# Energy efficiency in Europe: trends, convergence and policy effectiveness

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**Abstract**

This paper analyses energy efficiency in the EU, both in terms of reductions in energy intensity and in terms of physical indicators, looking at the differences among sectors and among Member States. We test econometrically the existence of convergence in energy intensity across Europe. We find a sensible catching–up of less performing countries, particularly in the agricultural and in the industrial sectors. Against this background, we analyse the role played by energy policies in EU Member States and we identify the most effective classes of policies and measures by means of a panel analysis of the EU-15 and Norway. It turns out that, in the residential sector, energy efficiency is particularly affected by heating regulations, by subsidies as well as tax reductions; in the transport sector, effective policies are tax reductions, incentives to eliminate old and polluting cars, car sharing, commuter plan and traffic management; in the industrial sector, mandatory technology standards, financing at low interest rate, information activities, education and outreach proved to be effective.

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**Keywords: energy intensity, energy efficiency, convergence, European energy policy**

# 1 Introduction: energy use in Europe

Representing 27 countries and roughly 500 million consumers the European Union (EU) is the world's second largest energy market and thus the decisions taken by European policy makers could heavily influence the way to tackle hot topics such as global warming, energy security and competitiveness. Indeed, as highlighted in the Green Paper Energy (European Commission, 2006), these three topics are high on the European Commission agenda, which has identified them as guiding principles of a prospective European Energy Policy. The achievement of such an ambitious goal requires however an immediate effort for finding the optimal balance between competitiveness and sustainability.
The EU Energy market is currently facing many relevant issues. A non-exhaustive list encompasses for instance the following items:

- The need for more investments: in order to meet the expected demand for energy and to renew infrastructures, investments of approximately one trillion euros will be needed over the next 20 years.
- Improve energy security to face threats such as the rise of oil and gas prices, EU's increased import dependency and the concentration of reserves. EU's import dependency[1] is currently around 50 percent and forecast to rise; moreover, while today half of EU's gas consumption comes from only three countries (Russia, Norway, Algeria), over the next 25 years gas imports are expected to increase to 80 percent.
- World energy demand, and consequently $CO_2$ emissions are forecasted to rise by some 60 percent by 2030. Global oil consumption has increased by 20 percent since 1994, and global oil demand is projected to grow by 1.6 percent per year. As a consequence, the question of environmental protection is high on the EU's agenda.
- Europe still lacks a fully competitive internal energy market, as well as a common energy policy that would help EU citizens and businesses reaping all the benefits of energy security and of lower prices.

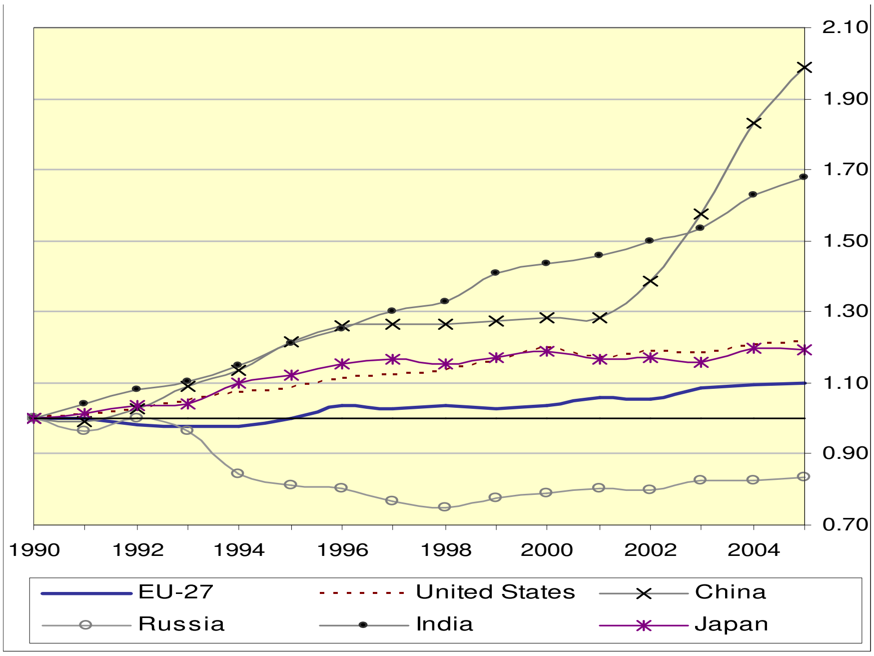
This paper is divided in three parts. First, it briefly analyses a set of indicators capable of summarizing how the EU is performing in the path towards a common energy policy. More precisely, the report highlights the European situation in terms of energy efficiency. Secondly it investigates whether EU countries' energy situation has converged in terms of energy intensity. The third section looks at energy policy issues, analysing in detail the main European policies and the Directives concerned with renewable energy sources and efficiency. In particular we try and identify, by means of an econometric panel analysis, which kind of policies and measures have contributed most to improving energy efficiency and to reducing energy intensity in the EU 15 and Norway during the period between 1980 and 2004.

