2. Energy Efficiency Trends in the Industry Sector

2.1. Energy use patterns

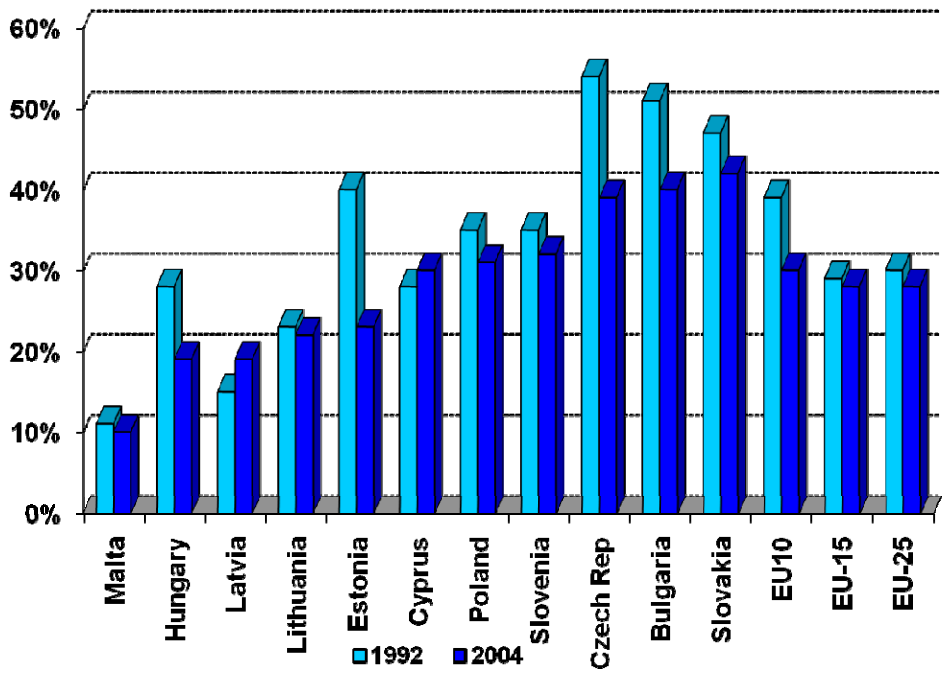
A decrease in industrial energy consumption in EU-10 countries and Bulgaria

In 2004 the industrial sector consumed around 28 % of the energy used by final consumers in the EU-25 (319 Mtoe), and slightly more in EU-10 countries (30%). Most of the consumption is in manufacturing[27] (about 97 %). EU-10 represents about 12% of the total industrial consumption of the EU-25. In the EU-10 as a whole and in most New Member Countries, the energy consumption of the industry sector has been decreasing; as a result, its share in final energy consumption has been falling (minus 9 points between 1992 and 2004, from 39 to 30%). In four countries (Hungary, Bulgaria, the Czech Republic and Estonia), the drop in the importance of the sector has been quite significant (between minus 9 and 17 points).

Significant contrast in fuel mix between EU-10 countries and the EU-25 average

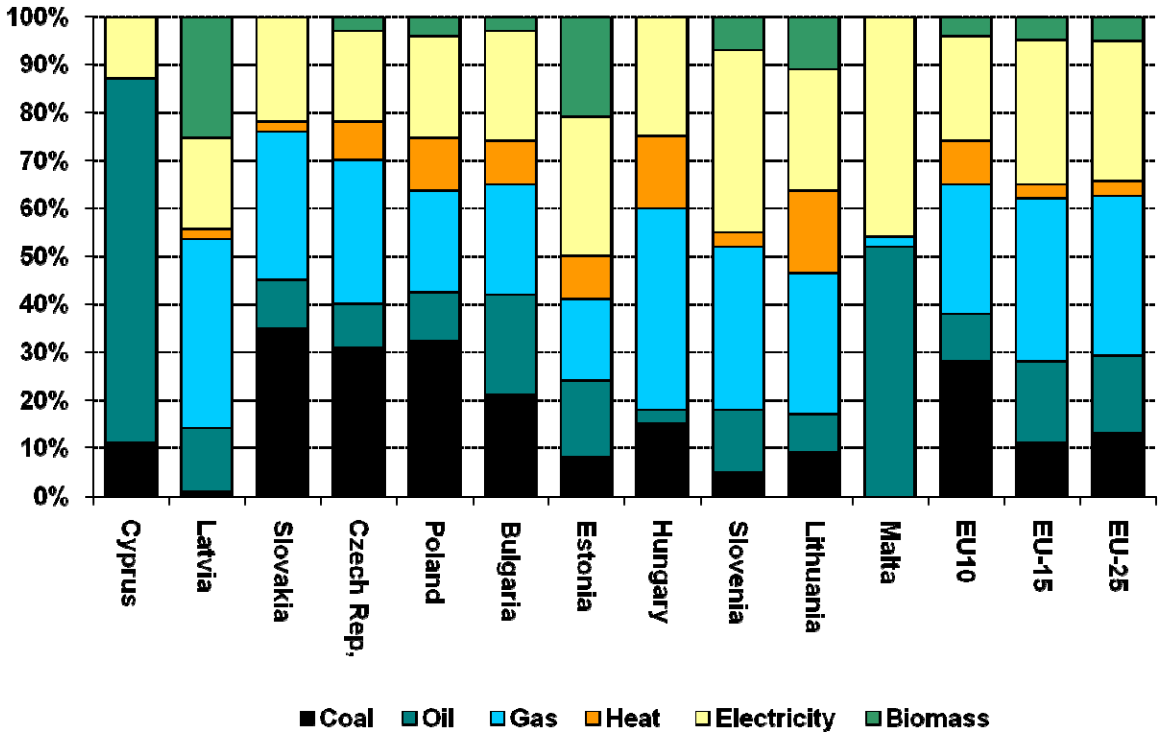
Natural gas was the dominant source of energy for industry in 2004 in the EU-25 with 33 %, whereas in EU-10 countries hard coal and lignite arrive first and have almost at the same market share as gas (respectively 28% and 27%) (**Figure 2-1**).

Figure 2-1: Share of industry in final consumption and energy mix in industry[28]



[27] Industrial energy consumption includes the manufacturing industry, construction and non-energy mining; it excludes the energy used for non-energy uses as well as the fuels used for the self-generation of electricity. The share is calculated in relation to the final consumption for energy uses under normal climate conditions.

[28] Share of industry in Czech Republic, Latvia, Lithuania : 1993 instead of 1992 (Malta : 1999)



In the EU-25, hard coal and lignite only has a market share of 11 %. Electricity ranks second in the EU-25 (29 %) and is much less used in New Member Countries (22% for EU-10). The contribution of oil is higher in the EU-25 than in the EU 10 (16 % versus 10%). Heat from district heating grids accounts for slightly less than 3 % of the total in the EU-25, whereas in the EU-10 it contributes to 9% of the industry consumption; wood and wastes have a share of around 5 %. Across EU-10 countries, very different fuel mixes can be observed, depending on industry specialisation and energy resources (**Figure 2-1**): there is a large contribution of wood and wastes in Baltic countries (above 20% in Estonia and Latvia, mainly used in the wood industry), and a high market share of natural gas (around 40 %) in Hungary and Latvia. Hard coal and lignite is quite important in Slovakia, Poland and the Czech Republic. There is a high share of non fossil fuels in some countries (above 40% in Hungary, Slovenia, Lithuania and Estonia).

