,565 ktoe). The remaining shares were completed by jet fuel (14.1%; 49,589 ktoe), biofuels (4.0%; 14,141 ktoe), LPG (1.7%; 5,813 ktoe), electricity (1.5%; 5,338 ktoe), gas (0.84%; 2,956 ktoe), and heavy fuel (0.28%; 984.2 ktoe). Solid fuels represent a negligible share in the final energy mix (0.002%; 8.6 ktoe).

A reduction in the gasoline share by 16.6% (55.5 Mtoe), together with increases by 11.0% (42.0 Mtoe) and 3.8% (13.4 Mtoe) in the shares of diesel and biofuels respectively constituted the most significant changes in the final energy mix in comparison to year 2000 scenario.

Focussing on petroleum products, its energy consumption has drop by 2.1% (7.1 Mtoe) from 2000 to 2014. Diesel has gradually increased its presence, registering an increase by 59.1%, while gasoline has declined by 41.4%. Heavy fuel has registered a significant fall by 27.1% (-364.9 ktoe) in the same period.

Automotive diesel oil and gasoline prices increased from 2002 until mid-2008 when a significant drop took place. Since mid-2009 the prices rose, reaching a maximum in September-October 2012 (maximum of the period 2000-2014) when the prices registered were 1.678 Euro/litre for gasoline 95 Ron and 1.488 Euro/litre for automotive diesel oil. Since that maximum, the fuel prices have been undergoing a progressive reduction; a significant drop between Q4 2014 and Q1 2015 was registered influenced by multiple factors both supply and demand related.

Analysing the renewable energies, it is observed that biofuels have highly developed during the period from 2000 to 2014. Its energy consumption rose by four times between 2005 and 2010 (from 3,199 ktoe to 13,137 ktoe), mainly due to biodiesels and biogasoline usage. Since 2010 the energy consumption of this fuel type has remained nearly constant.

The analysis of transport subsectors can lead to a better understanding of how the final energy is consumed in the transport sector. The subsectors studied are: road; rail; international aviation; domestic aviation; domestic navigation; pipeline transport; and other transports.

Road transport is extensively the main energy consuming subsector. It consumed 82.08% (289.4 Mtoe) of the final energy share in 2014. In the same year, the second consuming subsector was international aviation (12.56%; 44.3 Mtoe), followed by rail (1.77%; 6.2 Mtoe), domestic aviation (1.51%; 5.3 Mtoe), domestic navigation (1.22%; 4.3 Mtoe), pipeline transport (0.44%; 1.6 Mtoe) and other non-specified transport (0.43%; 1.5 Mtoe). The most remarkable change to year 2000 scenario is the energy consumption of pipeline transport has increased by nearly times three (from 534 ktoe to 1,561 ktoe).

From 2000 to 2014, domestic navigation has declined its final energy consumption the most (by 28.7%). Rail, domestic aviation and non-specified transport have declined their energy consumption by 23.9%, 16.5% and 6.5% respectively. In contrast, pipeline transport (by 192.4%), international aviation (by 14.8%) and road transport (by 2.0%) grew.

In 2014, petroleum products were the only fuel type in the aviation and navigation and it also was the main contributor (94.6%) in the road transport. Electricity represented the main consuming fuel in rail (66.4%) and other transports (69.5%) categories. Gas was the major fuel type used in pipeline transport (94.0%). With regard to renewable energies, biofuels occupied a share in road (4.9%), rail (0.5%) and other transports (0.6%).

Focusing on road transport, the final energy consumption has increased by 2.0% (5.7 Mtoe) in the period from 2000 to 2014. NMS-13 areas have increased their final energy consumption by 53.0%, while EU-15 have registered a drop by 3.3%.

As observed in the transport sector, 14 Member States consumed more than 90% of the final energy of the sector in 2014. Germany (52.7 Mtoe), France (41.4 Mtoe), United kingdom (37.6 Mtoe) and Italy (34.3 Mtoe) accounted for more than 55% of the total final energy consumption in the road transport.

The energy mix in the road transport is chiefly associated to petroleum products (i.e. diesel, gasoline, LPG and gas). In 2014, diesel was the most consumed fuel type (65.6%), followed by gasoline (27.0%), biofuels (4.9%), LPG (2.0%), gas (0.5%) and electricity which accounted for a minor share (0.02%) of the final energy consumption. Diesel is slightly substituting part of the gasoline oil.

During this 15-years period (2000-2014), it is highlighting a shift from fossil fuels to renewable energy sources representing the pathway towards a more sustainable mode of road transport; biofuels has increased its share by 4.6%.

In 2014, biodiesels were the major renewable fuel type with 80.2%. Biogasoline was the second with 18.8%. Biogas started to account in the final energy consumptions after 2008 and reached about 1% share of the renewable energy mix in 2014.

Analysing the vehicle types within the road transport, cars outstand as the main energy consumers in the road transport. There have not been remarkable differences between 2000 and 2013. In 2013, cars accounted for 59.3% (168.5 Mtoe) of the road final energy consumption, followed by trucks and light vehicles (35.5%; 100.9 Mtoe), buses (3.9%; 11.0 Mtoe) and two wheels vehicles (1.3%; 3.6 Mtoe).

The stock of vehicles in the EU-28 was mainly formed cars (78%; 239.7 million cars) in 2013. Trucks and light vehicles were the second vehicle type according to stock size with over 35.2 million units, followed by two wheels vehicles (32.2 million units) and buses (849 thousand units). All the vehicle types have increased their stocks. The total stock of vehicles has increased by 60.5 million units from 2000. Trucks and light vehicles are the vehicle type which has grown the most (30.6%; 8.3 million units), closely followed by two wheels vehicles (30.3%; 7.5 million units).

Analysing the energy consumption per vehicle, buses have the largest value (understandable due to their average size). In 2013, the average EU-28 energy consumption per bus was 12.99 toe/veh; while trucks and light vehicles consumed registered 2.87 toe/veh, cars 0.70 toe/veh and two wheels 0.11 toe/veh. In comparison to year 2000, cars have decreased their unitary energy consumption by 19.0%, two wheels by 14.5% and trucks and light vehicles by -23.2%. In contrast, buses have registered an increase by 6.9%. This last finding might be the result of the increase of usage of buses in the cities; reporting a positive effect as the number of cars on the road decreases.

Cars represented 78% of the stock of vehicles and 59.3% of the final road energy consumption in 2013. In 2000, the average energy consumption per car in the EU-28 was 0.87 toe per vehicle. There has been observed a gradual lowering on this value which has dropped by 19.5% (up to 0.7 toe/veh) in 2013. This drop might be the result of an increase in the energy efficiency performance of the vehicles but also because of the reduction in the annual distance travelled by car which has decreased by 1,402 km along the 14-years period (from 13,340 km in 2000 to 11,938 km in 2013). Nevertheless, further research should be needed in order to establish the causations.

With regard to the cars' engine technology, diesel-fuelled vehicles are the ones with the highest unitary energy consumption (0.88 toe/veh in 2013). The total average energy consumption per vehicle reduction during the period from 2000 to 2013 (-19.5%) is the result of a combined reduction by 34.6% in gasoline-fuelled cars, a reduction by 26.7% in diesel fuelled cars and a reduction by 9.5% in the LPG-fuelled cars.

From 2000 to 2013, the average specific consumption of gasoline and diesel cars already in the market have registered a reduction by 8.9% (from 8.1 litres/100 km in 2000 to 7.4 litres/100 km in 2013) and 8.0% (from 6.8 litres/100 km in 2000 to 6.3 litres/100 km in 2013) respectively. In the same period, the new cars gasoline- and diesel-fuelled entering into the market have also registered reductions in their specific consumption values. New gasoline and diesel cars have reduced by 25.7%; dropping to 5.4 litres/100 km and to 4.7 litres/100 km in 2013.

With regard to the EU average level of $CO_2$ emissions from new passenger cars, there has been registered a reduction by 28.3% (from 172.2 g $CO_2$/km to 123.4 g $CO_2$/km) during the period between 2000 and 2014.

In both, the average specific fuel consumption and average $CO_2$ emissions per kilometre there have been a decline from 2007 onwards. These trends may be the result of the implementation of EU regulations in the automotive sector (i.e. Regulation No 443/2009 and Regulation No 333/2014 on $CO_2$ emissions of new passenger cars).

Cyprus (88%), the Netherlands (80%) and Finland (77%) were the EU-28 Member States with the highest percentage of gasoline-fuelled passenger cars in 2013. Luxembourg (65%), Belgium (63%) and Austria (56%) were the States with the highest presence of diesel-fuelled passenger cars; while the highest shares of alternative-fuelled engines in passenger cars were registered in Lithuania (16.9%), Poland (16.5%), Italy (7.0%) and Sweden (5.9%).

A lower age of the vehicles fleet can help reducing the energy consumption and GHG emissions in the future as the energy consumption trends have decreased. In 2013, the highest share of newest passenger cars (below or equal 2 years) were found in Belgium (23%), Austria (20%) and Ireland (18%). In contrast, the oldest fleet of passenger cars (older than 10 years) were registered in Lithuania (85%), Poland (75%) and Latvia (72%). Luxembourg was the Member State with the highest number of passenger cars per 1,000 inhabitants in 2013 (672 cars); the second State was Italy (619 cars) and the third, Lithuania (609 cars). In contrast, the lowest number of passenger cars per thousand inhabitants were registered in Romania (235 cars), Hungary (307 cars) and Latvia (314 cars).

Domestic transportation which can be differentiated by passenger and freight transport was the major final energy consumer (over 80%) in 2013, where passenger transport accounted for the 63.7% and freight transport for the remainder 36.3%. Overall, the scenario of domestic transport has not largely changed compared to 2000 (drop by nearly 1%).

The passenger transport volume has risen by 8.4% in the period from 2000 to 2013, registering 6,464 billion pkm in 2013. Distinguishing by conveyance, passenger cars are the transportation with the highest volume of passengers (83.2% of the total; 4,672 billion pkm) in 2013, corresponding to an increase by 7.3% to year 2000.

Between the years 2000 and 2013, air transport has increased by 26.7%, tram and metro by 21.8%, powered 2-wheelers by 15.7% and railways by 14%; while sea transportation and buses and coaches have dropped by 7.1% and by 4.0% the volume of passengers.

In 2013, Lithuania was the EU-28 State with the highest volume of passenger cars (91.4%), followed by Portugal (89.1%) and Slovenia (86.3%). In contrast, Hungary (67.5%), Czech Republic (73.6%) and Latvia (77.3%) were the Member States with the lowest percentage of inland passenger transport in the same year. The average European passenger cars value was 83.2%. Hungary was the only State where motor coaches, buses and trolley buses exceeded one fifth of inland passenger transport in Hungary (22.3%). Regarding railway passenger traffic, the highest shares were recorded in Austria (12.7%), the Netherlands (10.5%) and Denmark and Hungary (10.2%). According to the data reported, Hungary presented the most balanced inland passenger transport among the EU-28 MSs in 2013.

Austria registered the highest passenger volume in rail transport at national level with the value 1,273 passenger-km per inhabitant; closely followed by Sweden (1,199) and France (1,193). In terms of international rail travel, only Luxembourg (207) and France (164) reported averages of more than 100 passenger-km per inhabitant.

In 2014, air passenger transport was especially representative in Malta and Cyprus which registered 10.0 and 8.6 passengers per inhabitant respectively. Eighteen countries registered higher values than the average European rate for 2014 which was 1.7 passengers per inhabitant.

In the same year, for sea transport the average EU-28 record was 0.8 passengers per inhabitant. Eight Member States registered higher values than the European record in that year. The importance of maritime passenger transport was particularly high in Malta (22.6), followed by Estonia (10.4), Denmark (7.3), Greece (6.9) and Croatia (5.6).

Total inland freight transport in the EU-28 was estimated to be over 2,200 billion tonne-kilometres (tkm) in 2013. In the period from 2008 to 2013, the total freight traffic has declined by 8% (288.1 billion tkm). Road was the mode of transport which most have dropped during these years (by 9.5%); while inland waterways was the mode of transport with the lowest decrease (by 1.1%). Rail was the second freight transport with highest presence in the EU-28 freight traffic (18%); value which has not experienced significant changes between 2008 and 2013.

Road transportation of loads between 25.6-30.5 tonnes was the most frequent in the European road conveyance in the year 2014 (588,867 Mtkm). The presence of freight traffic between 20.6-25.5 tonnes and above 30.5 tonnes has been the only capacities which have augmented (by 8.5% and by 12.3% respectively) in comparison with the year 2010. This might indicate a gradual trend to transportation of larger loads in the road transport.

As for the passenger cars, the fleet's age of the road goods transport is a factor affecting future energy consumption and emissions values. In 2014, over 50% of the vehicles fleet had 4 years or below in the EU-28. Vehicles of age below 2 years were the majority (16.4%) in that year. In comparison to the year 2010, the share of good transport of age below 2 years has increased by 5.9%. Overall, the fleet of vehicles up to 3 years of age have remained nearly the same (44.0% in 2010 vs 43.1% in 2014). Nevertheless, a general gradual aging of the fleet has been registered as vehicles up to 5 years old accounted for 67.1% in 2010, whereas accounted for 55.6% in 2014.

In 2014, Denmark was the European country with the newest fleet of vehicles (less than 2 years) dedicated to goods transport (31.6%). Within a larger range of age (vehicles dedicated to goods transport up to 5 years), Germany was the State with the newest vehicles' fleet with a share of 73.3%; closely followed by Luxembourg (69.6%), Denmark (69.2%) and Sweden (69.1%). In the same year, Greece had the oldest fleet of goods transport vehicles (61.3% of the vehicles were older than 10 years).

Transportation and storage of goods was the main economic activity related to freight traffic in the EU-28 in 2014 (e.g. it accounted for 100% of the freight traffic in Cyprus). In the State with the least share this activity even accounted for a large representative share (France; 68.2%). The second main economic activity was wholesale and retail trade and repair of motor vehicles and motorcycles which registered their highest shares in Greece (13.4%), Poland (10.9%) and Belgium (10.3%). Road freight transport related manufacturing activities found their highest shares in Poland and Croatia (6.2%), Austria (4.6%) Denmark (4.1%). The highest values for road freight transport related to construction were accounted in Greece (6.6%), Luxembourg (6.3%) and France (5.2%).

The transport sector was responsible of 22.2% of the $CO_2$ equivalent emissions in 2013. From 2000 to 2013 the $CO_2$ equivalent emissions have declined by 3.6% (33.1 MtCO2e). The maximum GHG emissions record took place in 2007 (990.3 MtCO2e), year which coincides with the maximum in the final energy consumption in the transport sector. Since 2007, a total reduction by 10.4% has been registered. However, the EU-28 GHG emissions have increased by 12.9% if compared to year 1990 (reference year for European GHG emissions targets). Overall, the greenhouse gas emissions in the transport sector have followed the trend of the energy consumption in the sector as per its direct causation.

From 2000 to 2013, the Member States with the highest reduction emissions rates have been Portugal (-18.5%), Italy (-16.4%), Germany (-12.8%), Spain (-9.0%), and the United Kingdom (-7.2%). In contrast, the States with the highest increase of greenhouse gas emissions during the same period have been Poland (58.9%), Romania (52.3%), Slovenia (41.5%), Czech Republic (37.1%) and Estonia (33.2%).

From 1990 to 2013, the Member States with the highest reduction emissions rates have been Lithuania (-40.5%), Estonia (-9.6%) and Latvia (-6.7%); while the highest increases have been registered in Luxembourg (134.7%), Czech Republic (128.6%) and Ireland (115.5%).

In the period 2000-2007, Germany was the only State that registered a reduction of GHG emissions; whereas in the period 2007-2013 only four countries registered an increase in the emissions: Romania (10.0%), Slovenia (4.4%), Germany (3.3%) and Poland (2.5%). The reduction rates in the period 2007-2013 might indicate the consequences of the impact produced by the financial and economic crisis in the sectors such as freight transportation.

Distinguishing by air pollutants the GHG emissions in 2013, road transport was main responsible for CO (89.4%), NMVOC (64.3%) and NOx (57.4%) emissions. International shipping was the main responsible of SOx emissions (90.4%), PM2.5 (40.8%) and PM10 (33%). If non-exhaust emissions are accounted for road transport, it would also be the main polluter of PM10 and PM2.5 (57.0% and 48.3% respectively). NOx was the most emitted pollutant in international and domestic aviation, while PM10 was the most emitted pollutant in railways and NMVOC in domestic shipping.

# 7. Energy Consumption and Energy Efficiency Trends in the Industry Sector

This chapter covers the energy consumption and the energy efficiency trends in the industry sector, which includes the construction, mining and manufacturing industries. The energy consumption trends are analysed also by energy types and main industry sub-sectors. Moreover, the market of electric motors and drives market is also analysed as these products are a major electricity consumer.

## 7.1 Final energy consumption and energy mix of the industrial sector

The industry sector accounted for 25.89% of the EU-28 total final energy consumption in the year 2014. This sets the industry sector at the second place after the transportation sector (33.22%) in the ranking of the most energy consuming economy sectors. Industry final energy consumption in the EU-28 has fallen by 17.6% in the 15-years period from 2000 to 2014. A similar decrease has been observed both in EU-15 and NMS-13 areas which have reduced their consumptions by 17.5% and 18.3% respectively. In 2014, industry final energy consumption reached 274.8 Mtoe, out of which 83.6% (229.7 Mtoe) was generated by EU-15 areas. The maximum annual consumption of this period took place in the year 2003 when it reached 335.6 Mtoe, while the minimum occurred in 2009 when the final energy consumption decreased to about 267 Mtoe, as illustrated in Figure 172. 2009 is the year with the lowest consumption not only in the analysed period but also in the 25-years period comprised between 1990 and 2014. This has probably been due to the impact of the financial and economic crisis [54].