Falling industrial consumption in EU-10 despite rapid increase in value added

Industrial energy consumption decreased despite a rapid industrial growth over the period 1996-2004 in the EU-10 (respectively by –2.7 %/year and 3.7 %/year), showing that energy consumption and growth are completely decoupled (**Figure 2-2)**. This situation contrasts with the EU-15 countries and thus with the EU-25 average.

Energy-intensive branches have a smaller share in energy consumption in EU-10

Steel and chemicals are the largest energy consuming industrial branches: together they made up 43 % of total industry consumption in 2004 in EU-10 (41 % in EU-25) **(Figure 2-3)**.

Figure 2-2: Energy consumption and value added in industry (EU-10 and EU-25)

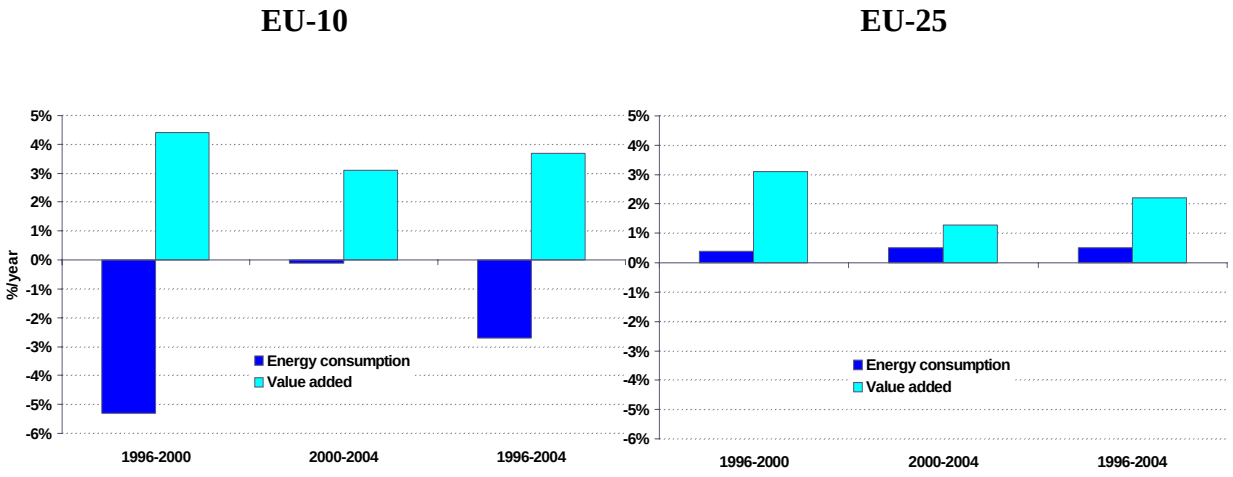
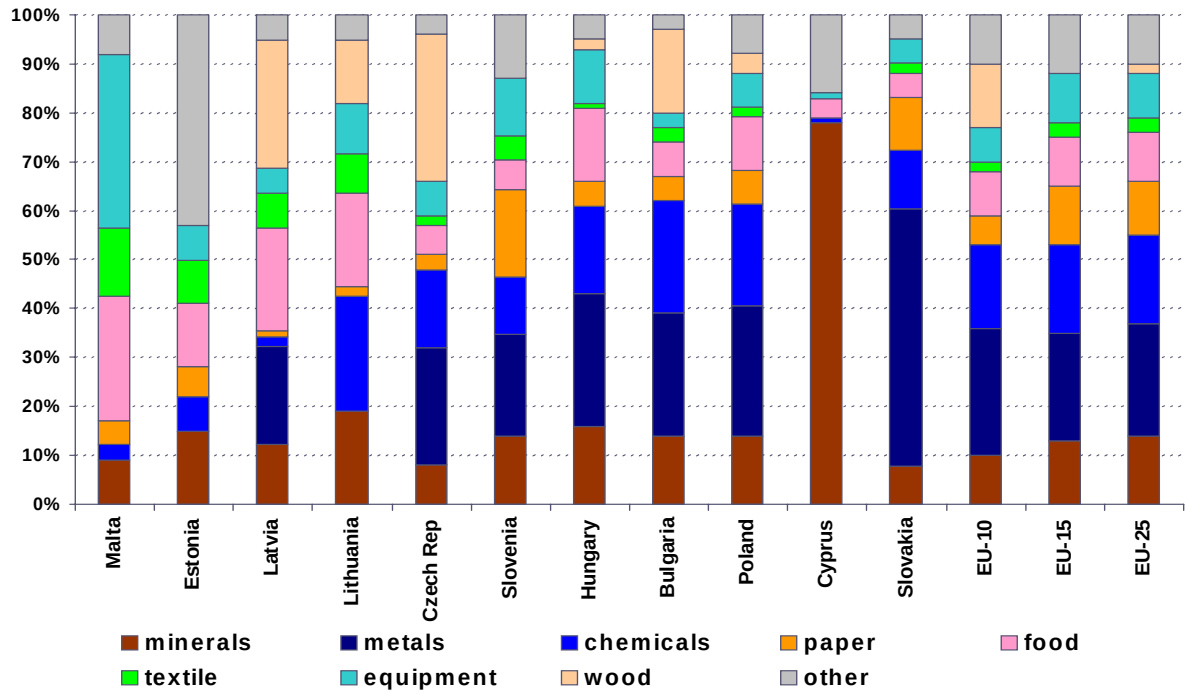


Figure 2-3: Energy consumption by industrial branch in EU-10 countries (2004)



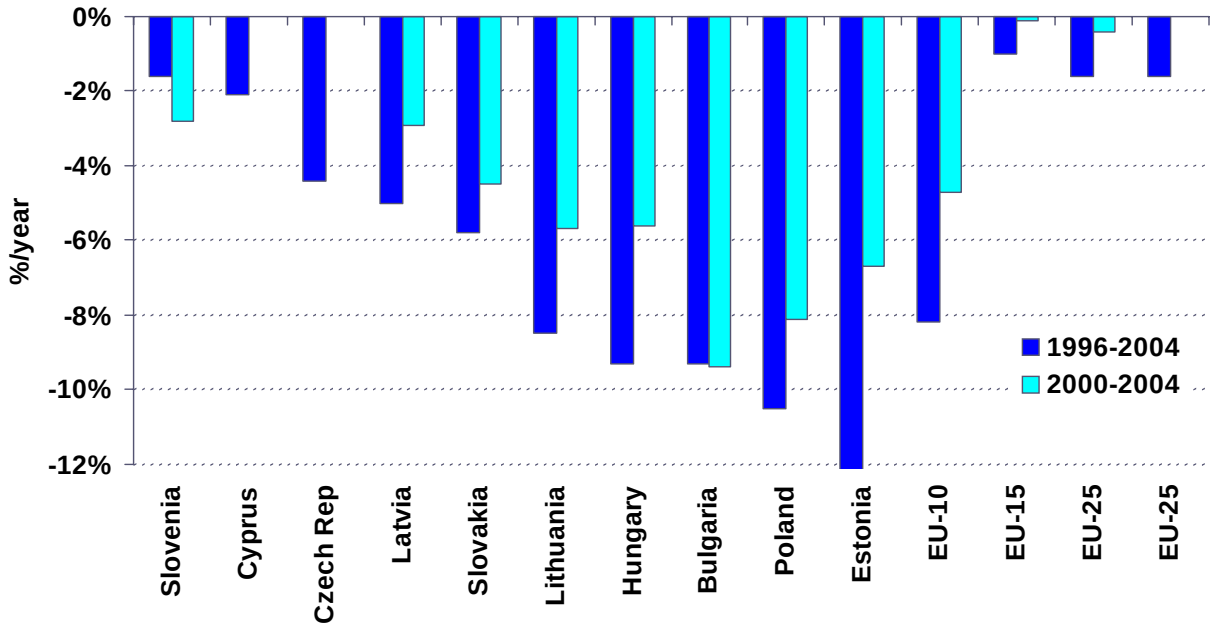
With the other energy-intensive branches (non-metallic minerals[29] and pulp and paper), their total share reached 59 % in 2004 (66 % in EU-25). The main difference comes from the pulp and paper industry that is more developed in the EU-15 (Scandinavian countries) than in New Member Countries (respectively 6 and 12 %). Primary metals play the dominant role in Slovakia (53%), Bulgaria, Hungary and Poland (25-27%). Other important sectors are: chemicals in Bulgaria, Lithuania and Poland (20-23%), non-metallic minerals in Cyprus (78%) and Lithuania (19%), food in Latvia, Lithuania and Malta (above 20%), and wood in Latvia and the Czech Republic (**Figure 2-3**).