**Figure 172: Industry sector: final energy consumption in the EU-28, 2000-2014. Source: Eurostat**

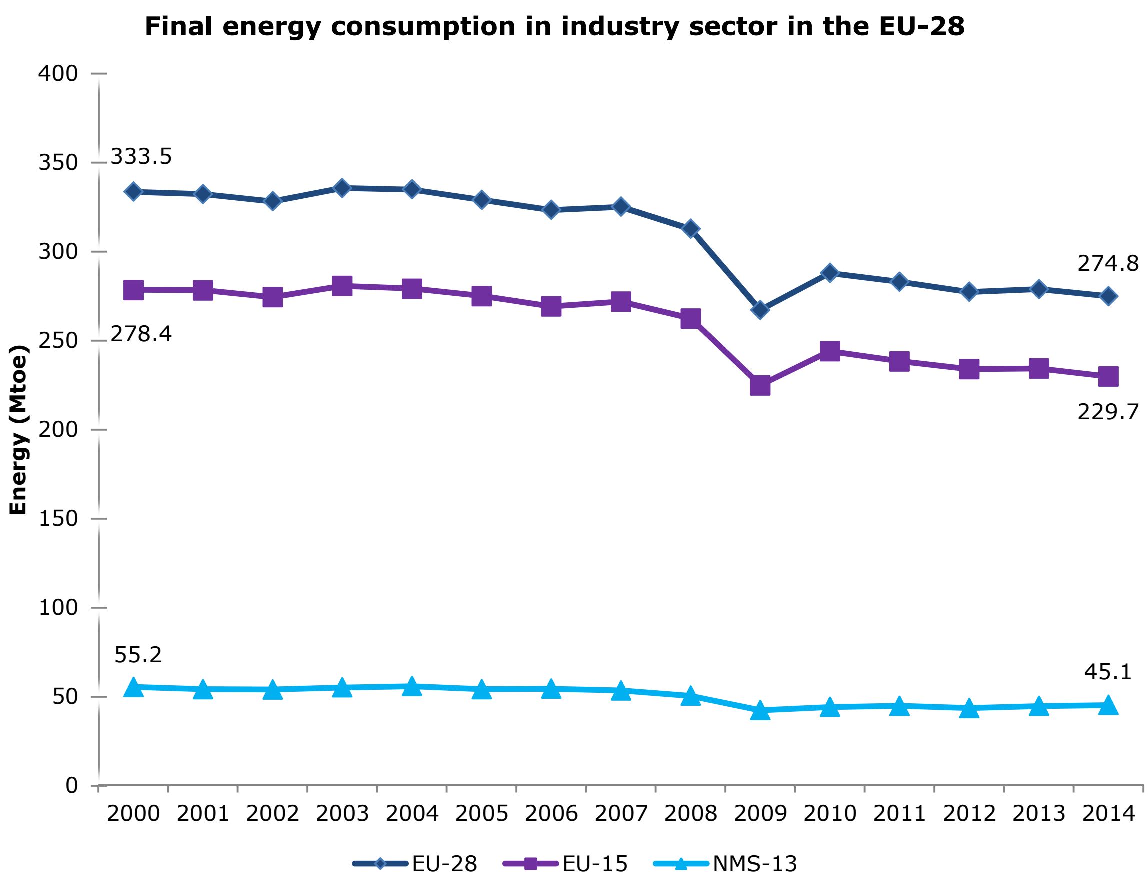
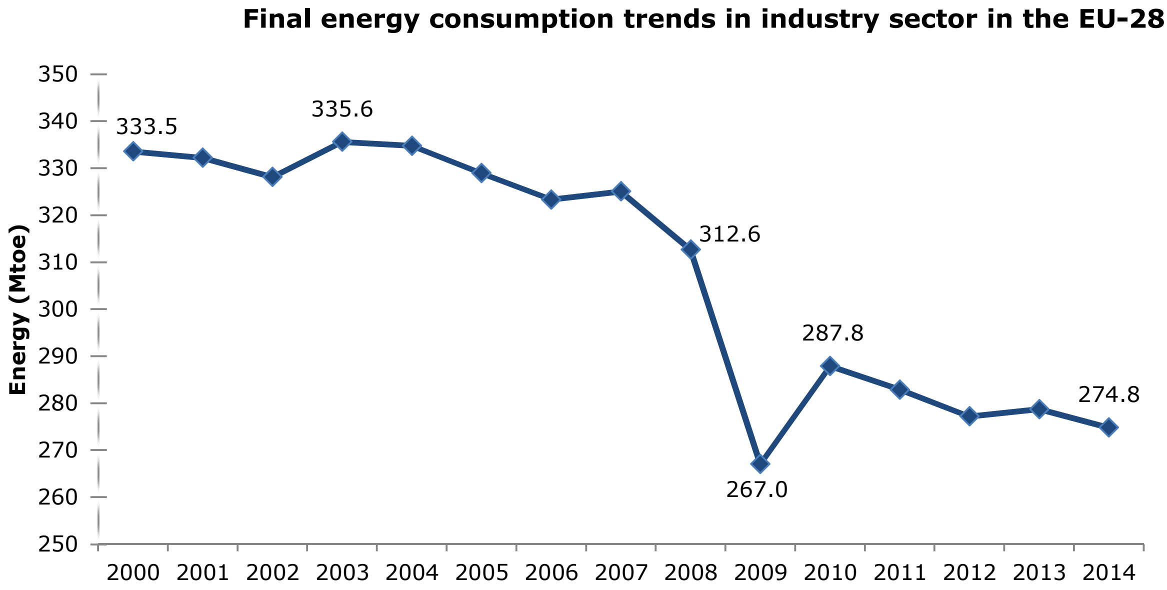
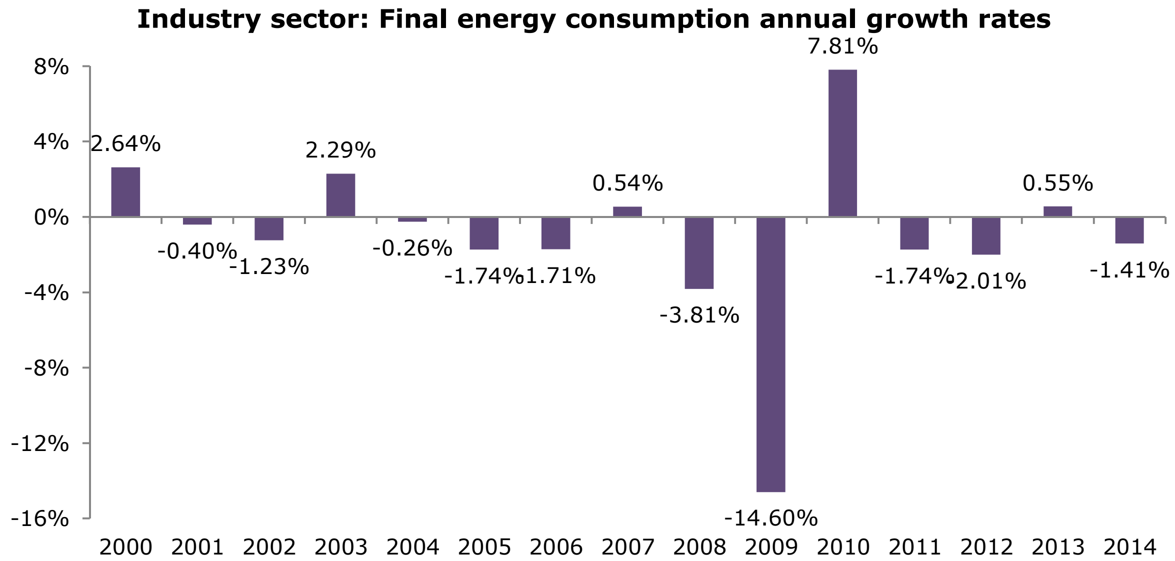


**Figure 173: Industry sector: final energy consumption in the EU-28, 2000-2014 (detailed). Source: Eurostat**




A decreasing trend in the final energy consumption has been registered during the last 15-years period with the exception of year 2003 when a 2.3% rise occurred and the year 2010 when the consumption rebounded from the dramatic drop by 14.6% in year 2009 (Figure 174). Since 2010, the decreasing trend has been continued reaching in 2014 the second lowest value over the 1990-2014 period. Energy consumption in industry is expected to keep this trend in the future due to the ongoing industry reallocation that could lead to a permanently smaller manufacturing sector in the EU (where TFP[130] growth rates and levels are relatively high) and to a larger services sector (where TFP growth rates and levels are traditionally lower than in manufacturing) [54].

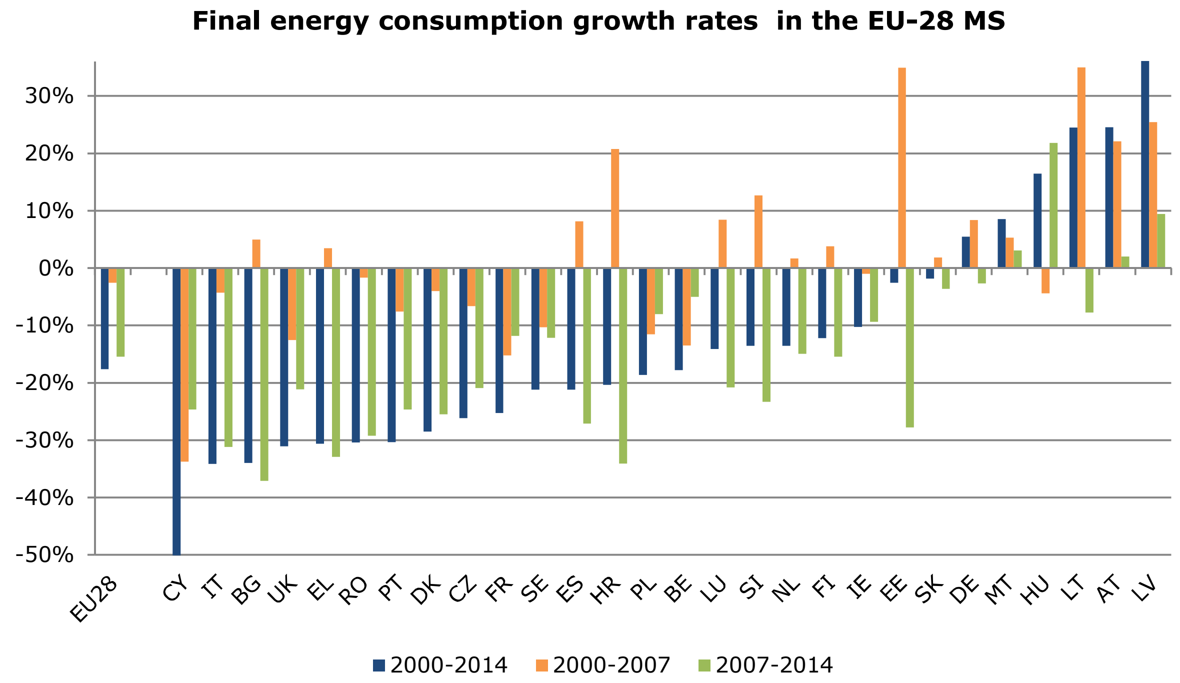
**Figure 174: Industry sector: final energy consumption annual growth rates in the EU-28, 2000-2014. Source: Eurostat**




[130] Total Factor Productivity (TFP) is a variable which accounts for effects in total output growth relative to the growth in traditionally measured inputs of labour and capital.

Looking at the final energy consumption growth rates across the EU-28 Member States, it can be observed that only six MSs have registered a positive growth rate from 2000 to 2014. These are: Latvia, Austria, Lithuania, Hungary, Malta and Germany. The highest growth rate has been observed in Latvia (37.3%), Austria and Lithuania (24.5%) and Hungary (16.5%). Fifteen EU-28 MSs have rates below the EU-28 average (-17.6%). The impact of the crisis on the industry manufacturing and production rates is evident. Only four Member States have increased their consumption in the period 2007-2014. However, the existence of negative growth rates before 2007 indicates that there are probably other factors for the observed trends besides the economic crisis. The lowest rates for the 2000-2014 period have been observed in Cyprus (-50.1%), followed by Italy (-34.2%) and Bulgaria (-34%).

**Figure 175: Industry sector: final energy consumption growth rates in the EU-28 Member States; 2000-2014, 2000-2007 and 2007-2014. Source: Eurostat**

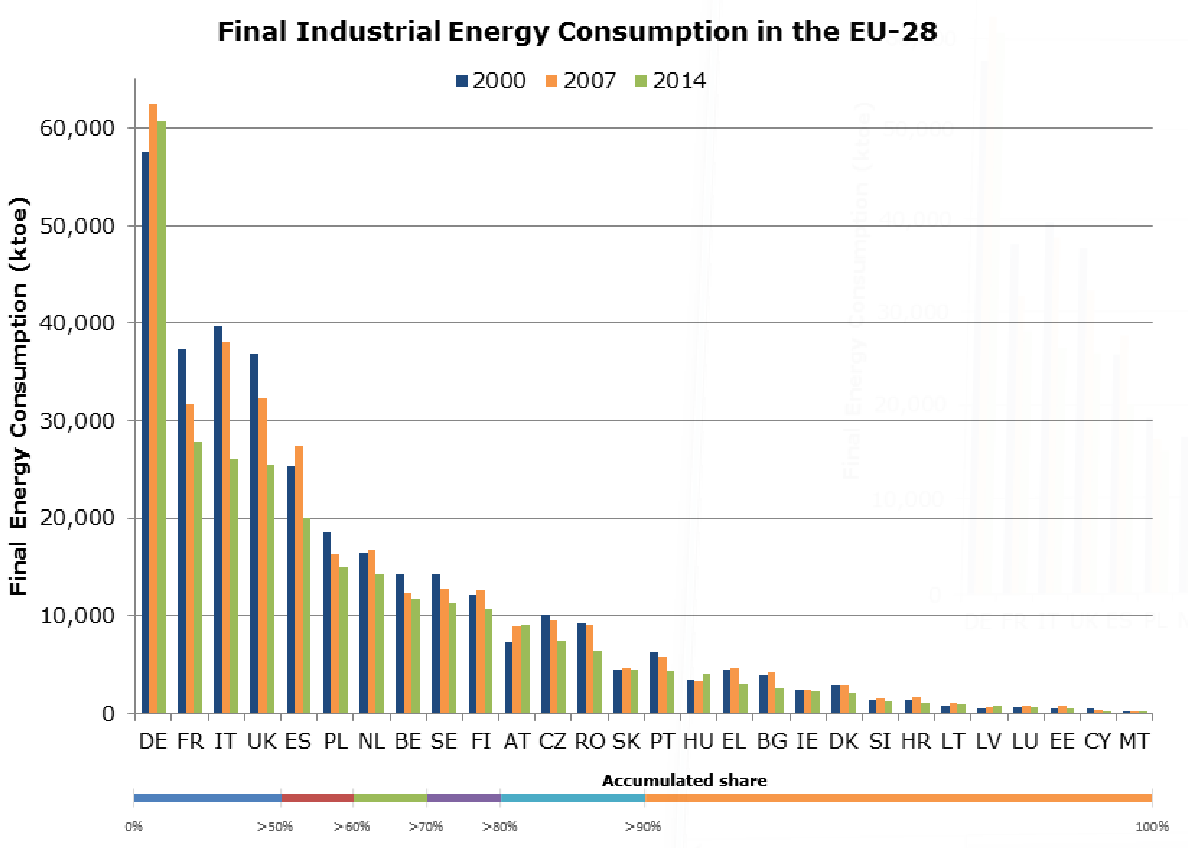



In 2014, the Member State with the highest consumption in the industry sector was Germany (60.7 Mtoe), followed by France (27.9 Mtoe) and Italy (26.2 Mtoe). In 2000, German industry was still the first energy consumer, followed by Italy and France which swapped their ranking positions in 2014.

Only four Member States consumed more than 50% of their total final energy consumption in the sector. These are: Germany, France, Italy and the United Kingdom. Half of the EU-28 Member States (14 countries) generated more than 90% of EU-28 industry final energy consumption in 2014 (Figure 176).

The European global energy consumption trend is therefore highly influenced by the consumption of a limited number of countries.

**Figure 176: Industry Sector: Final energy consumption with the cumulated share[131] of the EU-28 Member States, 2000, 2007 and 2014. Source: Eurostat**



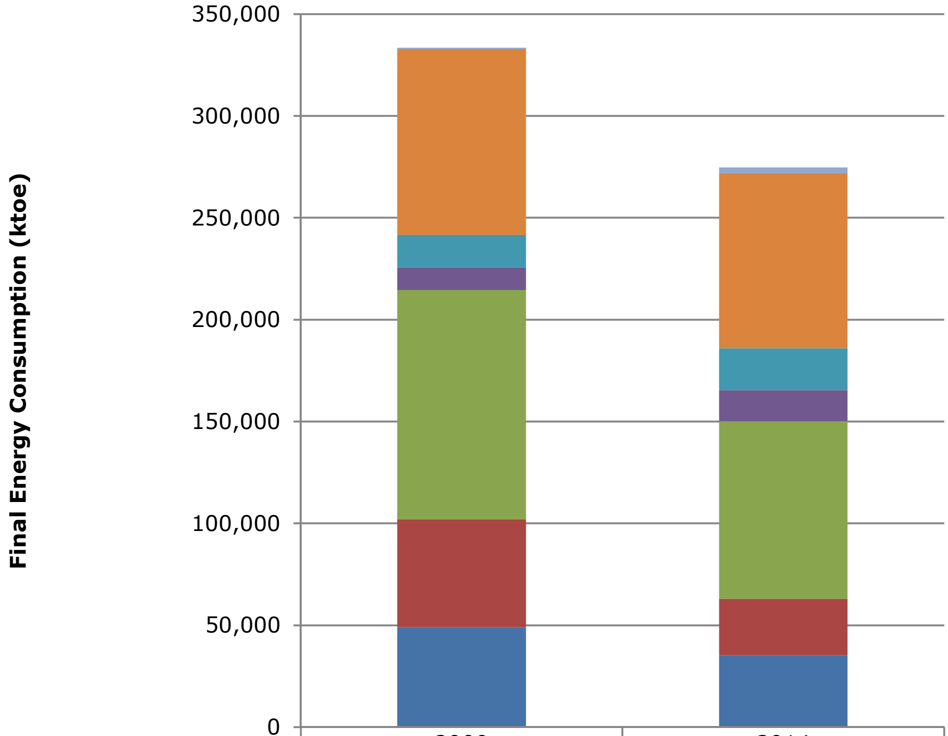

In 2014, gas and electricity were the main contributors to the energy mix in the industry sector with 87.2 Mtoe and 85.8 Mtoe respectively. These fuels represented over 60% of the energy mix; gas accounted for 31.75% and electricity for 31.21% of the total consumption. The rest of the energy mix was constituted by solid fuels (12.84%), petroleum products (10.07%), renewable energies (7.47%), derived heat (5.56%) and non-renewable waste (1.10%).

While the ranking of the energy fuels contribution has remained as in the year 2000, there are several changes to be noted. The usage of petroleum products has been reduced by 47.8% (above 25 Mtoe). Non-renewable waste, renewable energies and derived heat have enlarged their contributions in absolute value. On the other hand, petroleum products, electrical energy, gas and solid fuels have reduced the absolute value of their contributions as illustrated in the following two figures. Overall, electricity, renewable energy sources[132], derived heat and waste have grown in percentage, whilst the share of solid fuels, gas and petroleum products has decreased.

131 Cumulated share of the year 2014.

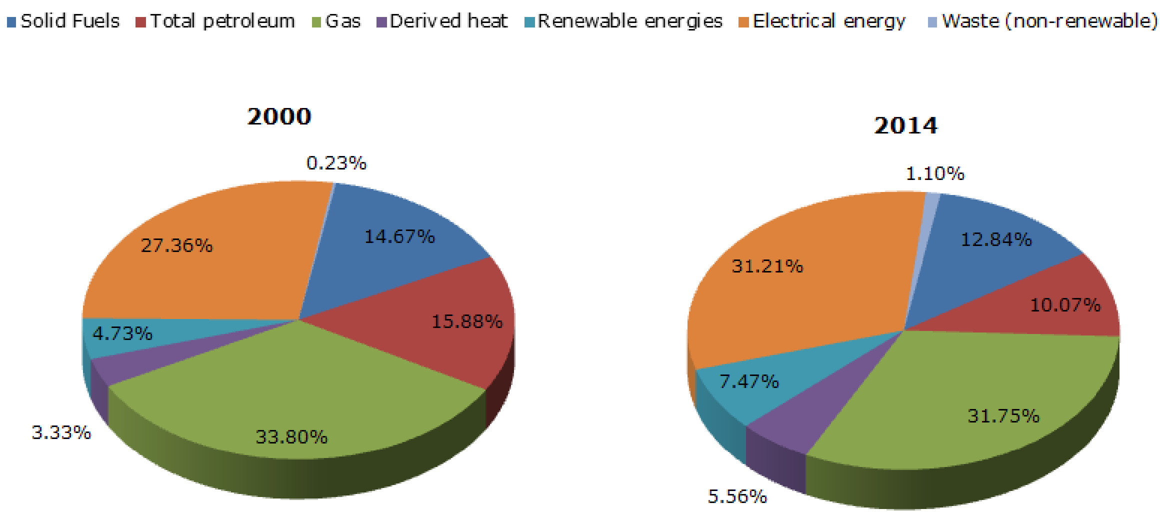
132 Renewable energy sources other than Hydro power, Wind power, Tide, Wave and Ocean and Solar photovoltaic. These sources are accounted under the contribution generated by electricity consumption.

Figure 177: Industry sector: final energy mix, 2000 and 2014. Source: Eurostat




| | 2000 | 2014 |
|---|---|---|
| Waste (non-renewable) | 754.2 | 3,032.7 |
| Electrical energy | 91,254.3 | 85,764.2 |
| Renewable energies | 15,772.7 | 20,523.2 |
| Derived heat | 11,115.5 | 15,263.0 |
| Gas | 112,734.5 | 87,233.4 |
| Total petroleum | 52,959.1 | 27,671.3 |
| Solid Fuels | 48,926.5 | 35,271.2 |

Figure 178: Industry sector: final energy mix by percentage, 2000 and 2014. Source: Eurostat

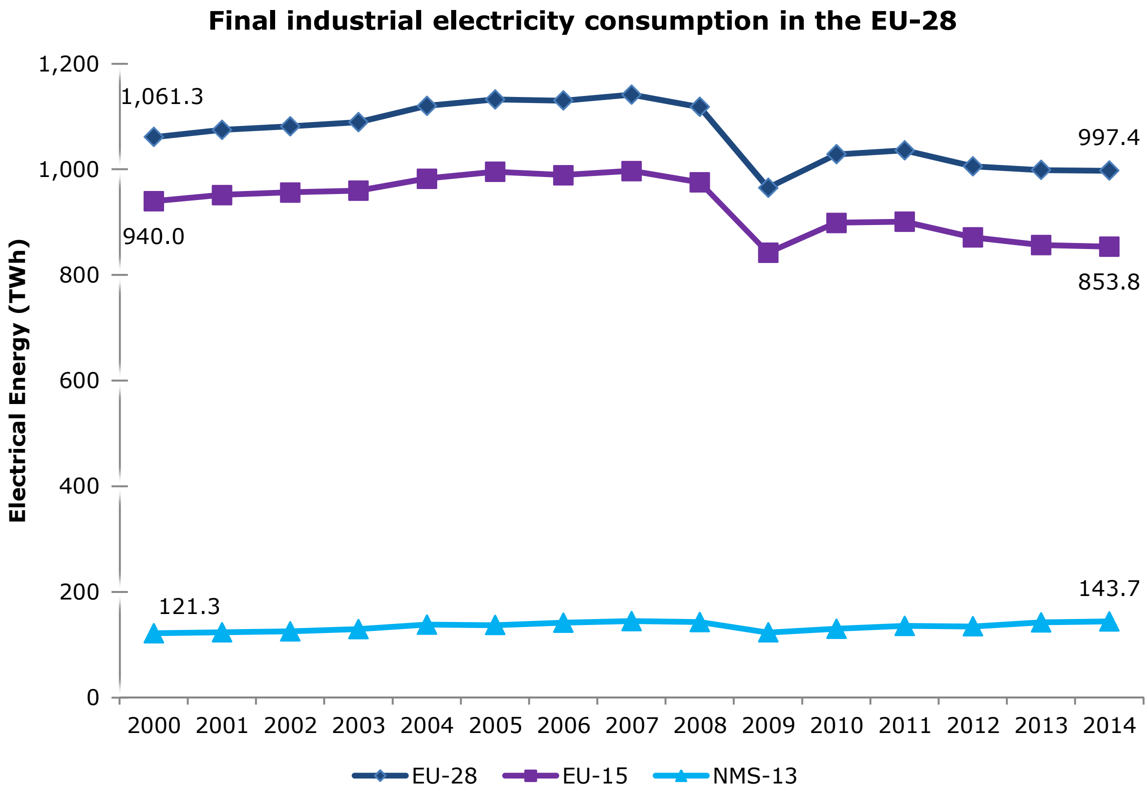


### Electricity consumption

The industry sector consumed 36.86% of the final electricity consumption of the EU-28 in 2014, this confirming industry as the main electricity consumer in Europe (see Figure 20).

The final industrial electricity consumption in the EU-28 has fallen by 6.0% in the 15-years period from 2000 to 2014. This decrease has been caused by the overall trend registered in the EU-15 areas (-9.2%). In contrast, the total electricity consumption of NMS-13 areas has increased by 18.4%. In 2014, the final electricity consumption amounted to 997.4 TWh, out of which 85.6% (853.8 TWh) was generated in EU-15 areas. The maximum consumption over the period considered took place in the year 2007 (1,141.5 TWh) which set the maximum also for the 25-years period from 1990 to 2014. The minimum value in the period 2000-2014 occurred in 2009 when the final electricity consumption dropped to 965.2 TWh as illustrated in Figure 179 and Figure 180.

**Figure 179: Industry sector: final electricity consumption in the EU-28, 2000-2014. Source: Eurostat**




A continuous growth in the industry final electricity consumption can be substantially observed until 2007 of the minor reduction registered in the year 2006 (0.16% in comparison to the previous year) is not taken into account. During years 2008 and 2009 the industry sector reduced its final electricity consumption (and its total final energy consumption) as for the impact of the financial and economic crisis on the sector's activity [55]. The two following years (2010 and 2011) reported an increase in the consumption in comparison to the previous years (by 6.6% and 0.7% respectively). Since 2011 a decreasing trend has been registered, although the negative growth rate is smoother year after year as shows Figure 181.

**Figure 180: Industry sector: final industrial electricity consumption in the EU-28, 2000-2014 (detailed). Source: Eurostat**

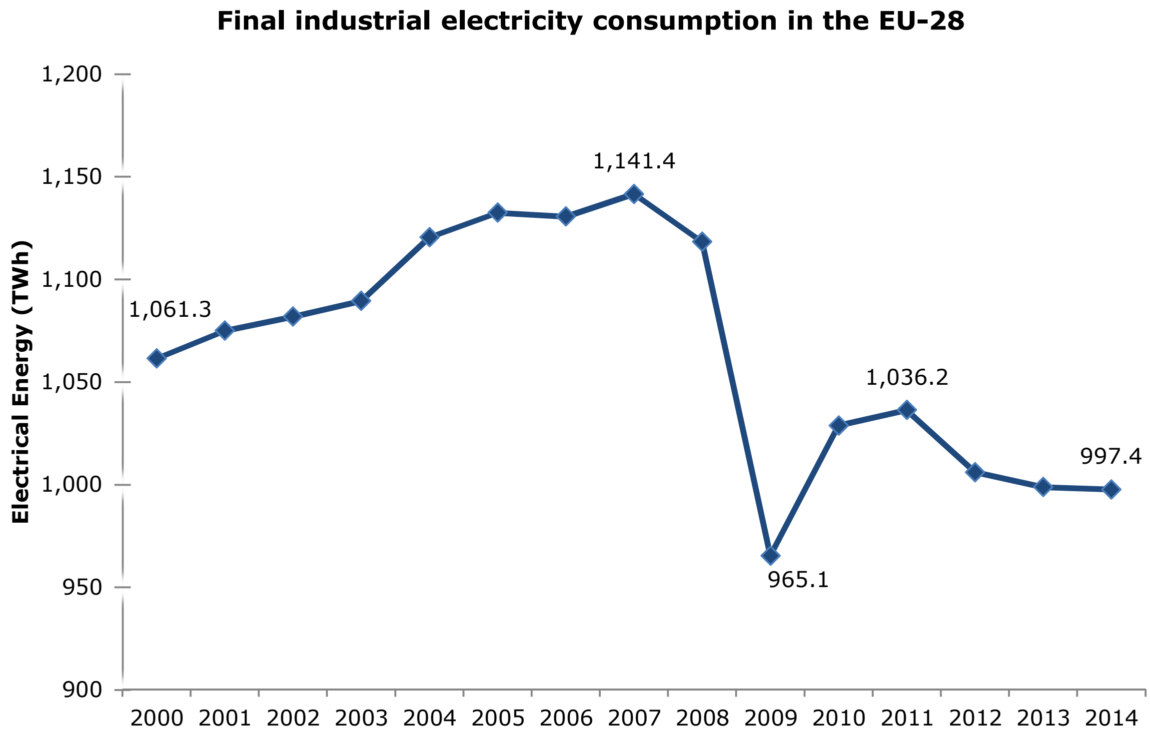



**Figure 181: Industry sector: annual final electricity consumption growth rates, 2000-2014. Source: Eurostat**

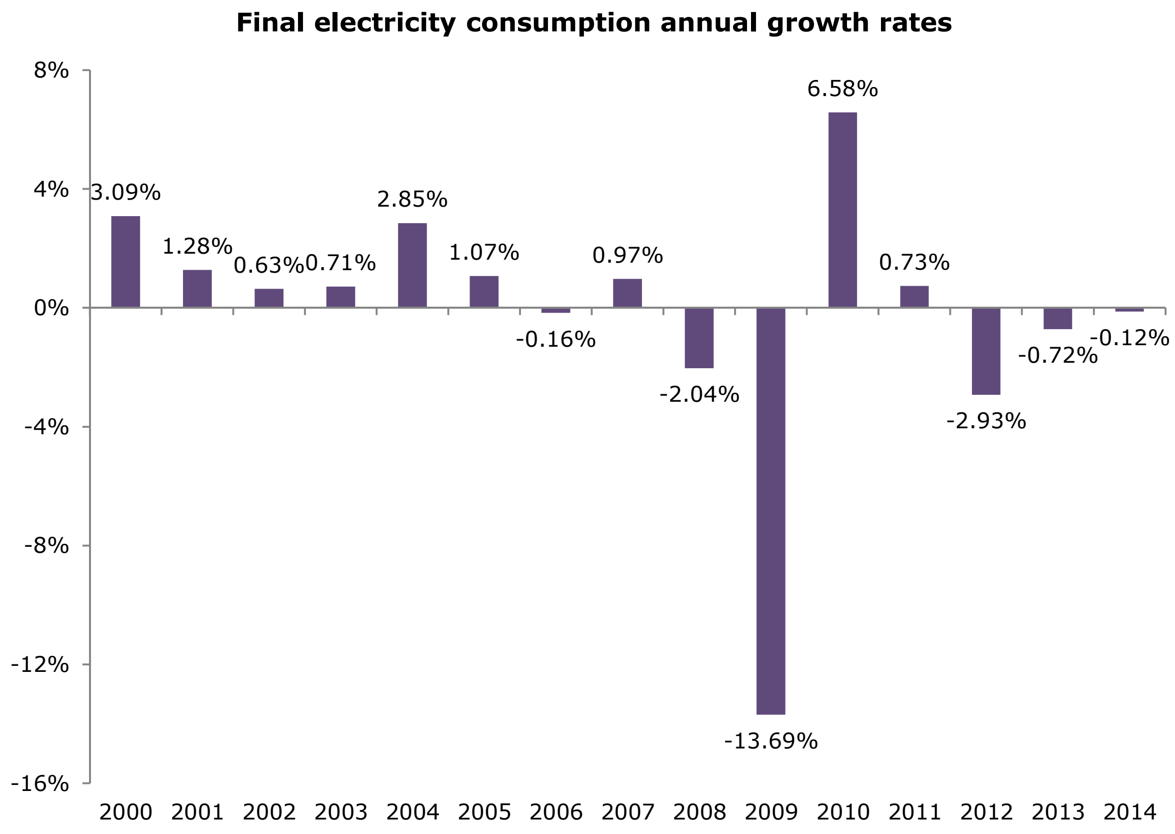
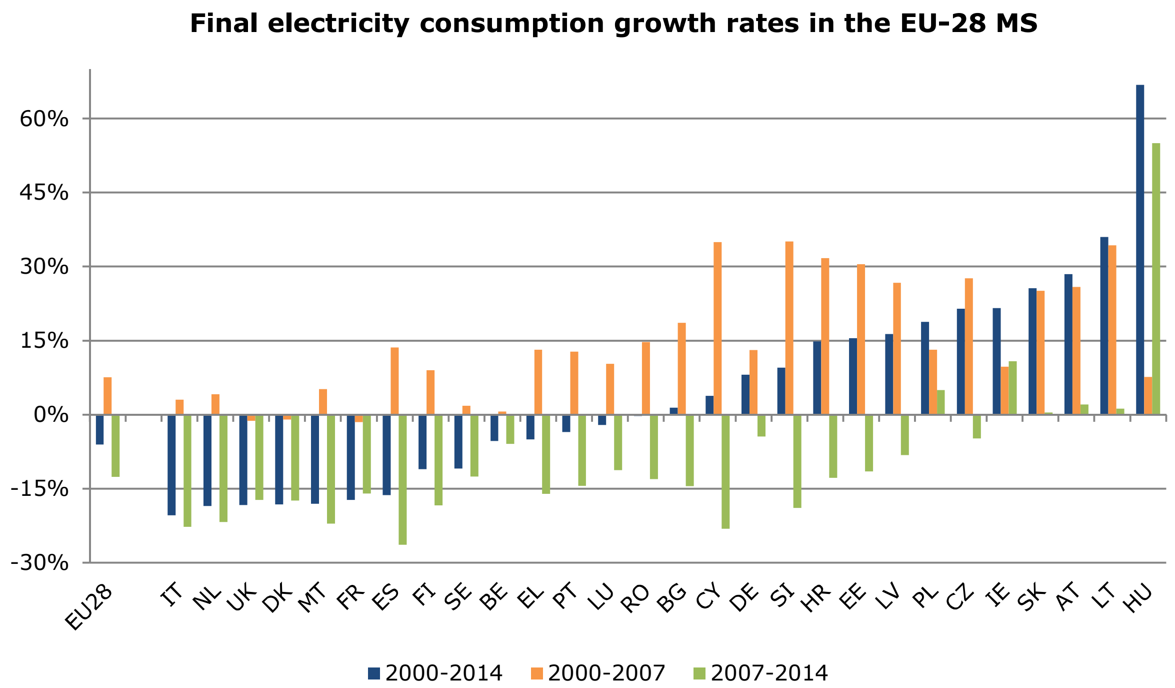


Figure 182: Industry sector: annual final electricity consumption growth rates in the EU-28; 2000-2014, 2000-2007 and 2007-2014. Source: Eurostat




Analysing the growth rates in the final electricity consumption in the EU-28 Member States, it can be observed that the countries with the highest growth rates in the period between 2000 and 2014 are Hungary (66.8%), Lithuania (36.0%) and Austria (28.4%). In the same period, the Member States with the lowest growth rates are Italy (-20.4%), the Netherlands (-18.5%) and the United Kingdom (-18.3%). Only nine Member States have registered a below European average growth rate (-6.0%) during the mentioned 15-years period. In the period from 2000 to 2007, only three states underwent a negative growth rate. In the period 2007-2014 the influence of the economic crisis has instead caused that most of the Member States (22 countries) have registered a negative growth rate. The six Member States with a positive growth rate in that period are: Hungary (55%), Ireland (11%), Poland (5%), Austria (2%), Lithuania (1.2%), and Slovakia (0.4%).

## Gas consumption

The industry sector consumed 38.05% of the final gas consumption of the EU-28 in 2014, representing the second gas consumer after residential sector (40.20%), see Figure 25.

When focussing on the industrial sector energy mix, gas accounted for 31.75% of the total final energy consumption in the same year, confirming gas as the main final energy type consumed in the industry sector (Figure 178).

Industry final gas consumption has fallen by 22.6% in the EU-28 in the 15-years period from 2000 to 2014. A similar decrease has been registered both in the EU-15 and NMS-13 areas which have declined their consumptions by 23.1% and 20% respectively. In 2014, the final total gas consumption amounted to 87.2 Mtoe, out of which 84.1% (73.4 Mtoe) was generated in EU-15 areas. The maximum consumption over the analysed period took place in the year 2003 (112.9 Mtoe). The minimum value in the period 2000-2014 occurred in 2009 when the final electricity consumption dropped to 82.1 Mtoe as illustrated in Figure 180. Since 2009, the European Union has been registering the lowest values of industry final gas consumption for the 25-years period between 1990 and 2014.

**Figure 183: Industry sector: final gas consumption in the EU-28, 2000-2014. Source: Eurostat**

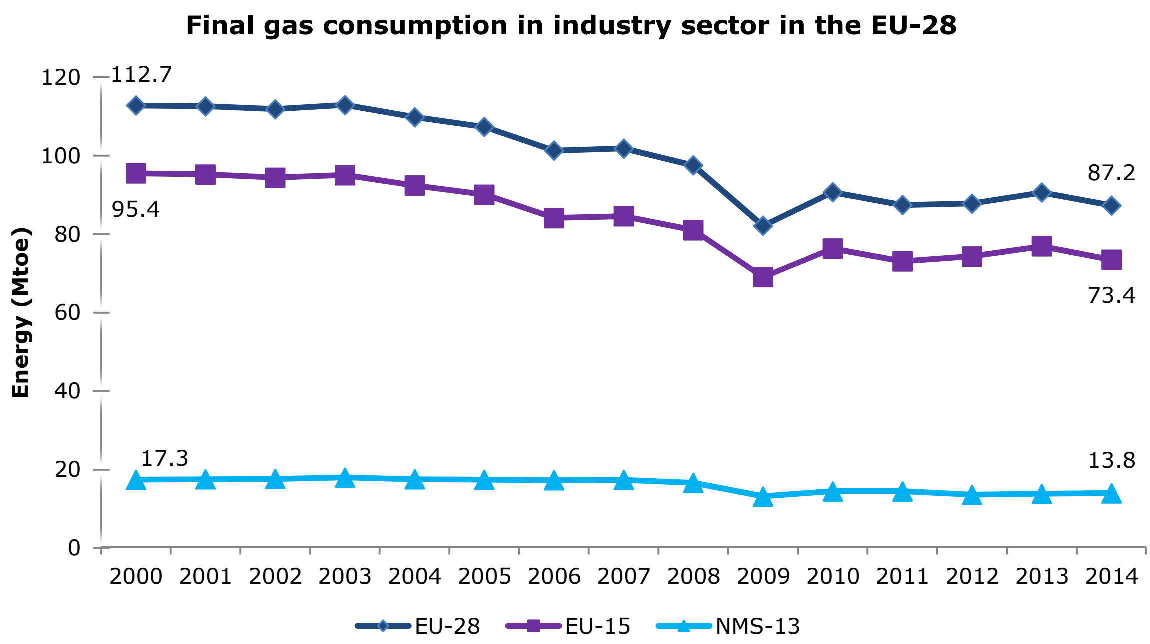
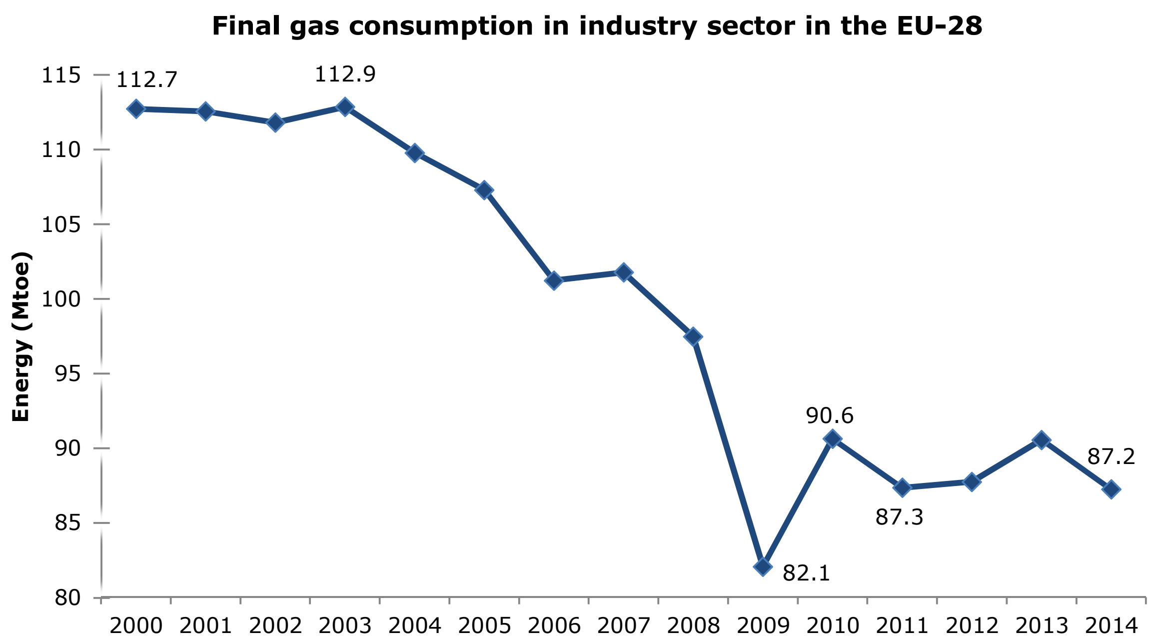



**Figure 184: Industry sector: final gas consumption in the EU-28, 2000-2014 (detailed). Source: Eurostat**




It can be observed that an overall decreasing trend has been followed during the whole analysed period. Until 2009, when the minimum value was registered, the growth rates are constantly negative with the exception of years 2003 and 2007 when rises by less than 1% occurred in comparison to the previous years. In 2009 (when the minimum historical value for the 1990-2014 period was registered) a drop by 15.8% has been observed in comparison to year 2008. From 2010 to 2014, the values have been fluctuating within a range between 87-90.5 Mtoe. In 2014, there was a fall by 3.7% in comparison to year 2013. The gas consumption in this year represents the second lowest consumption value after the 2009 value over the period 1990-2014.