[29] Non-metallic minerals: cement, glass and ceramics.

Very rapid improvement in the energy productivity of manufacturing industry

The energy productivity of manufacturing industry increased by 8%/year on average over the period 1996-2004 for the EU-10 as a whole[30] (**Figure 2-4**). This improvement was even over 8%/year in five new EU member countries (Lithuania, Hungary, Bulgaria, Poland and Estonia). After 2000, the energy intensity reduction is slower in most countries (twice slower on average for EU-10). Anyway, this rate of improvement is still much more rapid than in EU-15 countries or at the overall EU level.

Figure 2-4: Trends in energy intensities of manufacturing industry in the EU-10



At the EU-25 level, all energy intensive branches show a rapid decrease of their energy intensity (**Figure 2-5**). However, three branches (textiles/leather, food and pulp/paper/printing) actually increased their energy intensity[31].

[30] In other words, the energy intensity decreased by 8%/year.

[31] For textiles, this is linked to the dramatic decrease in value added while energy consumption was not reduced proportionally. The strong decline in chemicals before 2000 may be due to structural changes within the branch, with a shift from heavy to light chemicals (e.g. cosmetics, pharmaceuticals), which are difficult to assess, due to a lack of data on the consumption by type of chemical product.

Changes in manufacturing structure have been significant in some countries

In the EU-10, the structure of manufacturing value added changed a lot since 1996, with a rapid progression in the equipment branch[32] (plus 10 points from 29 to 39 %), compensated by a reduction in the role of metals and textiles (-4 points each), food (-3 points) and chemicals (-2 points) (**Figure 2-6**).

Figure 2-5: Final energy intensities of manufacturing branches in the EU-25

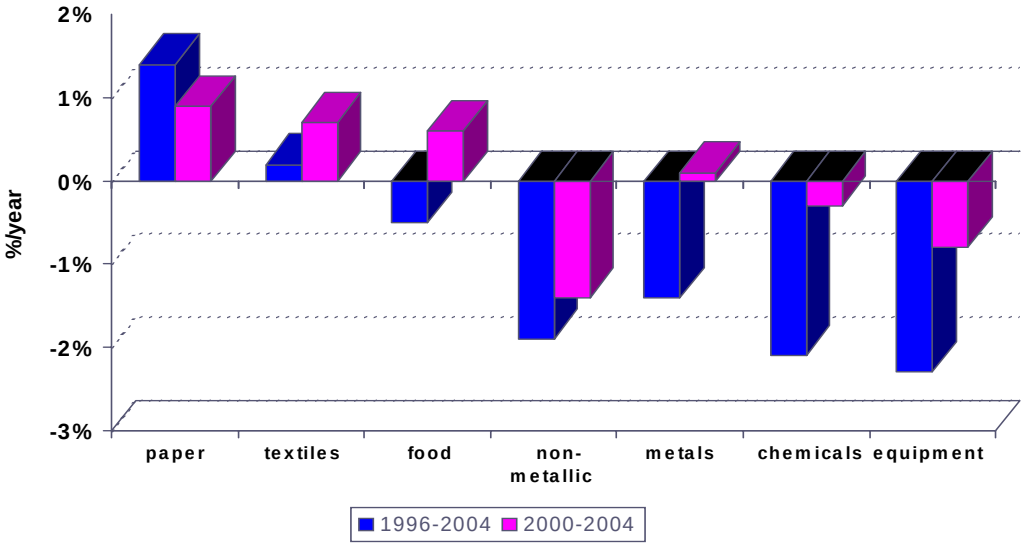
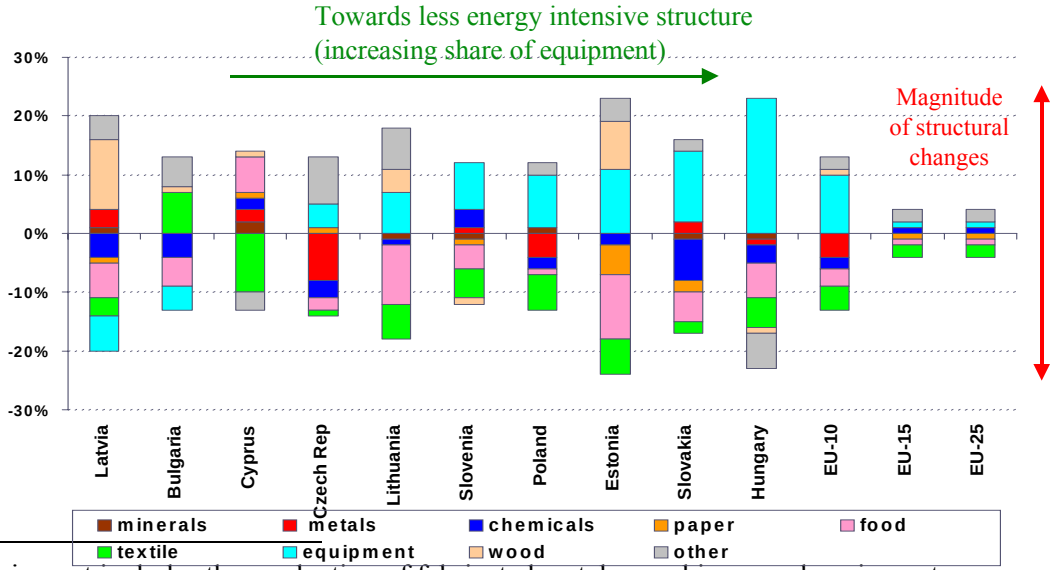


Figure 2-6: Changes in value added structure in the manufacturing industry[33]