**Figure 185: Industry sector: annual final gas consumption growth rates, 2000-2014. Source: Eurostat**

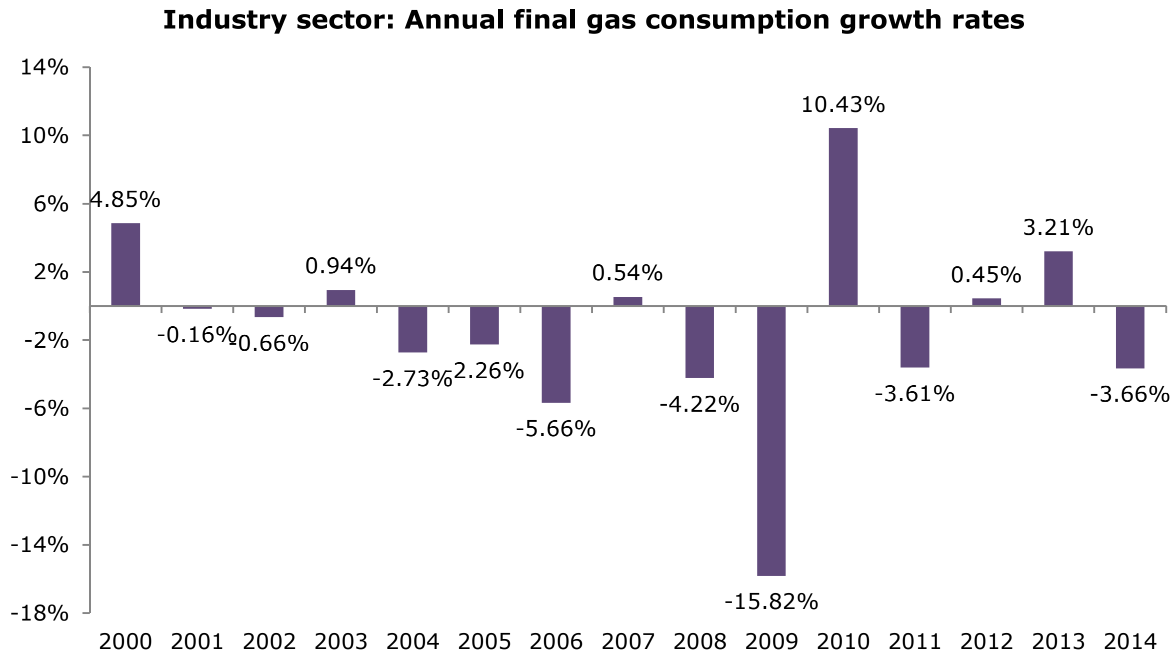
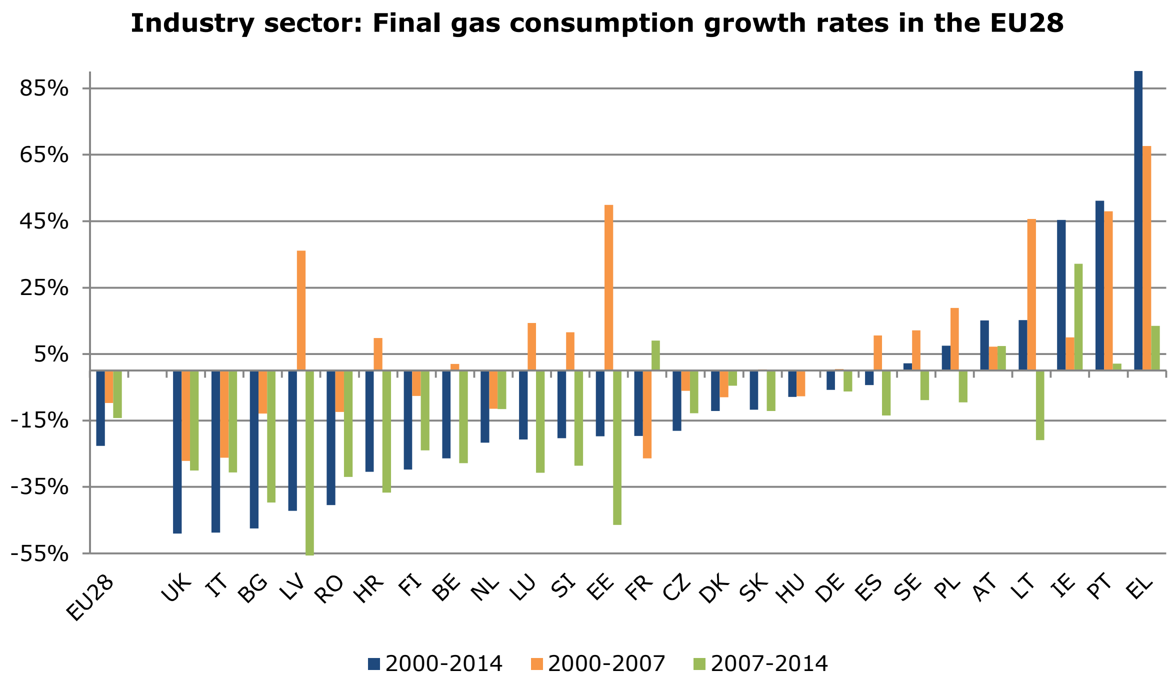



**Figure 186: Industry sector: final gas consumption growth rates in the EU-28; 2000-2014, 2000-2007 and 2007-2014. Source: Eurostat**




From 2000 to 2014, the industry final gas consumption has dropped by 22.6% in the EU-28. Eight Member States have registered a decrease below the average European decrease rate. The Member States with the highest growth rates are Greece (90.2%), Portugal (51.1%) and Ireland (45.3%). On the other hand, the EU-28 countries with the lowest rates are: the United Kingdom (-49.1%), Italy (-48.8%) and Bulgaria (-47.5).

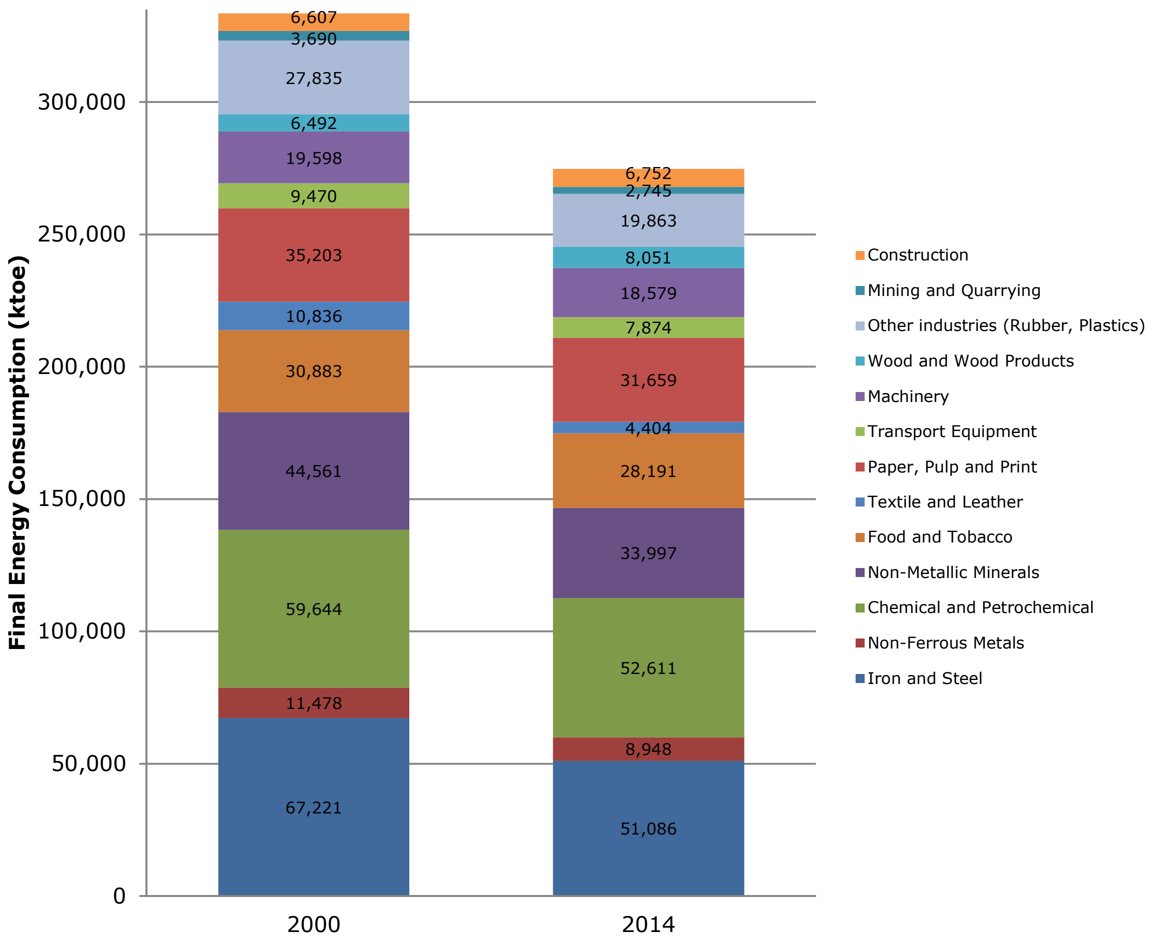
Across the EU-28 MSs, decreasing trends have been registered by 23 countries in the period 2007-2014. The countries with lowest growth rates are: Latvia (-57.5%), Estonia (-46.4%) and Bulgaria (-39.7%).

## 7.2 Industry subsectors

In this chapter, the final energy consumption in the industry sector is broken-down into the different industry subsectors. The industry subsector can be mainly divided into construction, mining and quarrying and manufacturing. Manufacturing, in turn, can be split into ten subsectors: iron and steel; non-ferrous metals; chemical and petrochemical; non-metallic minerals; food and tobacco; paper, pulp and print; transport equipment; machinery; wood and wood products; and other industries.

Energy consumption data of the all mentioned industry subsectors can be found in the Eurostat website [3]. This chapter analyses the consumption trends in these subsectors for the period 2000-2014.

**Figure 187: Industry sector: final energy consumption by subsectors, 2000 and 2014. Source: Eurostat**



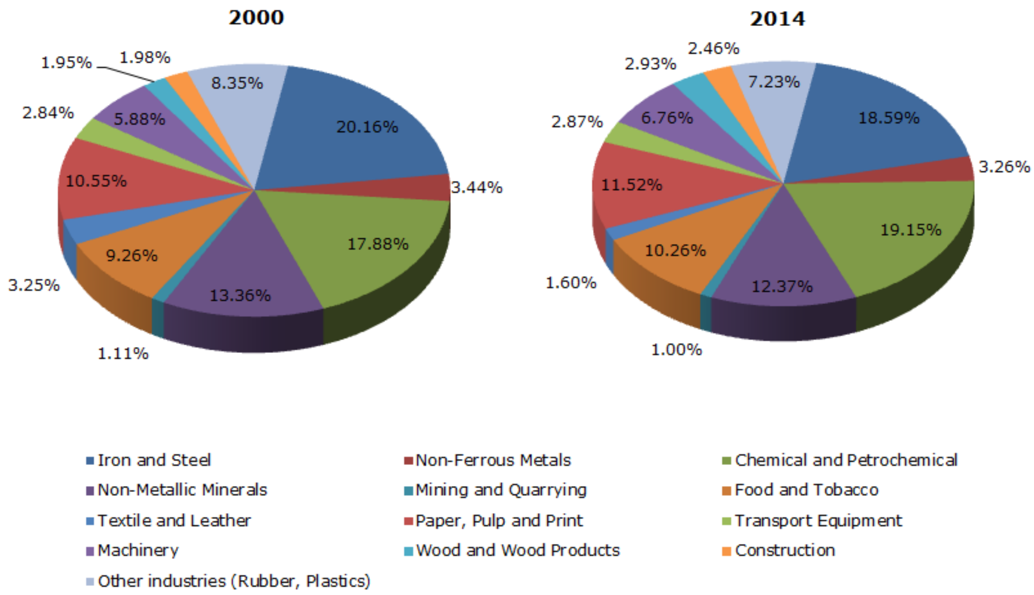

The industry final energy consumption per subsector is reported in the Figure 187 and Figure 188.

In 2014, the industry subsector with the highest energy consumption was the chemical and petrochemical subsector which accounted for 19.15% (52,611 ktoe) of the total final industrial energy consumption and was followed by iron and steel (18.59%; 51,086 ktoe) and non-metallic minerals (12.37%; 33,997 ktoe). The layout is completed by Paper, Pulp and Print (11.52%; 31,659 ktoe), Food and Tobacco (10.26%; 28,191 ktoe), Other Industries such as rubber and plastics (7.23%; 19,863 ktoe), Machinery (6.76%;

18,579 ktoe), Non-Ferrous Metals (3.26%; 8,948 ktoe), Wood and Wood Products (2.93%; 8,051 ktoe), Transport Equipment (2.87%; 7,874 ktoe), Construction (2.46%; 6,752 ktoe), Textile and Leather (1.60%; 4,404 ktoe) and Mining and Quarrying (1,00%; 2,745 ktoe).

Back in 2000, the most energy consuming subsector was iron and steel (20.16%), followed by chemical and petrochemical (17.88%). The rest of the industry subsectors have kept their ranking positions with regard to their final energy consumption with the exception of 'wood and wood products' and 'textile and leather' which have swapped their positions from ninth to twelfth and vice versa.

**Figure 188: Industry sector: final energy consumption percentage by subsectors, 2000 and 2014. Source: Eurostat**




The following table provides with an overview of the variations in the final energy consumption in the different energy subsectors between years 2000 and 2014. The absolute values of the final energy consumption and associated shares are presented for both years.

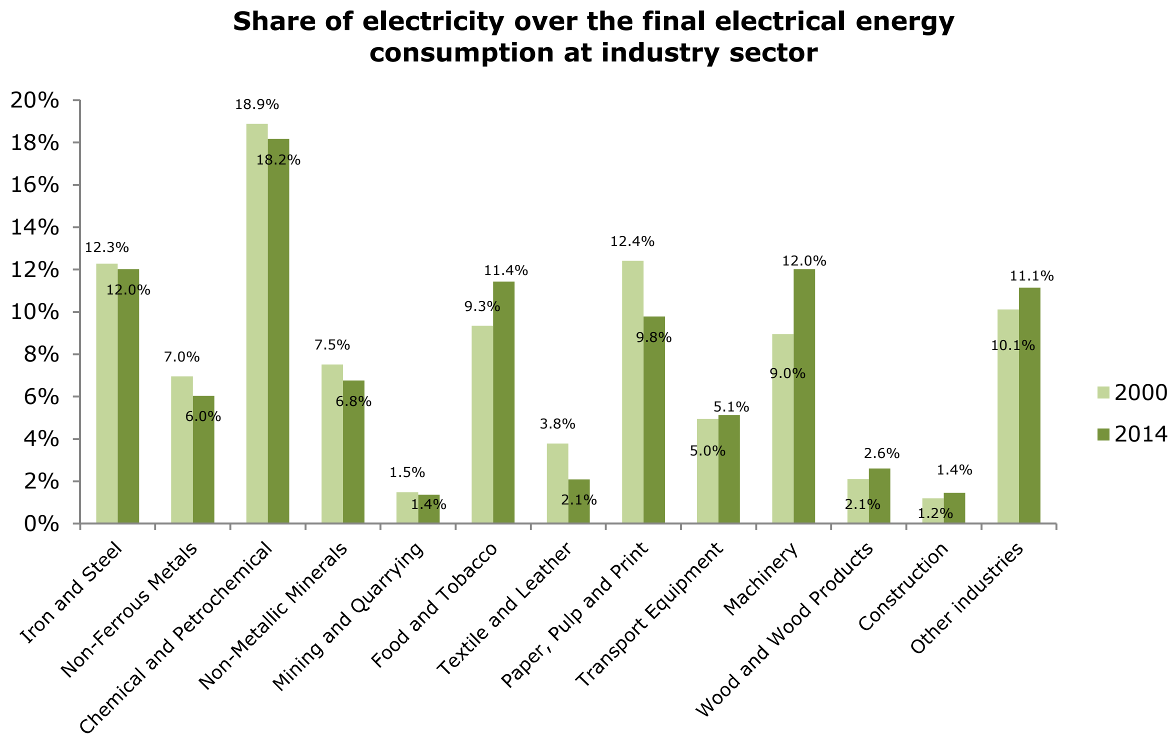
Among the three main industry subsectors (i.e. manufacturing, mining and quarrying, and construction), Mining and quarrying has registered the highest final energy consumption drop (by 25.6%). The manufacturing subsector has also undergone a fall by 17.9% in the period 2000-2014. In contrast, construction has increased its demand of final energy by 2.2%. Among the manufacturing subsectors, the only positive growth rate is found in wood and wood products (by 24.0%). The rest of the manufacturing subsectors has registered negative growth rates. The lowest growth rates have been observed in textile and leather (-59.4%), other industries (-28.6%) and iron and steel (-24%).

**Table 38: Growth rates and energy consumption shares in industry subsectors, 2000 and 2014. Source: Eurostat**

| | Final Energy (ktoe) | | Growth Rate (%) | Share in % | | Change of shares |
|---|---|---|---|---|---|---|
| | 2000 | 2014 | 2000-2014 | 2000 | 2014 | 2000-2014 |
| **Manufacturing** | *323,220* | *265,262* | *-17.9%* | *96.9%* | *96.5%* | ***-0.4%*** |
| Iron and Steel | 67,221 | 51,086 | -24.0% | 20.2% | 18.6% | **-1.6%** |
| Non-Ferrous Metals | 11,478 | 8,948 | -22.0% | 3.4% | 3.3% | **-0.2%** |
| Chemical and Petrochemical | 59,644 | 52,611 | -11.8% | 17.9% | 19.1% | **1.3%** |
| Non-Metallic Minerals (Cement, Glass) | 44,561 | 33,997 | -23.7% | 13.4% | 12.4% | **-1.0%** |
| Food and Tobacco | 30,883 | 28,191 | -8.7% | 9.3% | 10.3% | **1.0%** |
| Textile and Leather | 10,836 | 4,404 | -59.4% | 3.2% | 1.6% | **-1.6%** |
| Paper, Pulp and Print | 35,203 | 31,659 | -10.1% | 10.6% | 11.5% | **1.0%** |
| Transport Equipment | 9,470 | 7,874 | -16.9% | 2.8% | 2.9% | **0.0%** |
| Machinery | 19,598 | 18,579 | -5.2% | 5.9% | 6.8% | **0.9%** |
| Wood and Wood Products | 6,492 | 8,051 | 24.0% | 1.9% | 2.9% | **1.0%** |
| Other industries (Rubber, Plastics) | 27,835 | 19,863 | -28.6% | 8.3% | 7.2% | **-1.1%** |
| **Mining and Quarrying** | *3689.8* | *2,745.3* | *-25.6%* | *1.1%* | *1.0%* | ***-0.1%*** |
| **Construction** | *6606.8* | *6,752.0* | *2.2%* | *2.0%* | *2.5%* | ***0.5%*** |
| **Industry Total** | ***333,517*** | ***274,759.1*** | ***-17.6%*** | | | |

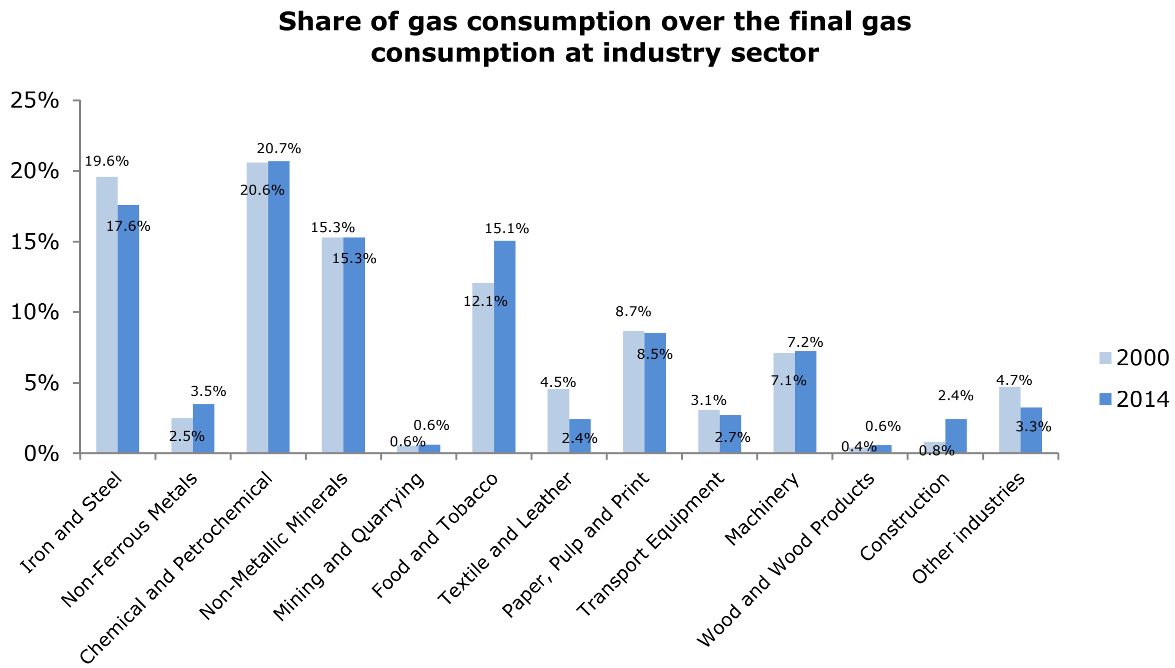
Electricity and gas consumptions in the industry subsectors are analysed in the following figures. The chemical and petrochemical manufacturing subsector registered the highest electricity consumption in 2014 with a consumption of 181.2 TWh accounting for 18.2% of the industry final electricity consumption. It was followed by Machinery and Iron and Steel (12.0%; 120.0 TWh) and Food and Tobacco (11.4%; 114.0 TWh). In 2000, Chemical and petrochemical was the main electricity consumer (200.5 TWh), followed by Paper, pulp and print (131.8 TWh) and Iron and Steel (130.4 TWh).

**Figure 189: Industry sector: share of electricity consumption by industry subsectors, 2000 and 2014. Source: Eurostat**




In 2014, the chemical and petrochemical manufacturing subsector was the main gas consumer with 20.7% (18,051 ktoe) of the share over the total final gas consumption. Iron and steel were second (17.6%; 15,335 ktoe), non-metallic minerals (15.3%; 13,336 ktoe) were third and Food and Tobacco (15.1%; 13,151 ktoe) were fourth.

**Figure 190: Industry sector: share of gas consumption by industry subsectors, 2000 and 2014. Source: Eurostat**



The following table provides with an overview of the changes between years 2000 and 2014 regarding the final electricity and gas consumptions in the different energy subsectors. The absolute values of final gas and electricity consumption are also presented for both years.

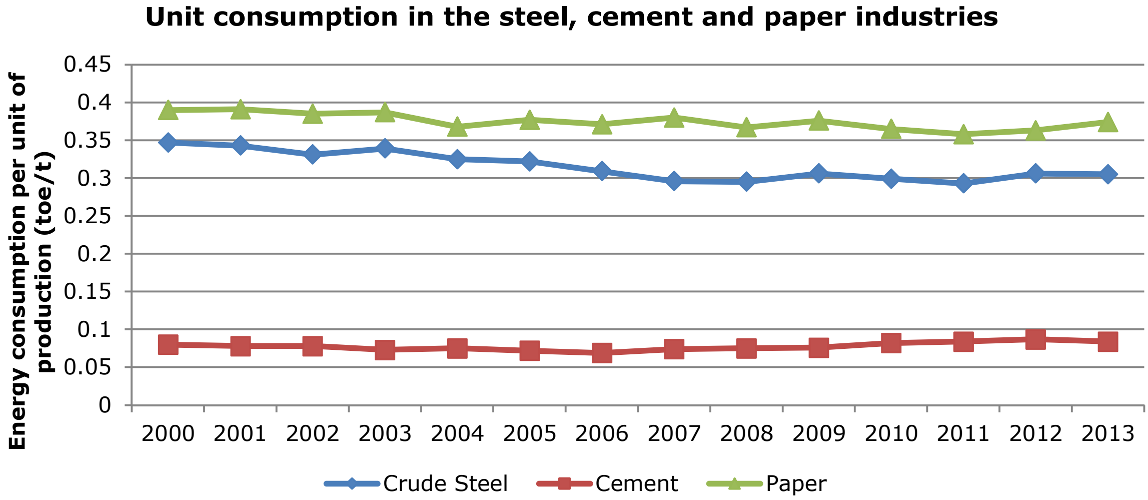
Mining and quarrying is the industry subsector which has registered the lowest electricity consumption growth in the period 2000-2014 (-13.9%). The lowest gas consumption growth rate (-23.9%) has taken place in the manufacturing subsectors. Among the manufacturing subsectors, Textile and Leather has registered the lowest growth rates for electricity and gas (-48.1% and -58.5% respectively). To be noted the increase by 129.7% in the gas consumption by the construction subsector during the 15-years period between 2000 and 2014.

**Table 39: Growth rates of final electricity and gas consumptions in industry subsectors, 2000 and 2014. Source: Eurostat**

| | Final Electricity (GWh) | | Growth Rate (%) | Final Gas (ktoe) | | Growth Rate (%) |
|---|---|---|---|---|---|---|
| | 2000 | 2014 | 2000-2014 | 2000 | 2014 | 2000-2014 |
| **Manufacturing** | *1.032.723* | *969.416* | *-6,1%* | *111.172* | *84.550* | *-23,9%* |
| Iron and Steel | 130.373 | 119.956 | -8,0% | 22.062,8 | 15.334,6 | -30,5% |
| Non-Ferrous Metals | 73.815 | 60.204 | -18,4% | 2.827,4 | 3.057,9 | 8,2% |
| Chemical and Petrochemical | 200.453 | 181.195 | -9,6% | 23.233,8 | 18.050,5 | -22,3% |
| Non-Metallic Minerals (Cement, Glass) | 79.809 | 67.427 | -15,5% | 17.255,6 | 13.335,8 | -22,7% |
| Food and Tobacco | 99.119 | 113.950 | 15,0% | 13.616,9 | 13.150,9 | -3,4% |
| Textile and Leather | 40.157 | 20.847 | -48,1% | 5.115,6 | 2.122,0 | -58,5% |
| Paper, Pulp and Print | 131.760 | 97.545 | -26,0% | 9.782,4 | 7.421,1 | -24,1% |
| Transport Equipment | 52.552 | 51.144 | -2,7% | 3.479,1 | 2.390,2 | -31,3% |
| Machinery | 95.008 | 119.970 | 26,3% | 8.002,8 | 6.312,2 | -21,1% |
| Wood and Wood Products | 22.397 | 26.012 | 16,1% | 477,6 | 529,6 | 10,9% |
| Other industries (Rubber, Plastics) | 107.280 | 111.166 | 3,6% | 5.317,5 | 2.844,9 | -46,5% |
| **Mining and Quarrying** | 15.777 | 13.577 | *-13,9%* | 634,9 | 551,8 | *-13,1%* |
| **Construction** | 12.787 | 14.445 | *13,0%* | 928,1 | 2.132,1 | *129,7%* |
| **Industry Total** | ***1.061.287*** | ***997.438,0*** | ***-6,0%*** | ***112.735*** | ***87.233,6*** | ***-22,6%*** |

When analysing a manufacturing industry, one interesting benchmarking parameter which allows the analysis of energy efficiency levels is the average energy consumption per unit of production in EU-28. This ratio is shown for three main industrial products: steel, cement and paper. Overall, this parameter shows stable values along the 2000-2013 period. In 2013, the energy consumption per ton of produced paper was 0.374 toe/t, representing a drop by 4.1% in comparison to year 2000. Paper has had the highest ratio over the three analysed products during the whole analysed period, as illustrated in Figure 191. In 2013, the production of one tonne of crude steel consumed 0.305 toe/t on average in EU-28. Crude steel is the product which has most reduced its energy consumption per unit of production (by -12.1%). Cement has instead increased its ratio of energy consumed per produced unit by 5% during the analysed period, reaching 0.084 toe/t in 2013.

**Figure 191: Average energy consumption per tonne of produced crude steel, cement and paper in EU-28, 2000-2013. Source: Odyssee**




Industrial Production Indexes (IPIs) allow measuring the changes of the output of industry, as showed in the following figure (Figure 192). This figure shows the value of this economic indicator for the different analysed manufacturing subsectors. It is observed that the most notable variations in the IPIs occurred after the financial crisis. All the manufacturing subsectors experienced a significant drop in their productions in 2009. Noticeably, textile and leather subsector's IPI has been continuously decreasing since 2000 and has accumulated a 69% drop till 2013. The most stable manufacturing subsector is Food and Tobacco.

**Figure 192: Industrial Production Indices of Manufacturing Industries (2005=100%), 2000-2013. Source: Odyssee**

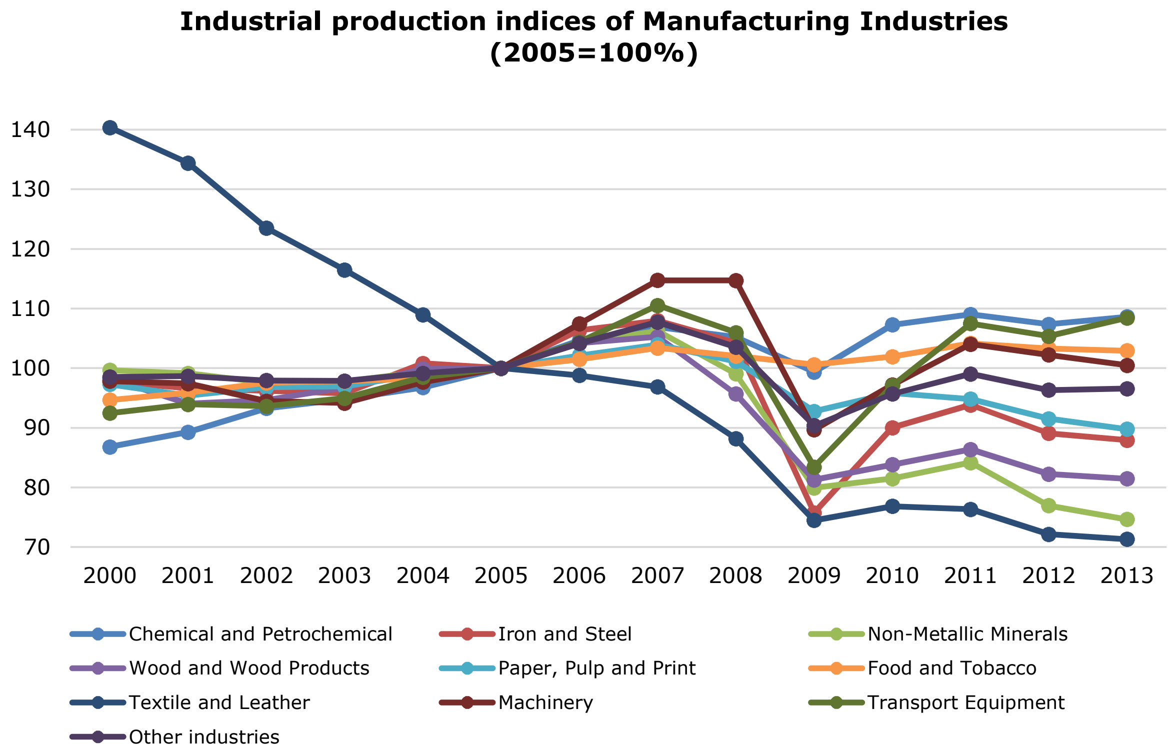
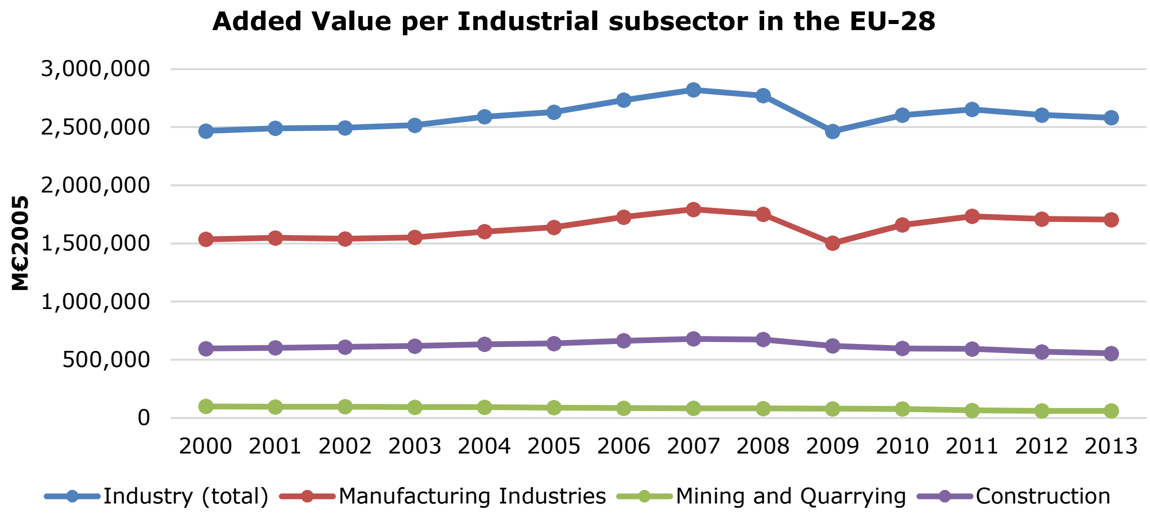
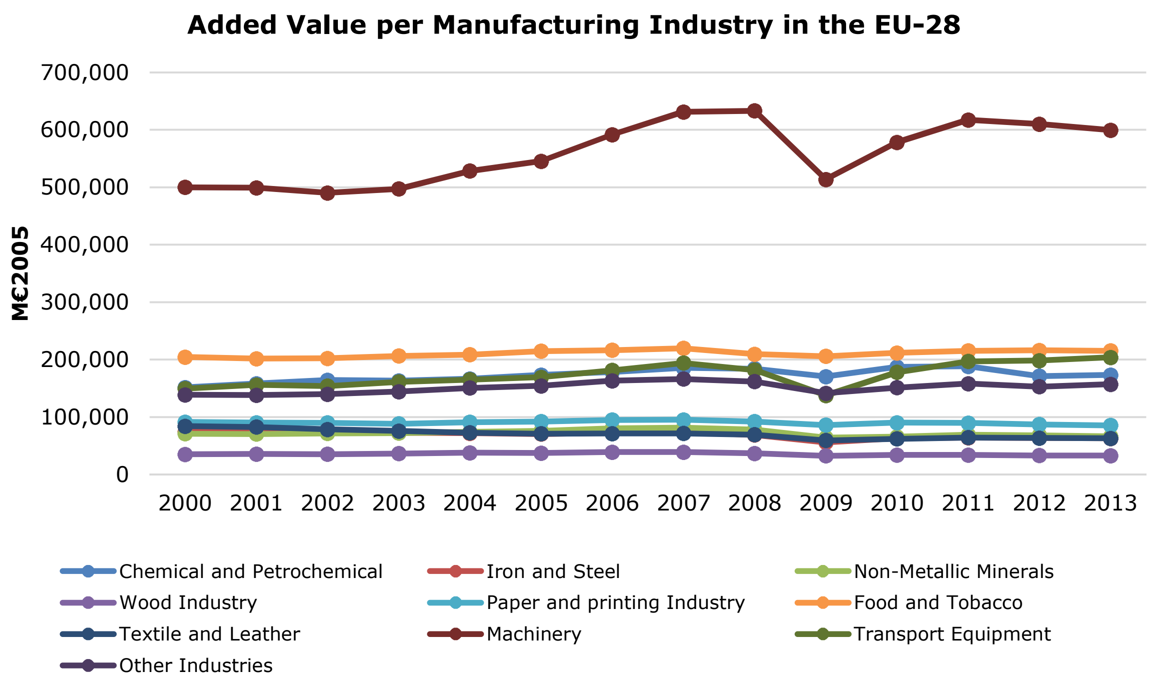


**Figure 193: Added value per industrial subsector in the EU-28, 2000-2013. Source: Odyssee**




The industry sector added value to GDP has risen by 4.6% in the period 2000-2013. Among the industry subsectors, manufacturing industries have increased their added value by 11% in the same period, while construction and mining and quarrying have decreased their contributions by 6.8% and 39.8% respectively. Within manufacturing industries the highest growth rates are found in transport equipment (36.3%), machinery (19.9%) and chemical and petrochemical (14.4%). On the other hand, the manufacturing industries with the lowest growth rates are textile and leather (-25.2%) and iron and steel (-14.8%). Machinery subsector is the largest contributor to the GDP added value among the manufacturing industries, its contribution (599,556 M€) is more than double than the second ranked industry (Food and Tobacco) which contributes with 215,392 M€.

**Figure 194: Added value per manufacturing subsector in the EU-28, 2000-2013. Source: Odyssee**



An overview of the industrial production indices and value added to GDP for the different industry subsectors are shown in the following table for years 2000 and 2013.