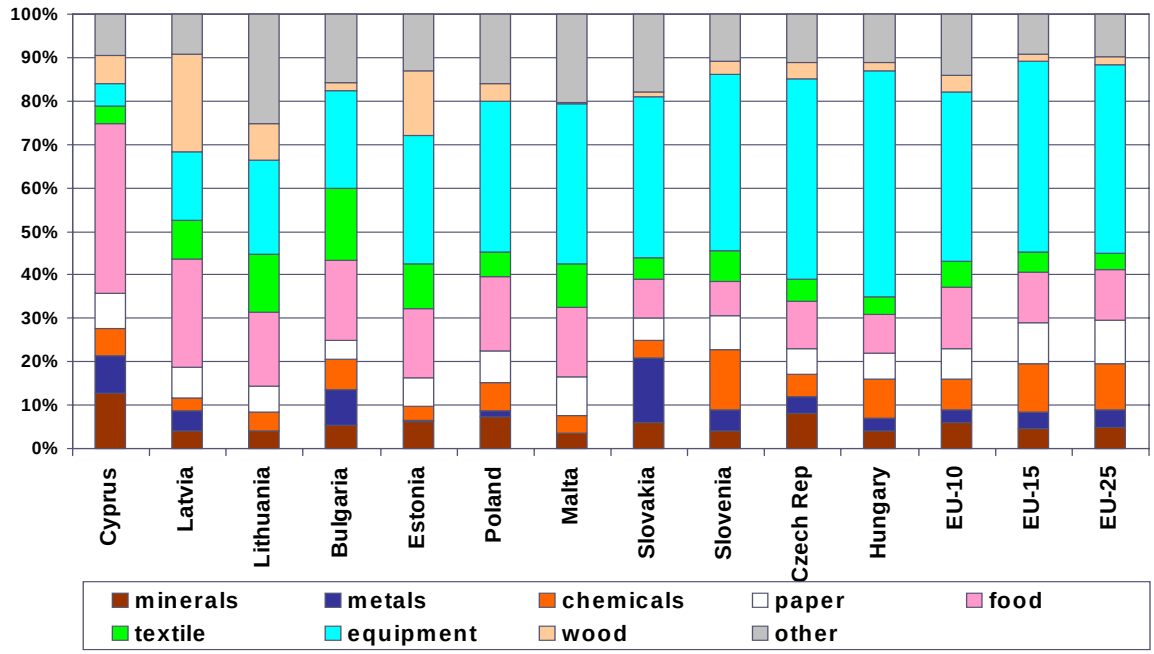


[32] Equipment includes the production of fabricated metals, machinery and equipment.

[33] This graph shows the variation in the share of each branch in the total value added of manufacturing industry between 1996 and 2004: a value of +10 % for instance for equipment for EU-10 indicates that the share of equipment increased by 10 points (e.g. from 29 in 1996 to 39 % of the total in 2004). The sum of the variation is by definition equal to 0, as the total structure is equal to 100 %; therefore the bars are symmetrical along the horizontal axis. The larger the bars, the greater the structural changes.

In some countries, these changes were even more significant, with a very strong progression of equipment in Hungary (+23 points) and to a lesser extent Estonia, Slovakia and Poland (around 10 points) and a rapid progression of wood in Latvia and Estonia. In almost all countries, there was a decrease in the contribution of energy-intensive branches (primary and non metallic minerals). However, the share of equipment production in the industrial activity is still lower in New Member Countries than in EU average (**Figure 2-7**).

Figure 2-7: Value added structure in the manufacturing industry (2004)



Changes in industry structure towards less energy-intensive branches contributed to reducing the industrial energy intensity in most new EU countries

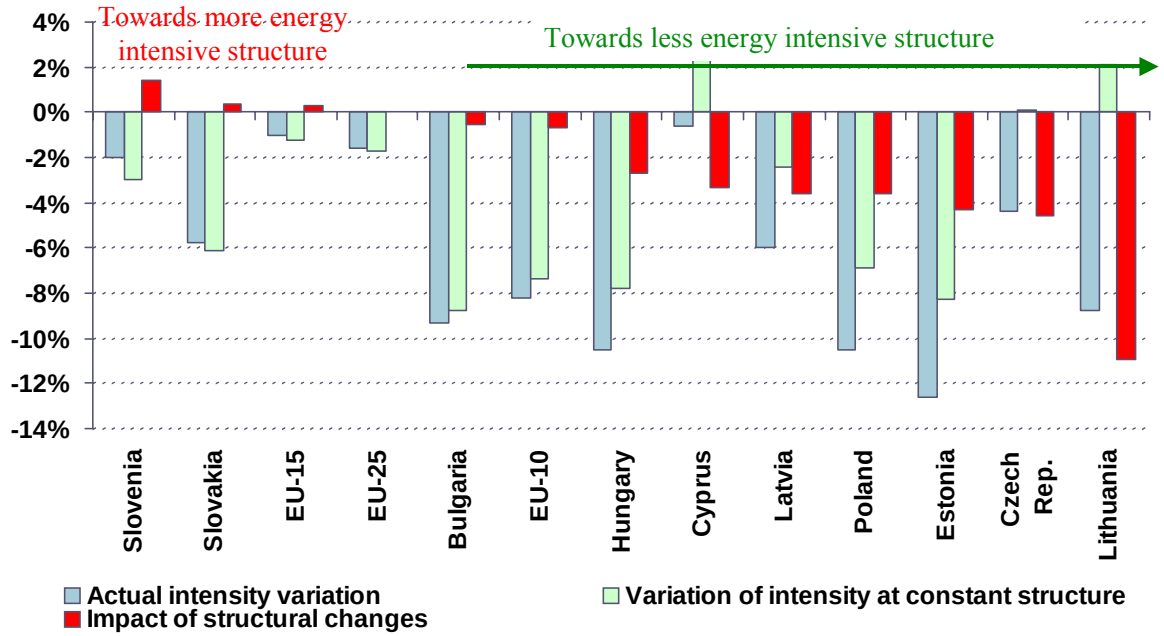
Industrial branches do not have the same energy intensity. Primary metals and non metallic minerals required for instance 25 to 15 times, chemicals and paper 6 to 5 times more energy to produce one unit of value added in 2004 than the equipment branch, which is the least energy-intensive branch. Because of these very different levels of energy intensity among the industrial branches, the increasing share of the equipment branch in the total value added will reduce the average energy intensity of manufacturing, all things being equal.

Comparing the variation in the observed energy intensity of the manufacturing industry with the final intensity at constant structure[34] of manufacturing shows the influence of the structural changes already described: the greater these structural changes, the wider the gap between these two intensities.

[34] The intensity at constant structure is "trimmed" of structural changes; it is calculated using the Divisia method at the level of 10 branches using a moving reference structure (that of the previous year).

In most countries, a shift towards less energy-intensive branches contributed to decreasing the energy intensity of manufacturing. The impact of these structural changes was particularly marked in Hungary, Cyprus, Latvia, Poland, Estonia and the Czech Republic: they explain a reduction between -3 and -5%/year of the energy intensity (**Figure 2-8**). They account for about 25% of this reduction in Hungary, 35% in Estonia and Poland, 60% in Latvia and 100% in the Czech Republic. In Slovenia, and, to a lesser extent, Slovakia, a higher share of energy-intensive branches had the opposite effect and lessened the energy intensity reduction, which is what also happened at the EU level.

Figure 2-8: Impact of structural changes in industry on the energy intensity[35]