**Table 40: Industrial Production Indices and Value Added to GDP for Industry Subsectors, 2000 and 2013. Source: Odyssee**

| | Industrial Production Index (2005=100%) | | Change of Production Index | Value Added to GDP (M€2005) | | Change of shares |
|---|---|---|---|---|---|---|
| | 2000 | 2013 | 2000-2013 | 2000 | 2013 | 2000-2013 |
| **Manufacturing** | *96.287* | *99.433* | ***3,15 %*** | *1,536,005* | *1,704,791* | ***11.0 %*** |
| Iron and Steel | 97.785 | 87.919 | **-9,87 %** | 74,230 | 63,226 | **-14.8 %** |
| Chemical and Petrochemical | 86.793 | 108.626 | **21,83 %** | 151,597 | 173,496 | **14.4 %** |
| Non-Metallic Minerals (Cement, Glass) | 99.642 | 74.637 | **-25,01 %** | 71,036 | 66,394 | **-6.5 %** |
| Food and Tobacco | 94.659 | 102.925 | **8,27 %** | 204,581 | 215,392 | **5.3 %** |
| Textile and Leather | 140.378 | 71.299 | **-69,08 %** | 84,224 | 62,998 | **-25.2 %** |
| Paper, Pulp and Print | 97.288 | 89.783 | **-7,51 %** | 91,610 | 85,776 | **-6.4 %** |
| Transport Equipment | 92.462 | 108.421 | **15,96 %** | 149,807 | 204,150 | **36.3 %** |
| Machinery | 97.830 | 100.482 | **2,65 %** | 500,176 | 599,556 | **19.9 %** |
| Wood and Wood Products | 98.274 | 81.453 | **-16,82 %** | 35,153 | 33,017 | **-6.1 %** |
| Other industries (Rubber, Plastics) | 98.524 | 96.567 | **-1,96 %** | 138,949 | 157,209 | **13.1 %** |
| **Mining and Quarrying** | *96.287* | *99.433* | ***3,15 %*** | *99,132* | *59,688* | ***-39.8 %*** |
| **Construction** | *93.346* | *83.533* | ***-9,81 %*** | *594,986* | *554,234* | ***-6.8 %*** |
| **Industry Total** | ***95.244*** | ***94.763*** | ***-0,48 %*** | ***2,468,274*** | ***2,581,835*** | ***4.6 %*** |

Table 40 shows that the textile and leather manufacturing subsectors are the subsectors with the highest decrease in the industrial production index (-49.2%). This is probably mostly due to the European textiles and clothing industry location decisions concerning where to set their locations that have been taken during the last years. A high degree of outsourcing and competition from low-wage environments, as well as high proportion of entry-level jobs for unskilled personnel, ease of transport and relatively low investment costs are probably the main factor that have influenced these decisions. Near-shore outsourcing to countries in the European Union and offshore outsourcing to non-EU countries are a well-known phenomenon particularly in the textiles and clothing industry. Overall, the European textiles and clothing companies respond to pressures for change by pursuing the following two business strategies [56]:

- Relocation of production and activities to low-cost countries;
- Development of added-value activities in the higher end of the value chain.

**Figure 195: Energy intensity per industry subsector in the EU-28 (GDP at purchasing power parities), 2000-2013. Source: Odyssee**

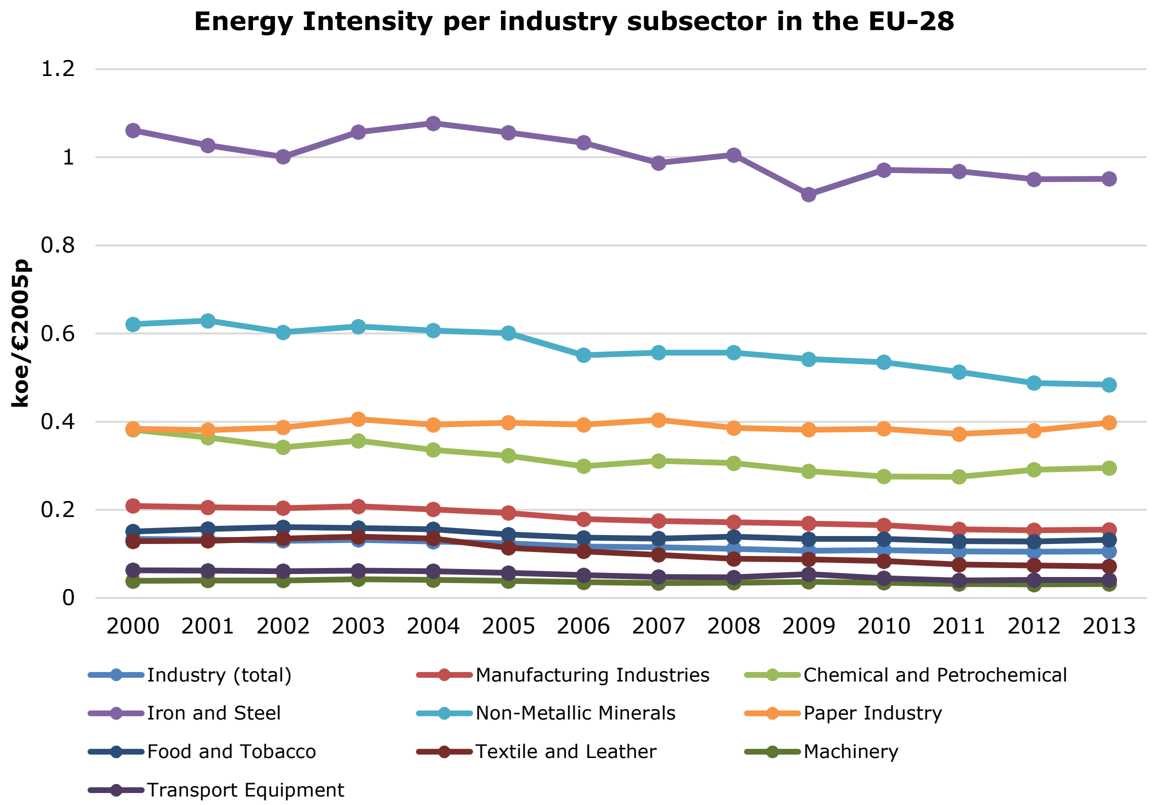
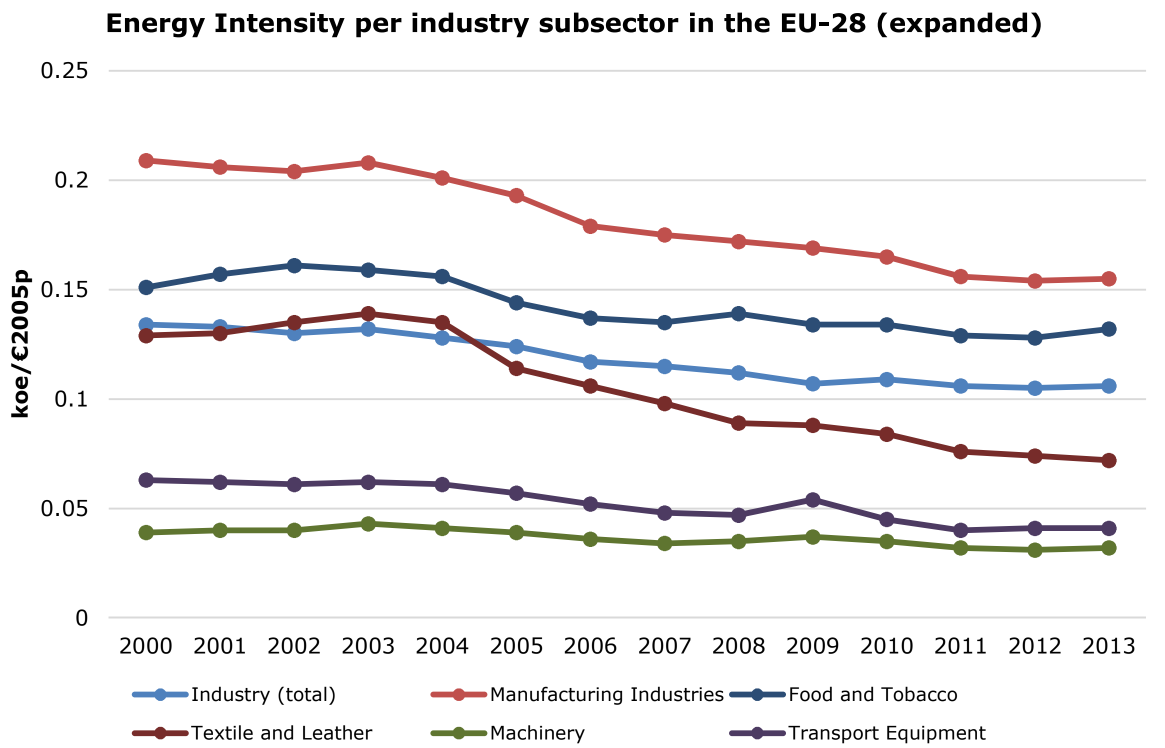



**Figure 196: Energy intensity per industry subsector in the EU-28 (GDP at purchasing power parities), 2000-2013 (expanded). Source: Odyssee**



Energy Intensity of the industry sector was 0.106 koe/€2005 in 2013, representing a drop by 20.9% in the period comprised between 2000 and 2013. The overall trend is a decreasing trend for all industry subsectors during the mentioned period with the exception of paper industry which has increased its energy intensity by 3.6%, reaching the value of 0,398 koe/€2005 in 2013. Again, it can be observed that textile and leather sector is where the biggest changes have taken place as it has reduced its energy intensity by 44.2% (from 0.129 koe/€2005 in 2000 to 0.072 koe/€2005 in 2013).

## 7.3 Energy Efficiency Trends of Electric Motors and Drives

Motors systems are a major electricity consumer and are responsible for about 70% of the industry electricity consumption and for about 35% of the non-residential buildings electricity consumption in the EU-28 [57]. This turns into an estimated electric motors consumption of 698 TWh in industry and 282 TWh in the non-residential buildings sector in 2014[133]. Therefore, the share of energy consumption of this type of products is a matter to be considered.

Electric Motors and drives are under the scope of the Eco-design Directive Lot 11 and directly covered by eco-design Commission Regulations[134]. The first final eco-design regulation for electric motors entered into force 12 August 2009. An amended regulation entered into force in January 2014. The amendment clarifies exceptions to the scope in article 1, to avoid loopholes in the application. This regulation covers motors in the power range between 0.75 and 375 kW.

Electric motor systems include a number of energy-using products (e.g. motors, drives, pumps or fans). Variable speed drives (VSDs) are an important energy performance improving component of these products, which is why this regulation requires certain sorts of motors to be equipped with variable speed drives.

The eco-design requirements for motors consist of the followings:

- From 16 June 2011, motors shall not be less efficient than the IE2[135] efficiency level.
- From 1 January 2015, motors with a rated output of 7.5 - 375 kW shall not be less efficient than the IE3 efficiency level or meet the IE2 efficiency level and be equipped with a variable speed drive.
- From 1 January 2017, all motors with a rated output of 0.75 - 375 kW shall not be less efficient than the IE3 efficiency level or meet the IE2 efficiency level and be equipped with a variable speed drive.

A new Eco-design preparatory study was launched in 2012 under the Lot 30 (Special motors and Variable Speed Drives [58]) in order to evaluate the adequacy of extending the scope of the regulation to motors not currently covered (e.g. in different power ranges or using different technologies). Electronic controllers such as VSDs and soft-starters were also subjects of the study.

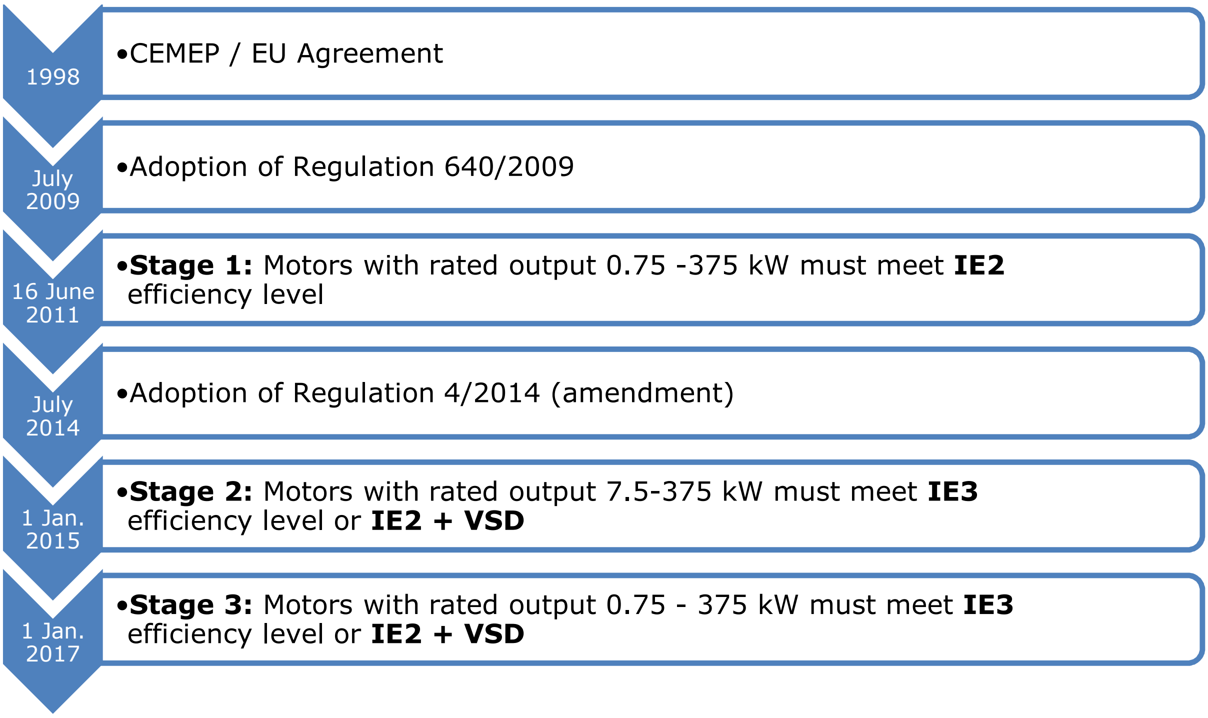
The following figure shows the timeline of the policy framework regarding electric motors; from the CEMEP/EU Agreement in 1998 to the last tier of the adopted regulations.

[133] These values are directly calculated by multiplying the estimated percentages times the energy consumption values reported in the specific chapters.

[134] Regulation 640/2009/EC and amended regulation 4/2014/EU

[135] The energy efficiency classes for electric induction motors (IE=International Efficiency) are defined in the standard IEC 60034-30-1 (Standard IEC Line Motors) published in March 2014. The defined IE classes are: IE1 (Standard Efficiency); IE2 (High Efficiency); IE3 (Premium Efficiency); and IE4 (Super Premium Efficiency).

**Figure 197: Timeline of EU motor policies[136]**




The above reported performance requirements, including the application of variable speed drives, is expected to allow saving 135 TWh in the EU in 2020.

### *7.3.1 Motor Market*

Motors market data reported in this section have been taken from official EU statistics so that they are coherent with official data used in EU industry and trade policy. ProdCom[137] is the official Eurostat source of statistics for the production of manufactured goods.

The following figure shows the sales of the European motor market by technology and power range for the year 2014.

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136 The agreement between CEMEP and the European Commission introduced the definition of three efficiency classes were defined for the power range of 1.1 kW to 90 kW (EFF3, EFF2 and EFF1 for motors with low, an improved and a high efficiency level respectively).

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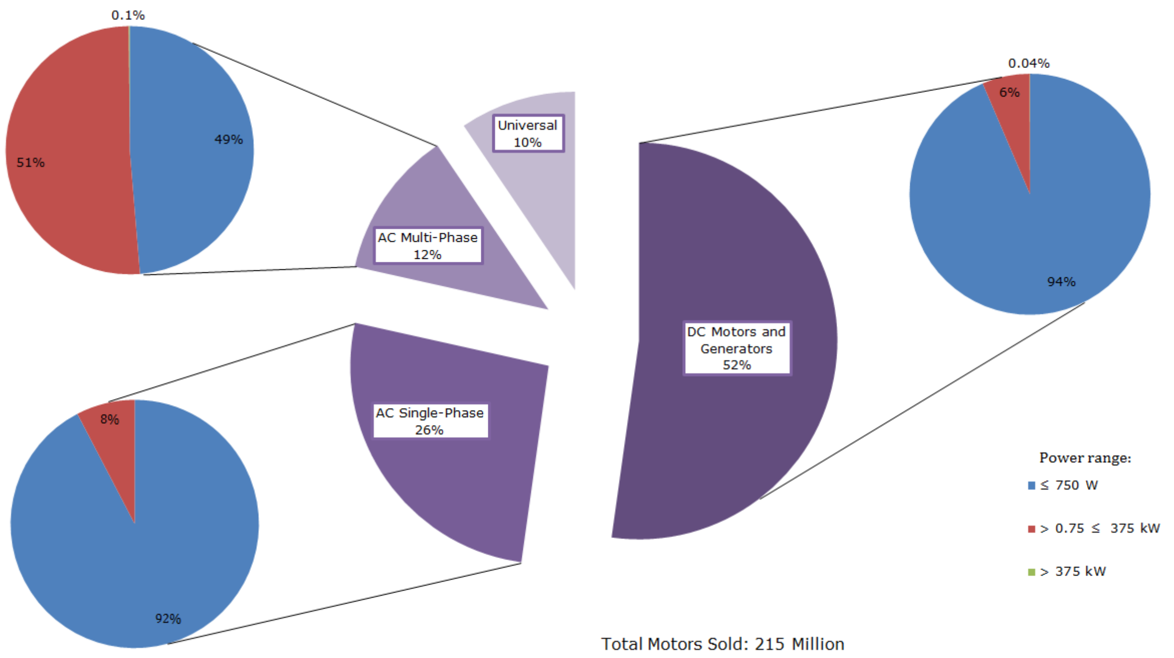
**Figure 198: European Motor Market by technology and power range, 2014. Source: Eurostat**




In 2014, over 215 million[138] motors were sold in the EU28, 87% of which were in the small power range, that is, under 750 W output power, which are currently unregulated in the EU. The share of large motors is very small (only 0.04%) and the remaining 13% of motors sold are in the medium power ranged. The previous figure, together with the Table 41 provide with the data of the EU-28 motors market sales volume in 2014.

In the small power range (≤ 750 W); DC motors account for 62% of the total number of units sold but more than a third are used in automotive applications which are outside the scope of this analysis.

In the medium range (0.75 to 375 kW); AC multi-phase motors are responsible for 54% of sold units among other technologies, being the 51% of all AC multi-phase from this range. The conventional Brushed DC motor market in this power range is expected to continue to decline as this technology is being replaced by three-phase induction motors [57]; for the year 2014 DC motors account only 6% in this power range.

In the large power range (> 375 kW); generators account 58% of sold units, while AC multi-phase motors account the remaining 42%.

[138] The value of 215 Million have been obtained by subtracting the sold volume of electric motors of an output ≤ 37.5 W (including synchronous motors ≤ 18 W, universal AC/DC motors, AC and DC motors – PRODCOM Code: 27111010) from the total sold volume due to inability to break down each type of technology. The precise value obtained from the data in this way is 215.442 million units.