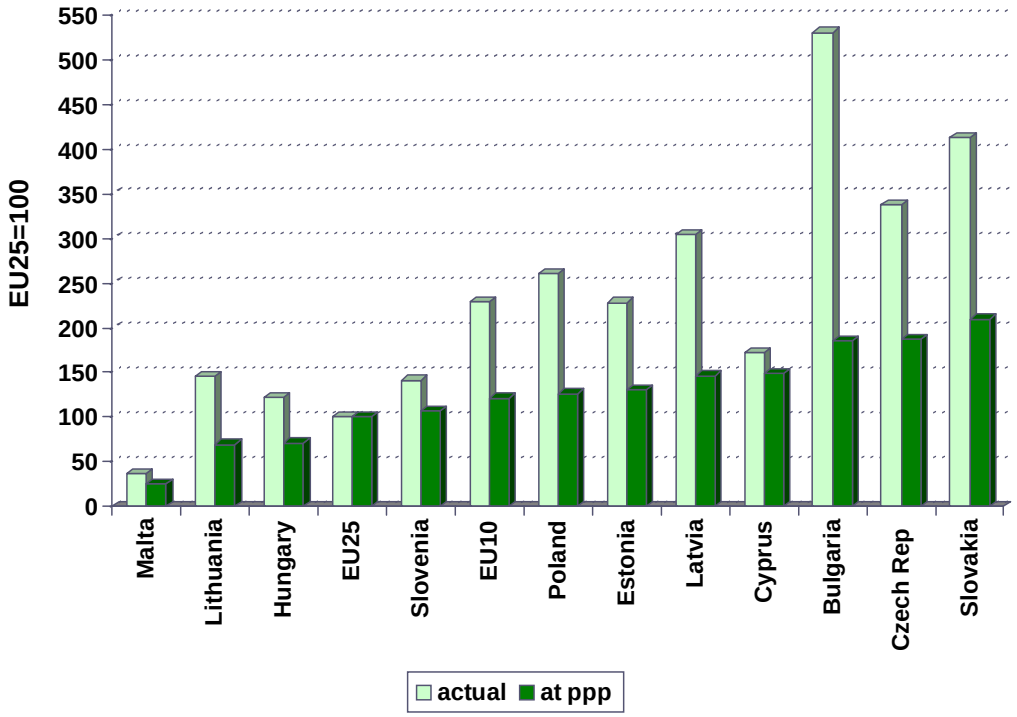


2.2. Comparing energy intensities

A direct comparison of the energy intensity of manufacturing industry across countries on the basis of market exchange rates shows very large differences, which do not reflect any reality in terms of energy efficiency (**Figure 2-9**). The lower prices level in New Member Countries than in EU-15 countries can first of all explain these differences. Therefore, as explained in Chapter 1, the comparison at purchasing power parities is more relevant and closer to technical energy efficiency **(Figure 2-9).**

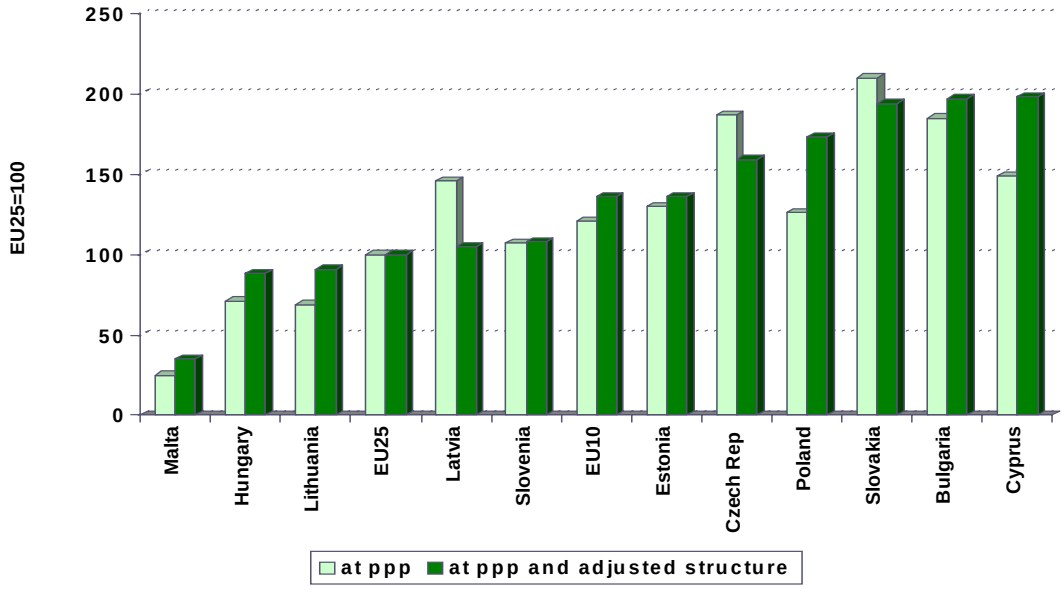
[35] Manufacturing industry (1996-2004)

Figure 2-9: Manufacturing energy intensities at purchasing power parities (2004)



Intensities at purchasing power parities are still influenced by differences in the industry specialisation. To correct for differences in the industry structures, a fictive intensity can be calculated with the actual sectoral intensities of each country and the same value added structure (EU-25 average). A higher intensity at adjusted structure means that country's share of energy intensive branches is lower than EU-25 average (case of most EU–10 countries, except Latvia, Czech Rep and Slovakia) (**Figure 2-10**).

Figure 2-10: Energy intensities in manufacturing at adjusted EU structure (2004)

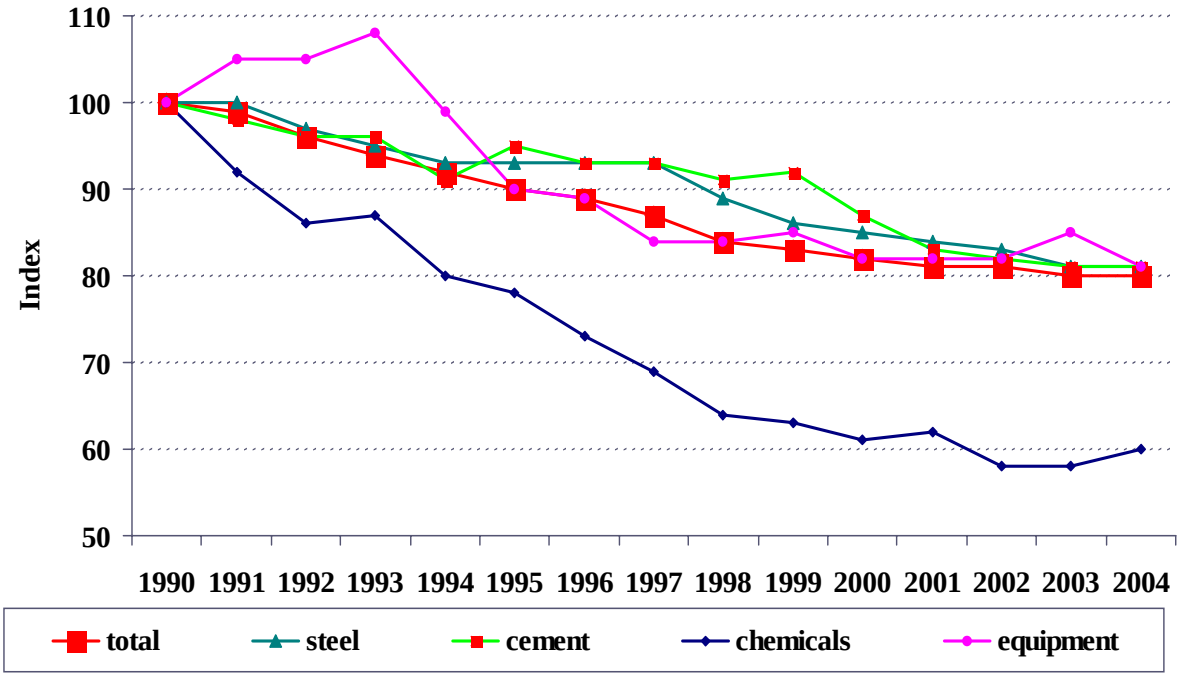


2.3. Overall energy efficiency trends

Energy efficiency has improved by 20 % in manufacturing industry

Energy efficiency improved by 20 % in manufacturing industry in the EU-25 over the period 1990-2004[36] (**Figure 2-11**). Energy efficiency improved in an uniform way in most branches (20 % for steel, cement and equipment). Only chemicals experience a strong reduction of their unit energy consumption (-40 %)[37].

Figure 2-11: Energy efficiency index in manufacturing industry (EU-25)



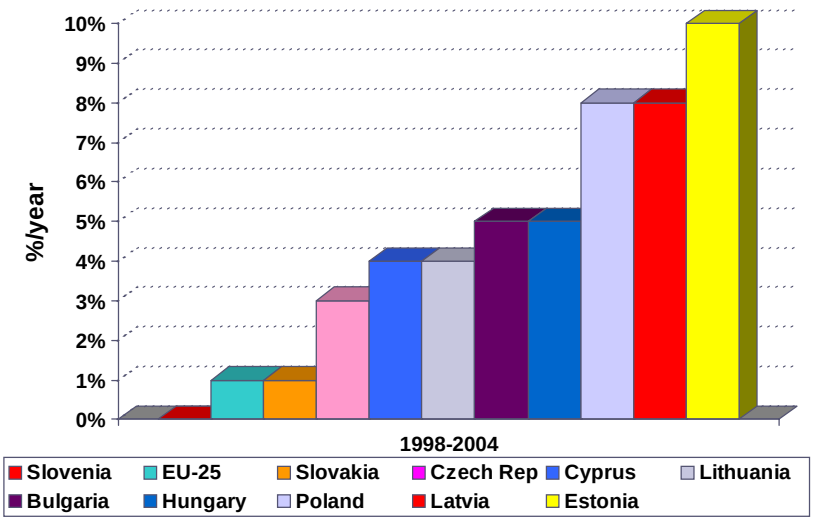
Energy efficiency improved on average by 5 % per year from 1998 to 2004.

Energy efficiency improved unevenly across the countries, by 5 %/year on average from 1998 to 2004 (**Figure 2-12)** with three countries with large improvements (>8%/year), Estonia, Poland and Bulgaria.

[36] Energy efficiency progress is measured with ODEX (see definition in Annex).

[37] In chemicals, the strong decrease in the index may also reflect internal structural change towards less energy- intensive products.

Figure 2-12: Energy efficiency trends in manufacturing industry in NMCs



2.4. Benchmarking of energy efficiency performance in energy-intensive industries

Comparisons of the unit energy consumption of industrial branches have to take into account the specificities of production process before any conclusion can be drawn as to the relative energy efficiency performance of countries, as will be shown below for steel, cement and paper.

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

There are two main processes to produce steel with very different energy requirements: the oxygen process which uses pig iron produced in a blast furnace as input and electric steel making in which iron scraps are melted in an electric furnace. The oxygen process requires 2 to 3 times more energy than the electric process[38]. Therefore, when comparing the average energy consumption per ton of crude steel among countries, it is important to take into account how the steel is produced, in other words the relative share of the two processes, i.e. the "process mix". **Figure 2-13** compares the unit consumption of steel in EU countries, showing the share of electric steel in total crude steel production. The vertical distance from the world benchmark (shown by a red line), which is based on the best available performance, shows the technological improvement possible at the given process mix of the country. The arrow to the x-axis which represents 100 % electric arc shows the potential theoretically open to process substitution (i.e. from an increasing penetration of electric steel)[39]. On average, new

[38] Conversion made in final energy terms on the basis of the calorific value of electricity.
[39] In reality, this potential might be more restricted due to the limited substitution possible between oxygen steel and electric steel.

EU member countries have lower energy performance than most EU-15 countries, at a given process mix: the difference can be roughly estimated at 30%.

Figure 2-13: Unit consumption of steel: energy efficiency potentials (2004)

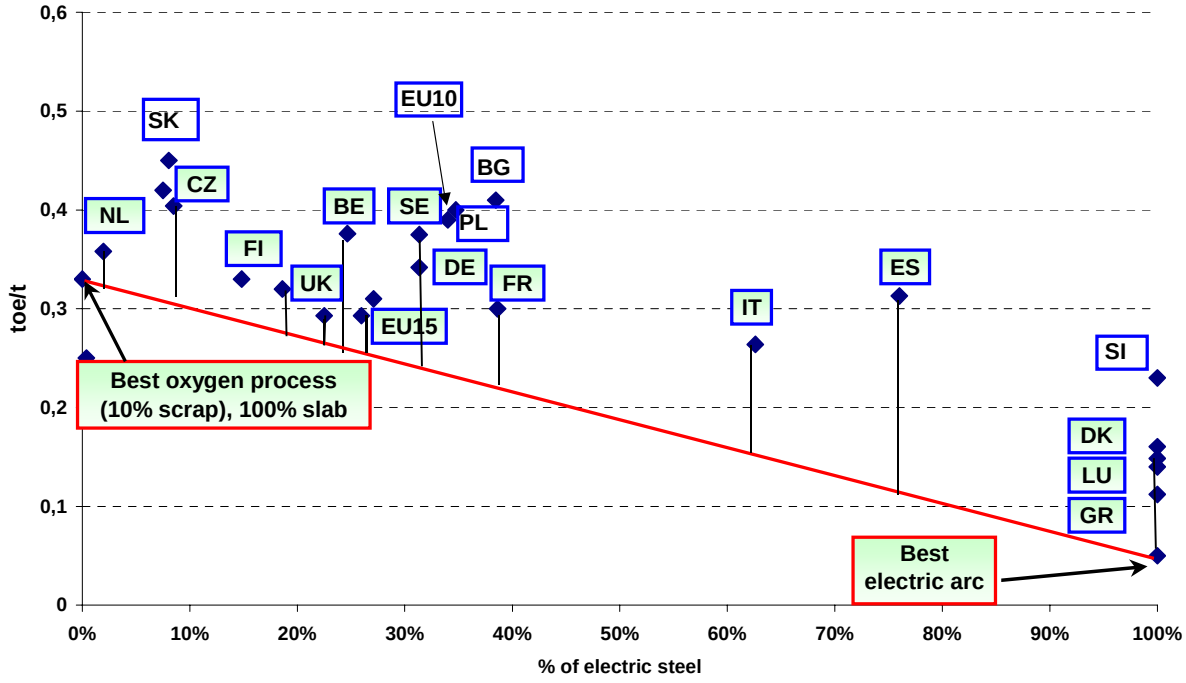
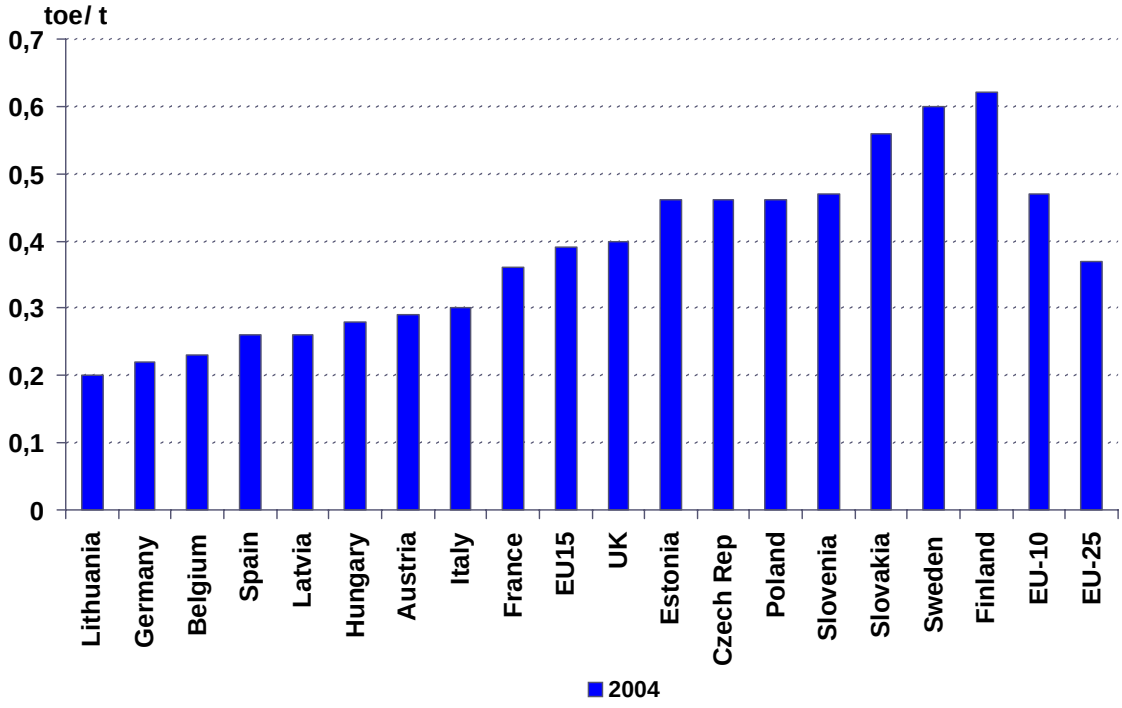