**Table 41: EU-28 motors market sold units per technology type in 2014. Source: Eurostat**

| Power range | Motors Technology | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DC Motors and Generators | | AC Single-Phase | | AC Multi-Phase | | Universal | | TOTAL | |
| | Sold Units* | Share (%) | Sold Units* | Share (%) | Sold Units* | Share (%) | Sold Units* | Share (%) | Sold Units* | Share (%) |
| | ***112476*** | ***52%*** | ***56608*** | ***26%*** | ***25958*** | ***12%*** | ***20401*** | ***9%*** | **215442** | |
| ≤ 750 W | 105245 | 94% | 52281 | 92% | 12638 | 49% | | | 170164 | 87% |
| > 0.75 ≤ 375 kW | 7188 | 6% | 4326 | 8% | 13290 | 51% | | | 24804 | 13% |
| > 375 kW | 43 | 0.04% | | | 31 | 0.1% | | | 74 | 0.04% |

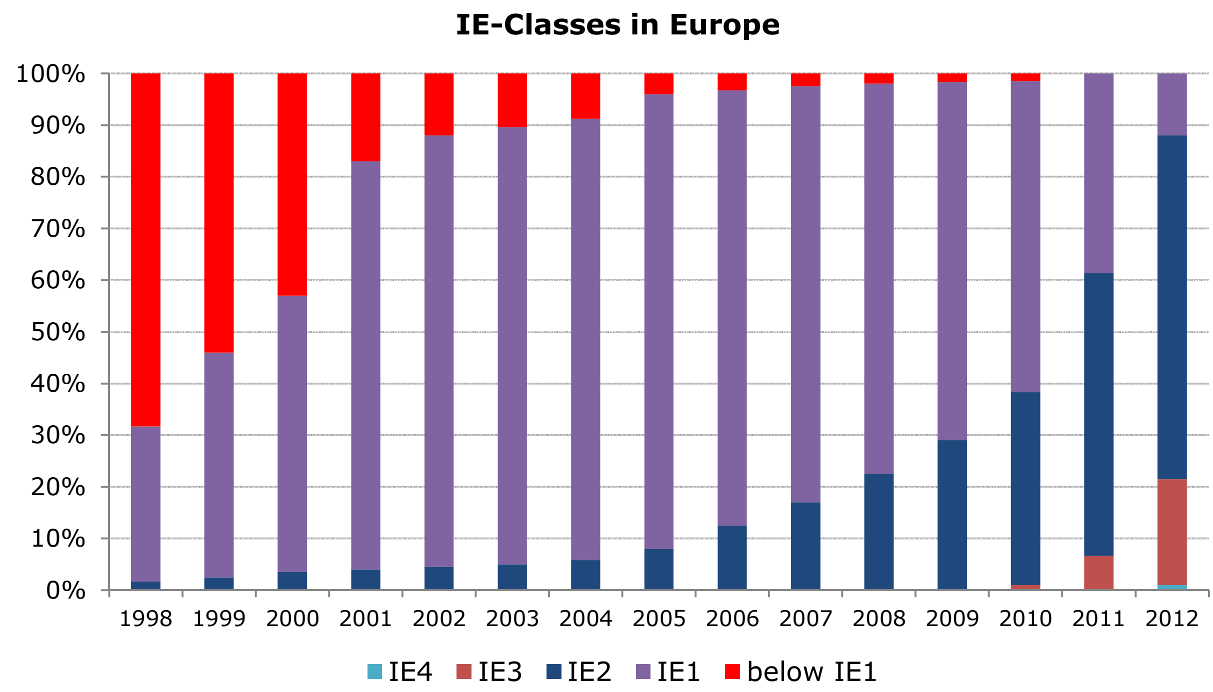
*Sold units expressed in thousands

The evolution of the EU motor market in terms of energy efficiency classes for the covered power range can be analysed by the CEMEP[139] data showed in Figure 199 and Figure 200. Back in 1998, when the first voluntary agreement was made between CEMEP and the European Commission, motors with efficiency below class IE1 had the highest share (about 70%); whilst their share was very low (below 2%) in 2010 and negligible in 2011.

The highest increase of share from a previous year was seen between 2000 and 2001, when a share of nearly 25% of the motor market was absorbed by IE1 class motors; reducing significantly the presence of below IE1 class units.

Since 1998, the presence in the market of IE2 class motors has been increasing year after year, becoming the IE class with highest share since 2011. In the period 2010-2012, IE3 class units started to obtain a clear place in the market by achieving 20% of the share in 2012. IE4 class motors penetrated into the market in 2012 with a share of about 0.2%.

**Figure 199: Evolution of the EU motor market in terms of energy efficiency (0.75-375 kW), in the period 1998-2012. Source: CEMEP**



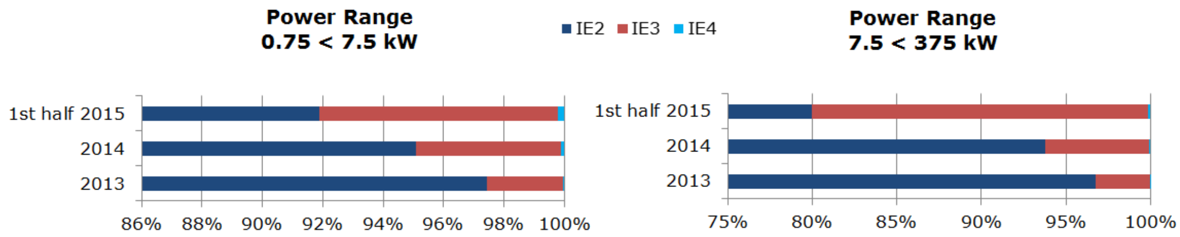

[139] European Committee of Manufacturers of Electrical Machines and Power Electronics

The most recent available data of motors market allows splitting the above analysed 0.75-375 kW range in two power sub-ranges. Figure 200 shows that along the last three years the IE2 efficiency class has hold the majority of the market in both power range classifications (0.75-7.5 kW and 7.5-375 kW). Regarding the power range 0.75 kW to 7.5 kW, IE 3 class has increased by 5.4% its presence in the market (sold units) in the period comprised between 2013 and the first half of 2015. IE4 efficiency class has raised its share of sold units (by < 0.15%). For the higher power range (7.5 kW to 375 kW), during 2013 and 2014 the IE3 class sold units increased by 2.9% (from 3.2% to 6.1%). The sales of IE3 class underwent a significant raise during the first half of 2015 by reaching 19.9% of the share. As in the case of 0.75-7.5 kW power range, the IE4 efficiency class sales have slightly increased between 2013 and 1st half 2015 (by < 0.1%).

Despite the annual increases in the market shares of the most efficiency classes (i.e. IE3 and IE4) within the market, the demand at European level is lower than expected[140].

The second tier of the regulation EC 640/2009 started in 2015 in the power range 7.5 kW to 375 kW. The influence of this second tier and the third tier (from January 2017) may be present in the next 2 years respectively.

**Figure 200: European motors market demand of energy efficiency classes IE2-IE4, 2013-1st half 2015. Source: CEMEP[141]**




| | 2013 | 2014 | 1st half 2015 |
|---|---|---|---|
| IE2 | 97.5% | 95.1% | 91.9% |
| IE3 | 2.5% | 4.8% | 7.9% |
| IE4 | < 0.05% | 0.1% | < 0.2% |

| | 2013 | 2014 | 1st half 2015 |
|---|---|---|---|
| IE2 | 96.8% | 93.8% | 80.0% |
| IE3 | 3.2% | 6.1% | 19.9% |
| IE4 | < 0.05% | < 0.1% | < 0.15% |

## 7.4 Overview – Industry sector

The industry sector accounted for 25.89% of the EU-28 total final energy consumption in the year 2014, confirming industry as the second energy consuming economic sector after transport (33.22%).

The EU-28 industry final energy consumption has fallen by 17.6% (from 333.5 Mtoe to 274.8 Mtoe) in the 15-years period from 2000 to 2014. This decrease has been followed by both EU-15 and NMS-13 areas which have reduced their consumptions by 17.5% and 18.3% respectively. The maximum annual consumption of this period took place in the year 2003 (335.6 Mtoe) and the minimum occurred in 2009 (< 267 Mtoe). 2009 is also the year with the lowest consumption over the 25-year period comprised between 1990 and 2014.

For the period 2000-2014, the highest energy consumption growth rate across the EU-28 Member States has been observed in Latvia (37.3%), Austria and Lithuania (24.5%) and Hungary (16.5%). On the other hand, the lowest rates have been registered in Cyprus (-50.1%), Italy (-34.2%) and Bulgaria (-34%).

[140] Source: CEMEP.
[141] The bases for the survey are approximately 3.0 Million motors sold p.a. in Europe.

Germany (60.7 Mtoe), France (27.9 Mtoe) and Italy (26.2 Mtoe) were the Member States with the highest consumption in the industry sector in 2014. These three States together with the United Kingdom (25.5 Mtoe) accounted for more than 50% of the total European final energy consumption in the sector. Half of the EU-28 Member States (14 countries) consumed more than 90% of the EU-28 industry final energy consumption in the same year.

Concerning the energy mix in industry sector, gas (87.2 Mtoe) and electricity (85.8 Mtoe) were the main energy types consumed in 2014. These two fuel types represented together over 60% of the total final energy consumption in the EU-28 (gas: 31.75%; electricity: 31.21%). The rest of the energy mix was made by solid fuels (12.84%), petroleum products (10.07%), renewable energies (7.47%), derived heat (5.56%) and non-renewable waste (1.10%) in the same year. The highest reduction has been found in the usage of petroleum products (by 47.8% - more than 25 Mtoe from 2000 to 2014). In comparison to year 2000, electricity, renewable energy sources, derived heat and waste have grown their shares, whilst solid fuels, gas and petroleum products have decreased their shares values.

Industry sector consumed 36.86% of the final electricity consumption of the EU-28 in 2014, confirming the sector as the main electricity consumer.

The industry electricity consumption has fallen by 6.0% in the EU-28 from 2000 to 2014. This decrease has been mostly caused by the EU-15 area (-9.2%), whereas NMS-13 area has increased its electricity demand by 18.4%. The year 2007 registered the maximum industry electricity consumption (1,141.5 TWh) for the 25-years period from 1990 to 2014.

The highest electricity consumption growth rates over the period 2000-2014 have been experienced by Hungary (66.8%), Lithuania (36.0%) and Austria (28.4%). The Member States with the lowest growth rates are Italy (-20.4%), the Netherlands (-18.5%) and the United Kingdom (-18.3%). Twenty-two Member States have registered a negative growth rate over the period 2007-2014. The only states with a positive growth rate in that period are: Hungary (55%), Ireland (11%), Poland (5%), Austria (2%), Lithuania (1.2%), and Slovakia (0.4%).

The industry sector consumed 38.05% of the final gas consumption of the EU-28 in 2014, ranking as second gas consuming sector after residential sector (40.20%).

EU-28 gas consumption in industry has fallen by 22.6% in the 15-years period from 2000 to 2014. This decrease has been registered in both EU-15 and NMS-13 areas which have declined their consumptions by 23.1% and 20% respectively.

In the analysed period (2000-2014), the maximum annual gas consumption took place in the year 2003 (112.9 Mtoe) which achieved the maximum value since 1990 (114.1 Mtoe). The minimum value of the period occurred in 2009 (82.1 Mtoe). Since 2009, the European Union has been registering the lowest values of industry final gas consumption for the 25-years period between 1990 and 2014.

The final gas consumption of the EU-28 has dropped by 22.6% from 2000 to 2014. Across the EU-28 MSs, eight Member States have registered below average European growth rates. The Member States with the highest growth rates over this period are Greece (90.2%), Portugal (51.1%) and Ireland (45.3%). On the other hand, the lowest final gas consumption decreases have been observed in the United Kingdom (-49.1%), Italy (-48.8%) and Bulgaria (-47.5).

The industry sector can be broken-down into subsectors for a deeper analysis. Construction, mining and quarrying and manufacturing industries form the main subdivision.

Mining and quarrying has registered the highest final energy consumption drop (25.6%) over the 2000-2014 period. The manufacturing subsector has also undergone a fall by

17.9%. Opposite trends has been registered in the construction subsector which has increased its demand of final energy by 2.2%.

The manufacturing industries can be itemized into ten subsectors which are: iron and steel; non-ferrous metals; chemical and petrochemical; non-metallic minerals; food and tobacco; paper, pulp and print; transport equipment; machinery; wood and wood products; and other industries.

Among them, the highest final energy consumption has been registered in the chemical and petrochemical subsector (19.15%; 52,611 ktoe), followed by iron and steel (18.59%; 51,086 ktoe) and non-metallic minerals (12.37%; 33,997 ktoe). In the manufacturing subsectors the overall final energy consumption trend is a decreasing one. Only one subsector (wood and wood products) has increased its final energy consumption (by 24.0%). The lowest growth rates over the period considered have been observed in textile and leather (-59.4%), other industries (-28.6%) and iron and steel (-24%).

In 2014, chemical and petrochemical manufacturing industry was the industry subsector with the highest electricity (181.2 TWh; 18.2%) and gas consumptions (15,335 ktoe; 20.7%).

The manufacturing subsectors which follow in the electricity consumption ranking are Machinery and Iron and Steel (12.0%; 120.0 TWh) and Food and Tobacco (11.4%; 114.0 TWh). In 2000, Chemical and petrochemical was the highest electricity consumer (200.5 TWh), followed by Paper, pulp and print (131.8 TWh) and Iron and Steel (130.4 TWh).

In the case of gas consumption, the chemical and petrochemical manufacturing subsector is followed by iron and steel (17.6%; 15,335 ktoe), non-metallic minerals (15.3%; 13,336 ktoe) and Food and Tobacco (15.1%; 13,151 ktoe) in 2014.

When analysing the Industrial Production Indexes (IPIs) of the different manufacturing industries for the period from 2000 to 2013, it can be observed that the most notable variations in the IPIs occurred after the financial crisis. All the manufacturing subsectors experienced a significant drop in their productions in 2009. Textile and leather subsector's IPI has been continuously decreasing since 2000 and has accumulated a 69% drop till 2013. The most stable manufacturing subsector is Food and Tobacco which keeps IPI within a 10% range.

Regarding the economic contribution to the GDP, the machinery subsector is the largest contributor among the manufacturing industries (599,556 M€). The second one is food and tobacco industry (215,392 M€).

The Energy Intensity (EI) of the industry sector has instead dropped by 20.9% in the period 2000-2013. In 2013, the EI was 0.106 koe/€2005. The overall trend is a decreasing one during the mentioned period with the exception of paper industry which has increased its energy intensity by 3.6%, reaching the value of 0,398 koe/€2005 in 2013. Again, the textile and leather sector is the manufacturing industry sector where the largest changes have taken place as it has reduced its energy intensity by 44.2% (from 0.129 koe/€2005 in 2000 to 0.072 koe/€2005 in 2013) led by reductions in both energy consumption and added value to the economy.

Motors systems are a major consumer of electricity in industry. It is estimated that motor systems account for 70% of the electricity consumption in industry and for 35% of the non-residential buildings electricity consumption.

Electric motors and drives are currently subject to the second eco-design tier of their eco-design regulations EC 640/2009 and EC 4/2014 (which goes from January 2015 to January 2017). These regulations cover motors of power range between 0.75 and 375 kW and establish motors energy efficiency class.

In 2014 over 215 million motors were sold in the EU28, 87% of which were in the small power range (under 750 W output power); which is currently unregulated in the European Union.

In the small power range, DC motors account for 62% of the total number of units sold but more than a third are used in automotive applications which are, again, outside of the legislative framework focus.

In the medium range (0.75 to 375 kW) which is the regulated power range, AC multi-phase motors are responsible for 54% of sold units among other technologies, being the 51% of all AC multi-phase from this range. The conventional Brushed DC motor market share in this power range was 6% in the year 2014 and the decreasing trend is expected to continue in favour of other more efficient technologies.

The large power range (> 375 kW) is mainly formed by generators (58% of sold units), while the remainder share (42%) is taken by the AC multi-phase motors which are the machines type covered by the medium power range regulation.

The market penetration rates (sold units) of the different energy efficiency motor classes from 1998 to 2014 show a gradual transition of motor industry to more efficient classes since 1998 when the first voluntary agreement was made between CEMEP and the European Commission. Back in 1998, class IE1 motors were the majority (about 70%), while the share of these motors was very low (below 2%) in 2010 and negligible in 2011.

IE2 class motors' presence has grown year after year since 1998 and became the IE class with highest share in 2011 (around 55%). In the period between 2010 and 2012, IE3 class motors have started to obtain a clear place in the market by reaching 20% of the share by 2012. The most efficient class (IE4) penetrated into the market in 2012 with a share about 1%.

When analysing the latest motors market data, a split into the power range between 0.75kW and 375 kW can be applied, resulting two power sub-ranges: 0.75-7.5 kW and 7.5-375 kW. In the period from 2013 to 1st half 2015, the IE2 class motors have kept their majority on sales at European level. In the power range from 0.75 kW to 7.5 kW, IE 3 class has increased by 5.4% its presence in the market (sold units) in the period comprised between 2013 and the first half of 2015. IE4 efficiency class has raised its share of sold units (by < 0.15%). In the power range from 7.5 kW to 375 kW, the IE3 class sold units increased by 2.9% (from 3.2% to 6.1%) during 2013 and 2014. The sales of IE3 class underwent a significant raise during the first half of 2015 by reaching 19.9% of the share. With regard to the IE4 efficiency class sales have slightly increased between 2013 and 1st half 2015 (by < 0.1%). Despite the annual increases in the market shares of the most efficiency classes (i.e. IE3 and IE4) within the market, the demand at European level is lower than expected. The influence of the different tiers of the Commission Regulation 640/2009 (second tier from January 2015 and third tier from January 2017) may turn out in the next 2 years respectively.

# 8. Conclusions

This report describes and analysed the energy consumption[142] patterns in the EU-28 for the period 2000-2014. Moreover, an analysis through market assessment of main energy-related products (e.g. major domestic appliances, motors, cars, etc.) is also presented. Such analyses are important, as they can provide with some indications and approach regarding the impact and effectiveness of policies aiming at energy efficiency in the EU. The sectors covered are the residential, tertiary, transport and industry sectors.

The results show that EU inland gross energy consumption, primary energy consumption and final energy consumption have declined from 2000[143] by 7.15%, 6.76% and 6.32% respectively. The breakdown into sectors shows that the largest decline of final energy consumption has been registered in the industry sector (-17.62%), in the residential sector there has been a remarkable decrease (-9.52%), in the transport sector there has been registered a slight increase (+2.21%) and the tertiary sector has grown the most (+16.48%).

Energy indicators such as energy intensity of final energy (by 35.82%) and final energy per capita (by 10.02%) have been reduced during over the analysed period, both signs of a higher competitiveness of the European Union as global actor.