Figure 2-14: Unit energy consumption in the pulp and paper industry (EU-25)

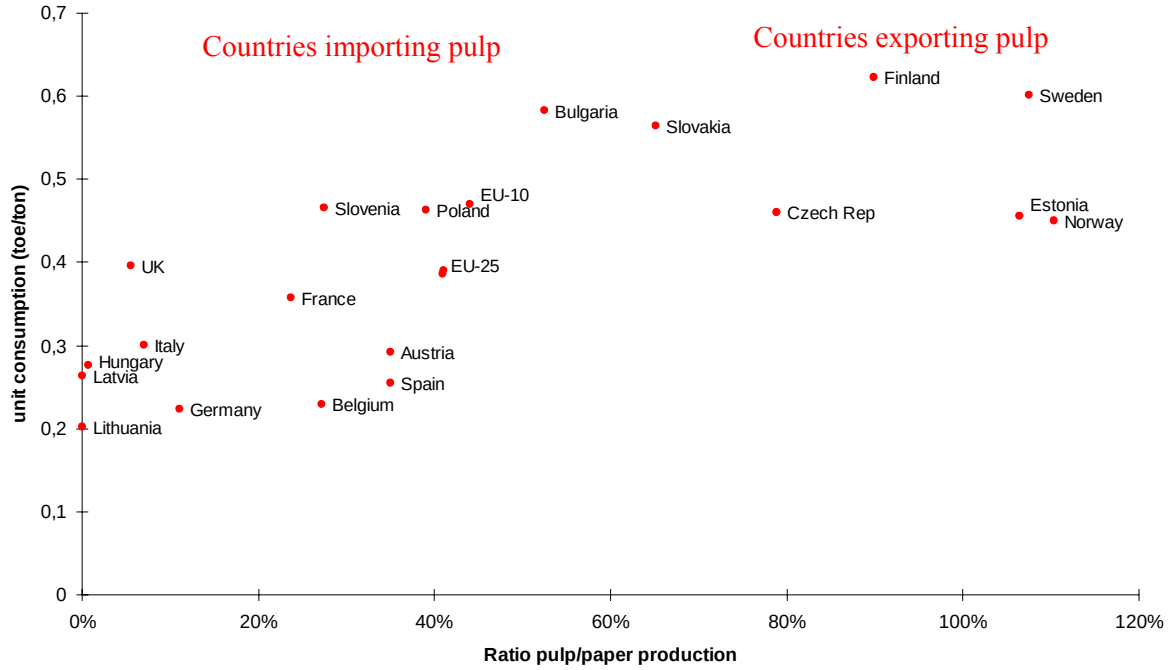


The energy performance of pulp and paper depends on the production of pulp

Unit energy consumption in the pulp and paper industry is very different among EU countries: it varies by a factor of 2 to 3 from a minimum between 0.2 toe per ton of paper to a maximum of 0.6 toe/ton in 2004 (**Figure 2-14**).

To explain such differences, it is necessary to take into account how the paper is produced. Paper is produced from raw pulp or from recycled paper. Pulp production is energy-intensive. The pulp used in a given country may be produced in the country or imported from other countries. If it is imported, this means that the energy consumption for the pulp production has taken place in the exporting countries (in particular Sweden, Finland, or Norway). Therefore, the energy performance of the paper industry of a given country is linked to the share of pulp produced in the country in relation to the paper production: the higher this ratio, the higher the unit consumption as shown in **Figure 2-15**. Energy efficiency performance can only be benchmarked among countries with a similar ratio of pulp/paper production. New EU members seem to have poorer energy performance than EU-15 countries.

Figure 2-15: Pulp and paper industry: energy efficiency potentials (2004)

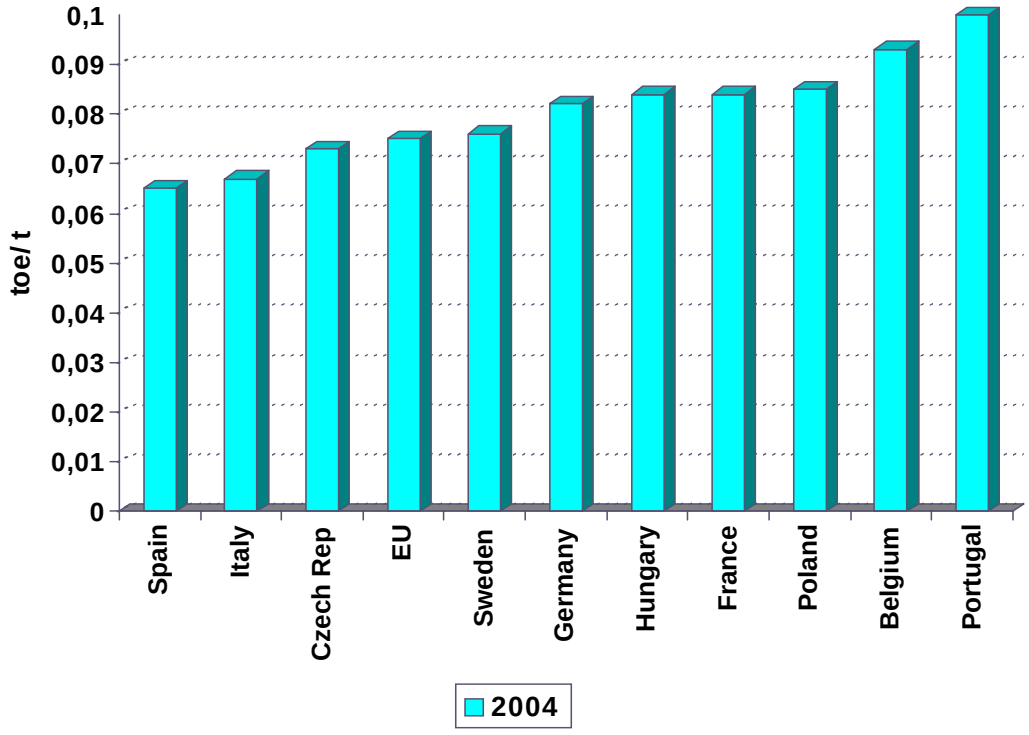


For cement, comparisons of energy efficiency are more relevant if made for clinker

Cement production is very energy-intensive. However, most of the energy consumption occurs during the fabrication of clinker in high temperature kilns, and not for producing cement itself which consists of grinding clinker with additives (e.g.

ashes). Therefore, differences between countries in the average energy consumption per ton of cement, as shown in **Figure 2-16**, not only reflect different levels of energy efficiency, but also differences in the composition of cement (% of additives) and the share of clinker produced in the country. In the same way, the fall in this unit consumption observed between 1990 and 2004 may well reflect increased imports of clinker and more additives in cement[40].