**Table 42: Overview of energy consumption in the EU-28, 2000-2014. Source: EC DG-JRC**

| | 2000 | 2007 | 2014 | Growth Rate 2000-2014 (%) |
|---|---|---|---|---|
| Inland Gross Energy Consumption (Mtoe) | 1,730.2 | 1,810.5 | 1,606.5 | -7.15% |
| Primary Energy Consumption (Mtoe) | 1,613.7 | 1,690.7 | 1,504.7 | -6.76% |
| Total Primary Energy Supply per capita (toe/cap) | 3.315 | 3.393 | 2.968 | -10.44% |
| Energy Intensity[144] - Primary Energy (toe/1,000 Euro) | 0.1689 | 0.1309 | 0.1078 | -36.12% |
| Final Energy Consumption (Mtoe) | 1,132.8 | 1,172.90 | 1,061.2 | -6.32% |
| Final Energy Supply per capita (toe/cap) | 2.327 | 2.354 | 2.094 | -10.02% |
| Energy Intensity - Final Energy (toe/1,000 Euro) | 0.1185 | 0.0908 | 0.0760 | -35.82% |

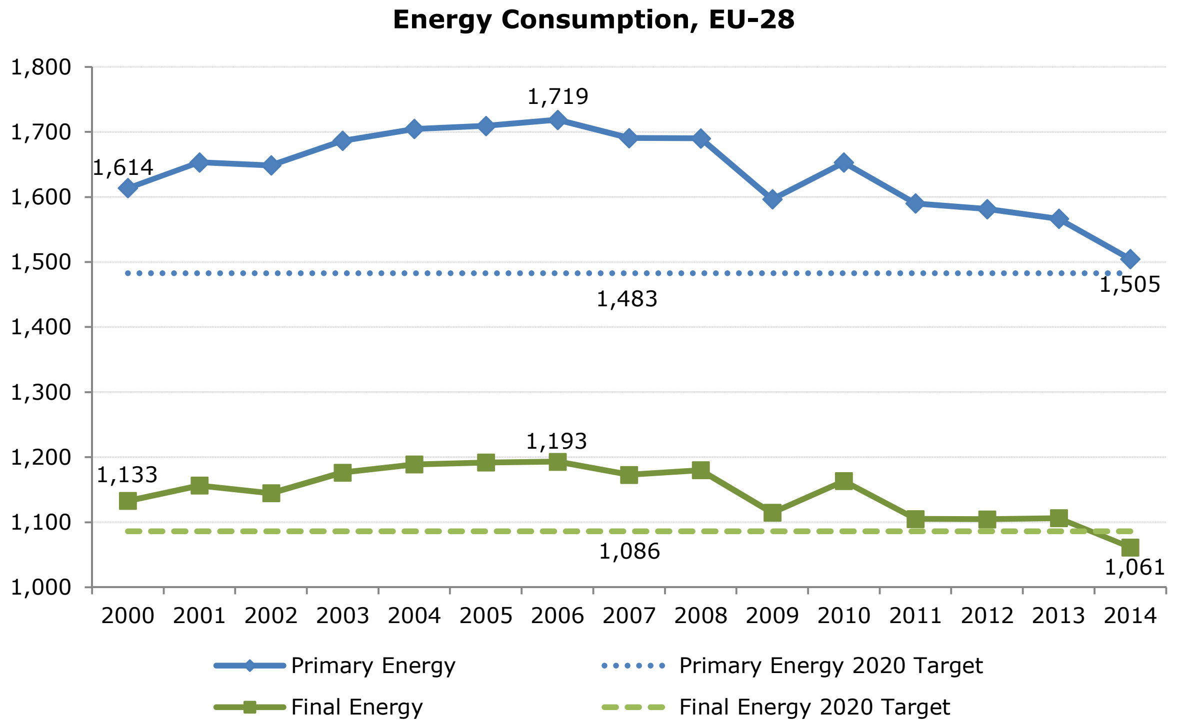
| | 2000 | | 2014 | | Growth Rate 2000-2014 (%) |
|---|---|---|---|---|---|
| | FEC (ktoe) | Share (%) | FEC (ktoe) | Share (%) | |
| Residential Sector | 290,928 | 25.68% | 263,222 | 24.80% | -9.52% |
| Tertiary Sector | 121,244 | 10.70% | 141,223 | 13.31% | 16.48% |
| Transport Sector | 344,893 | 30.45% | 352,501 | 33.22% | 2.21% |
| Industry Sector | 333,517 | 29.44% | 274,759 | 25.89% | -17.62% |

The main findings and results of the report with a focus on the European energy consumption trends for the period from 2000 to 2014 are:

[142] It has been focussed on the final energy consumption.
[143] All growth rates refer to changes from 2000 to 2014, unless another period is specified.
[144] GDP values at market prices have been considered to calculate the energy intensity values reported in the table.

- The EU-28 final energy consumption registered a lower value than the EU target for 2020 in 2014 (1,061 Mtoe vs 1,086 Mtoe of the target); representing a reduction by 2.3% below the target.
- The EU-28 primary energy consumption is on track to reach the 2020 targets (1,505 Mtoe consumed in 2014 vs 1,483 Mtoe of the target). The EU-28 primary energy consumption was 1.5% above the 2020 target in 2014.
- The tertiary sector is the only economic sector which has increased its final energy consumption over the analysed period; the rest, i.e. residential, transport and industry sectors have declined it. However, it has also started to decline its energy consumption.
- The European Union has reduced its energy intensity and energy consumption per capita, sign of higher competitiveness as global actor.
- Overall, the current final energy consumption trends show that the financial and economic crisis (which started in 2007 and peaked in 2008) has caused a change in the dynamics and growth rates of the different sectors and Member States.
- The EU primary energy consumption registered in 2014 was the lowest value over the 25-years period from 1990 to 2014.
- The EU final energy consumption registered in 2014 was the second lowest value over the 25-years period from 1990 to 2014 after the year 1994.
- The financial and economic crisis, paradoxically, has contributed to get the energy consumption numbers back on track according to the EU energy and environmental targets for 2020.
- The growth rates of the Member States on show the different trends related to specific energy-related scenarios and the efforts by the national governments.
- Four Member States (i.e. Germany, France, the United Kingdom and Italy) consumed over 50% of the final energy consumption and fourteen Member States (half of the European Union States) consumed more than 90% of the total final energy consumption in 2014.
- Greece (-29.4%), Spain (-19.3%) and Ireland (-19.0%) are the countries which have registered a highest final energy consumption reduction across the EU-28 Member States from 2007 to 2014.

**Figure 201: Energy consumption trends with 2020 EU-28 energy targets, 2000-2014. Source: Eurostat**




Specific findings and insights can be individually addressed for each of the analysed economic sectors:

## Residential Sector

The residential sector has registered a decrease in the final energy consumption by 9.52% in the period from 2000 to 2014. In 2014, the residential sector has reported a significant drop (-11.70%) in comparison to 2013, representing the highest fall over the analysed period.

The residential energy consumption depends on many variables: heating degree days, population, GDP, number of dwellings, total floor area, efficiency level of the equipment and performance of the building. Different combinations of these variables were used in order to assess whether the residential energy consumption has declined even after these variables were considered. After correcting for population and for population and heating degree days together, there was still reduction in the residential consumption. The GDP is an important variable to consider as it has grown significantly over the covered period. Combinations of the effect of GDP per capita and HDD; energy consumption analysis per dwelling (per square meter); and residential consumption per capita, for HDD, GDP per capita and square meters all return similar results: the EU has registered a very gradual decline in the residential energy consumption from 2000 onwards.

The main findings and conclusions regarding the residential energy consumption trends are:

- In 2014, the residential final energy consumption has registered the lowest value since the year 1990.
- The energy mix in the residential sector is mainly formed by gas (35%) and electricity (25.6%) consumption.
- The final residential electricity consumption has grown (+9.4%) in the EU-28 during the 15-years period 2000-2014.

- The final residential gas consumption has dropped (-15.3%) between 2000 and 2014.
- The residential sector was the third electricity consumer (29.01%) and the main gas consumer (40.20%) among the analysed sectors in 2014.
- The weather and climate conditions have an influence in the residential energy consumption. The results show that the colder the year the higher the energy consumption. There has been observed a positive correlation between the final energy consumption (also in the electricity and gas consumption specifically) and the Heating Degree Days. Nevertheless, correlation does not always mean causation as there are multiple affecting factors such as building characteristics (i.e. building envelope, insulation level, location, etc.) or social and cultural reasons (lifestyle, habits, etc.) among others.
- In the EU, there has been observed a lowering trend in the size of the households in terms of persons per household over the analysed period, which might lead to future increase of the residential energy consumption per capita values.
- Energy consumption per household may be considered a reference parameter to compare and analyse the energy consumption trends at residential level.
- Energy prices are raising in the European Union. Electricity has grown by 33% (up to EUR 0.2078/kWh) and gas by 29.5%[145] (up to EUR 0.0514/kWh) from the second semester 2008 to first semester 2015.
- The disposable income of households or adjusted gross disposable income can represent a more interesting economic indicator when focussing on residential energy consumption than using the GDP values.
- Energy-related Products (e.g. MDA, heating and cooling appliances, lighting, ICT & electronic equipment, etc.) are the main (in some cases totally) responsible of the residential energy consumption.
- Major Domestic Appliances (cold appliances, washing machines, tumble driers and dishwashers) are lowering their average annual declared energy consumptions in the recent years as per effect, among others, of energy policy actions (i.e. eco-design and energy labelling requirements).
- The markets of the analysed domestic appliances show that the highest shares of sold products belonged to the top energy efficiency classes (2 or 3 top classes, depending on the appliance) in the year 2014. As per this reason, the implementation of the eco-design and labelling requirements under energy European policy actions have seemed to be effective and successful in most of the analysed products.
- Market sales show that there is a trend to larger capacity models of domestic appliances (i.e. refrigerator-freezers, washing machines, dishwashers and tumble driers) during the recent years; although it is not clear whether this trend has been manufacturer or customer-driven.
- The most efficient models (top energy efficiency labels) of domestic appliances have been found to be the models with the largest capacities in 2014.
- The European Union is a leading by example economy as it has implemented the most stringent standards regarding eco-design and labelling policies for water heaters and water storage tanks during the recent years, ahead of other economies such as India, China and USA.
- The electricity consumption for lighting has declined (by 7.8%) in the EU-28 from 2000 to 2013. Alike, the average annual electricity consumption per household for lighting purposes has fallen (by 18%) from 2005 to 2013.
- Mains-Voltage halogen lamps were the top sold lamps (58% of the total sold units; 270.3 million sold units) in 2013.
- CFLs have reduced by 8% its market share from 2010 to 2013; despite CFLs are the second top sold types of lamps.

[145] It refers to the average European price for domestic consumers. Band DC (electricity) and band D2 (gas).

- LED lamps (both retrofit and dedicated lamps) have registered a significant development from 2007 to 2013, and it is representative of the bright perspective of this technology.
- The energy consumption reduction has been led by several factors among which highlight several European energy policy actions such as the phase-out of traditional incandescent lamps (GLS). This trend is expected to continue as the phase-out of halogen lamps is foreseen in the EU for September 2018.
- Market monitoring is a supportive tracking tool which may enhance the impact assessment of the energy products policies in terms of market penetration, market sales and consumer purchasing habits.

### Tertiary Sector

The tertiary sector has registered an increase in the final energy consumption by 16.48% in the period from 2000 to 2014. Nonetheless, the final energy consumption has dropped (by 6.4%) in 2014 when compared with 2013.

The main findings and conclusions regarding the tertiary energy consumption trends are:

- In 2014, the final energy consumption has registered a dropped in comparison to the year 2013. However, the sector is registering the highest energy consumption numbers in the 25-years period from 1990 to 2014 during the recent years (2008 onwards) with the exception of year 2014.
- The energy mix in the tertiary sector is mainly formed by electricity (49.12%), gas (29.64) and petroleum products (10.82%) consumption.
- The final tertiary electricity consumption has grown (by 27.5%) in the EU-28 during the 15-years period 2000-2014.
- The final tertiary gas consumption has dropped (by 21.3%) between 2000 and 2014.
- The tertiary sector was the second electricity consumer (29.89%) and the third gas consumer (18.26%) among the analysed sectors in 2014.
- The tertiary energy consumption in the tertiary sector is expected to increase in the following years as per the on-going EU tertiarization trend.
- Weather and climate conditions are an influencing factor in the tertiary energy consumption as comfort conditions (e.g. temperature or humidity levels) play a key role within the sector.
- Weather conditions (heating and cooling degree days) and the final energy consumption (especially the gas consumption) present a positive correlation which may be influenced by comfort conditions. Despite there are multiple influencing factors, it may indicate causation between these two variables.
- Energy per employee may be considered a reference parameter to compare and analyse the energy consumption trends at tertiary level.

### Transport Sector

The transport sector has registered an increase in the final energy consumption by only 2.21% in the period from 2000 to 2014.

The main findings and conclusions regarding the tertiary energy consumption trends are:

- Since 2008 onwards, the transport sector is registering the lowest energy consumption numbers in the 25-years period from 1990 to 2014 years.
- There has been a complete reverse in the energy consumption dynamics from 2008 onwards for the period 2000-2014. It may be result of the impact financial and economic crisis as well as higher fuel prices and more efficient vehicles.
- In 2014, the transport sector registered the second lowest value of final energy consumption (after 2009) over the 25-years period from 1990 to 2014.
- The energy mix in the transport sector in mainly formed by petroleum products (93.63% in 2014).
- The transport sector was the least electricity (2.29%) and gas (1.29%) consumer among the analysed economic sectors in 2014.
- Road transport is clearly the main final energy consumer (82.08% in 2014) among the transport subsectors.
- Diesel and gasoline consumption stand out among the petroleum products; while diesel is the most consumed fuel in the road transport (55.4% in 2014).
- Biofuels have highly developed from 2000 to 2014 mainly due to biodiesels and biogasoline usage. Biodiesels were the major renewable fuel type (80.2% of the total biofuel consumption in 2014).
- Cars represent the largest stock of vehicles and are the major final road energy consumer (78% and 59.3% respectively in 2013).

- The average specific consumption of gasoline and diesel cars has decreased (by 8.9% and by 8.0% respectively) from 2000 to 2013.
- The impact of energy and environmental policy actions in the automotive industry (e.g. $CO_2$ emission regulation for new passenger cars) may be reflected in the decrease of parameters such as the average specific consumption as the decline starting of those parameters coincides with the implementation dates of the mentioned standards.
- A lower age of the vehicles fleet can help reducing the energy consumption and GHG emissions in the future as the energy consumption of the vehicles has decreased in the recent years.
- Passenger transport and within this passenger cars represent the highest energy consumer modes of transport.
- Transportation and storage of goods was the main economic activity related to freight traffic in the EU-28 in 2014.
- The transport was the main responsible GHG emitter among the analysed economic sectors (it accounted for 22.2% of the $CO_2$ equivalent emissions in 2013).
- The GHG emissions in the transport sector have increased (by 12.9%) from 1990-2013.
- The road transport is the main responsible of GHG emission. It is the main emitter of the air pollutants: CO, NMVOC, NOx, PM10 and PM2.5.

## Industry Sector

The industry sector has registered a decrease in the final energy consumption by 17.62% in the period from 2000 to 2014.

The main findings and conclusions regarding the industry energy consumption trends are:

- Since 2008 onwards, the industry sector is registering the lowest energy consumption numbers in the 25-years period from 1990 to 2014 years.
- 2014 registered the second lowest value of final energy consumption in the industry sector after 2009.
- The industry sector was the main electricity consumer (36.86%) and the second gas consumer (38.05%) among the analysed economic sectors in 2014.
- The energy mix in the industry sector was mainly and evenly formed by gas (31.75%) and electricity (31.21%) in 2014.
- In overall, the industry sector has reduced its final energy consumption registers as per the consequence of an output production reduction. For instance, iron and steel (the highest energy consumption manufacturing subsector) has dropped by 24.0% its final energy consumption during the period 2000-2014; and its industrial production index (IPI) and value added to GDP have also fallen by 9.87% and 14.8% respectively from 2000 to 2013.
- The financial and economic crisis has further reduced the production output and has boosted the final energy consumption decrease.
- Despite the IPI reduction (by 0.48%) from 2000 to 2013, the sector has enlarged the value added to GDP (by 4.6%) in the same period.
- The IPI reduction has not been evenly registered across the industry subsectors. For instance, textile and leather subsector's IPI has been continuously decreasing since 2000 and has accumulated a 69% drop till 2013; while Food and Tobacco has remained with stable values within a 10% range.
- The chemical and petrochemical has been the highest energy consumer among the industry manufacturing subsectors during the period 2000-2014.
- The machinery subsector has been the largest contributor to the GDP among the manufacturing subsector during the period from 2000 to 2013.
- The market of electric motors has undergone a gradual transition to more efficient models since 1998 (year of the voluntary agreement CEMEP-EC).

Nevertheless, the top sold units were class IE2 in 2014 resulting in an unexpected lower market penetration of the top energy efficiency classes (IE3 and IE4).

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## List of abbreviations and definitions

| Acronym | Meaning |
|---|---|
| AC | Air Conditioning |
| AE | Annual Energy consumption |
| BAT | best available techniques |
| CDD | Cooling Degree Day |
| CFL | Compact Fluorescent Lamp |
| CHP | Combined Heat and Power |
| CO | Carbon monoxide |
| $CO_2$ | Carbon dioxide |
| COP | Coefficient of Performance |
| DC | District Cooling |
| DH | District Heating |
| EC | European Commission |
| EE | Energy Efficiency |
| EEA | European Economic Area |
| EEAP(s) | Energy Efficiency Action Plan(s) |
| EED | Energy Efficiency Directive (2012/27/EU) |
| EEI | Energy Efficiency Index |
| EEOS(s) | Energy Efficiency Obligations Scheme(s) |
| EER | Energy Efficiency Ratio |
| EFTA | European Free Trade Association |
| EI | Energy Intensity |
| EPBD | Energy Performance of Buildings Directive (2010/31/EU) |
| ErP(s) | Energy related Product(s) |
| ESD | Energy End-use Efficiency and Energy Services Directive (2006/32/EC) |
| ETS | Emissions Trading System |
| EU | European Union |
| EU15 | The EU15 comprises the following 15 countries: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom. |
| EU28 | Group of countries which comprises all the Member States of the European Union. These are: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and United Kingdom. |
| EuP(s) | Energy using Product(s) |
| FL | Fluorescent Lamp |
| GDP | Gross Domestic Product |
| GLS | General Lighting Service, a designation of an incandescent lamp standard |
| GWh | Gigawatt-hour |
| GWP | Global Warming Potential |

| **Acronym** | **Meaning** |
|---|---|
| GWth | Thermal Gigawatt |
| HHD | Heating Degree Day |
| HRE | Heat Roadmap Europe |
| ICT | Information and Communication Technologies |
| IPI | Industrial Production Index |
| JRC | Joint Research Centre |
| ktoe | thousand tonnes of oil equivalent (1,000 toe) |
| LED | Lighting Emitting Diode |
| LFT | Linear Fluorescent Tube |
| LPG | Liquefied Petroleum Gas or Liquid Petroleum Gas |
| LV | Low Voltage |
| MDA | Major Domestic Appliances |
| MEPS | Minimum Energy Performance Standards |
| MS(s) | Member State(s) |
| $MtCO_2e$ | million tonnes of carbon dioxide equivalent |
| Mtoe | million tonnes of oil equivalent (1,000,000 toe) |
| MV | Mains-Voltage |
| MW | Megawatt |
| MWth | Thermal Megawatt |
| NEEAP | National Energy Efficiency Action Plan |
| $NH_3$ | Ammonia or Azane |
| NMHC | Non-Methane Hydrocarbons |
| NMS | New Member State |
| NMS13 | The NMS13 comprises the following 13 countries: Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, and Slovenia. |
| NMVOC | Non-Methane Volatile Organic Compounds |
| $NO_2$ | Nitrogen Dioxide |
| NOx | Nitrogen Oxides |
| NZeB | Nearly Zero-energy Building(s) |
| PPP | Purchase Power Parity |
| PRODCOM | Production Communautaire Statistics |
| SCOP | Seasonal COP |
| SEER | Seasonal EER |
| SME | Small and Medium Enterprise |
| SOx | Sulphur Oxides |
| sqm | Square metres |
| SSL | Solid-State Lighting - refers to LED, OLED or PLED lighting technology |
| TFP | Total Factor Productivity |
| THC | Total Hydrocarbons |
| toe | tonnes of oil equivalent. Unit of measurement of energy consumption : 1 TOE = 41.868 GJ = 11.63 MWh. |
| TWh | Terawatt-hour |
| VA | Voluntary Agreement |
| VSD(s) | Variable Speed Drive(s), also known as Adjustable Speed Drive (ASD) |

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## JRC Mission

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

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