Figure 2-16: Unit energy consumption in the cement industry (EU-25)



In other words, benchmarking energy performance in the cement industry should be made based on clinker production as shown in **Figure 2-17**. For clinker, there may still be differences due to the process mix (wet versus dry process), although the wet process has been almost completely phased out.

2.5. CO_2 emissions

Large CO_2 savings in industry; 60 % from fuel substitutions

Direct emissions from the industrial combustion of fossil fuels (oil, natural gas and coal) made up 17 % of total CO_2 emissions from energy use in the EU-25 in 2004[41], down from 20 % in 1990. This is much smaller than the share of this sector in the final

[40] Because of differences in energy prices, there is a trend to increase imports of clinker.
[41] If indirect emissions are also included (i.e. emissions from the production of the electricity and heat used by industry), the contribution of industry almost doubles (31 %).

energy consumption (28 %), even more so since emissions from the combustion of fuels used for self-generation of electricity are included in this figure, whereas the consumption of these fuels is excluded from the final energy consumption of industry.

Figure 2-17: Benchmarking of unit energy consumption for clinker (EU-25)

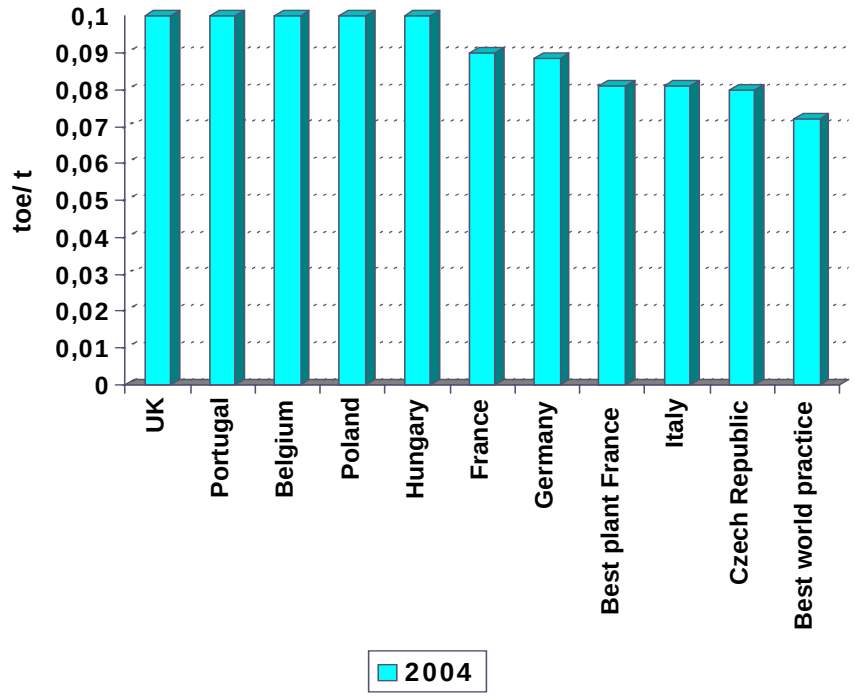
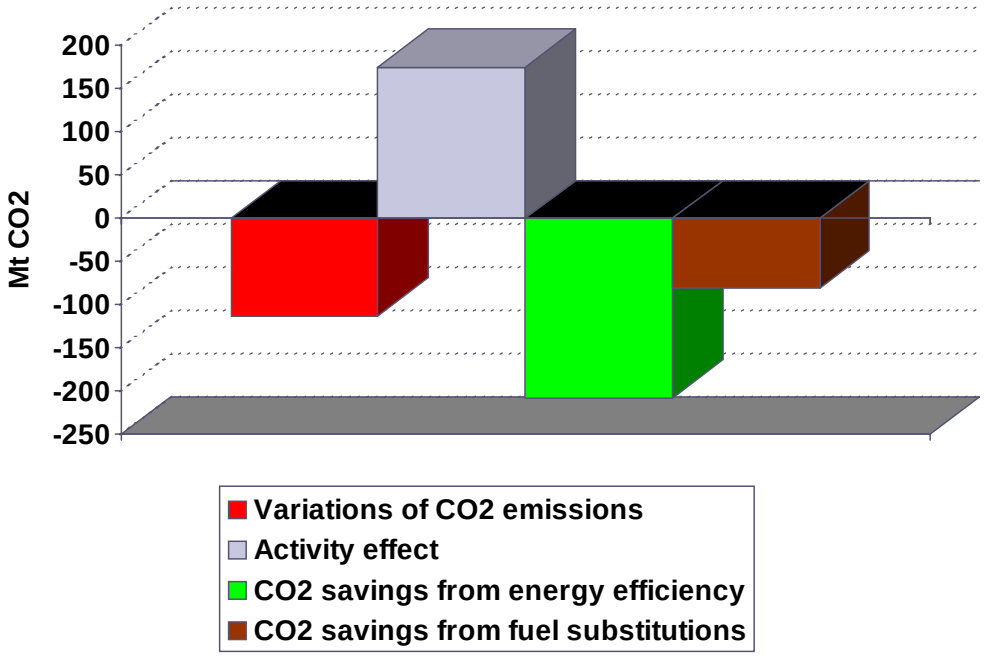


Figure 2-18: Variations in CO_2 emissions from industry in the EU-15



This remarkable position of industry in total CO_2 emissions is due to the fact that CO_2 emissions of industry were 15 % below their 1990 level in 2004: this corresponds to a reduction of 113 Mt CO_2[42]. This was achieved despite a 23 % increase in the industrial production. This reduction in the level of emissions was made possible by significant CO_2 savings from energy intensity reduction accounting for 72 % of total savings (208 Mt CO_2) and from fuel switching, accounting for 28 % (81 Mt CO_2) (**Figure 2-18**). As opposed to the EU-15, the contribution of fuel switching is much less significant (60% of CO_2 savings for EU-15). It is too early to see the impact of the Emission Trading Directive that came into effect in 2005.

2.6. Conclusions

- Energy efficiency in the manufacturing industry improved on average by 5 % per year in new EU countries since 1998. As a result, energy efficiency improvements were large in the EU-25 (20 % between 1990 and 2004), than in EU-15 countries (12%).

- The energy productivity of manufacturing industry increased by 8%/year on average over the period 1996-2004 for the EU-10 as a whole. This improvement was even greater in five countries (Lithuania, Hungary, Bulgaria, Poland and Estonia). In general, the energy productivity progress slowed down after 2000 (twice slower on average for EU-10).

- Structural changes in industry only made a minor contribution towards the reduction in the energy intensity of industry on average in EU-10 countries. In some countries, however, a shift towards less energy-intensive branches contributed greatly to decreasing the energy intensity of manufacturing (especially in Hungary, Cyprus, Latvia, Poland, Estonia and the Czech Republic).

- Comparing the energy intensity of manufacturing industry within the EU-25 is more relevant if intensities are measured at purchasing power parities and adjusted to the EU-25 average value added structure; the range between the 2 extremes is reduced from a factor of 5.5 to a factor of 2.

- CO_2 emissions of EU-25 were 15 % below their 1990 level in 2004 despite a 23 % growth in industrial production over the period because of large CO_2 savings. Energy intensity reduction accounted for most of the total savings (72 %).

[42] Source EEA, 2006