To frame our discussion in its appropriate context, let us look briefly to the general situation of energy consumption in Europe.
Indexing the level of energy consumption in 1990, the European consumption decreased right after, and from 1996 it smoothly increased at a rate which is sensibly lower than the one shown by the other world economies (Figure 1). In fact the level of consumption increased by ten per cent in 15 years. Europe contributes to 16 percent of total world energy consumption, which is as much as China, and less than the amount consumed by the USA (Figure 2).
Disaggregating demand by energy fuels, European consumption is mainly composed by oil, gas and electricity (Figure 3), and their shares are equal respectively to 42, 25 and 20 percent. Solid fuels, in spite of being historically an important source of energy, at the present only marginally contribute to the total energy mix. Renewable energy sources and industrial waste own a limited share of total consumption and their contribution remained invariant during the last 15 years.
Looking at energy demand from a different angle, it is worth noticing that the service and household sectors taken together (this aggregate is labelled "other sectors" in) contribute to the largest share of total final energy consumption, then followed by industry and finally by transport. Over the 15 year period, the demand in the industry sector has slightly decreased, while an opposite trend characterizes the transport sector (Figure 4).
Moving to the production side, in particular electricity generation, solid fuels remain a significant energy source, contributing to 28 percent of total generation, although their use has diminished a little over time. The largest source is represented by nuclear, making more than 30 percent of total production. A

[1] Import dependency is calculated using the following formula: net imports / (gross inland consumption + bunkers). Source: EU-25 Energy Fiches (TREN C1).

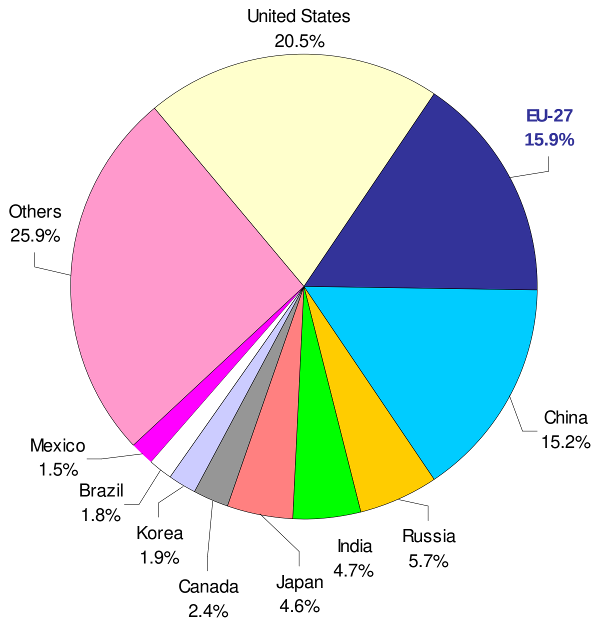
sustained upward thrust is displayed by gas, which at present guarantees 21 percent of total production. Renewables own a relevant share, which amounts to 14 percent.

**Figure 1 comparison of EU and the rest of the World. Gross-inland energy consumption**



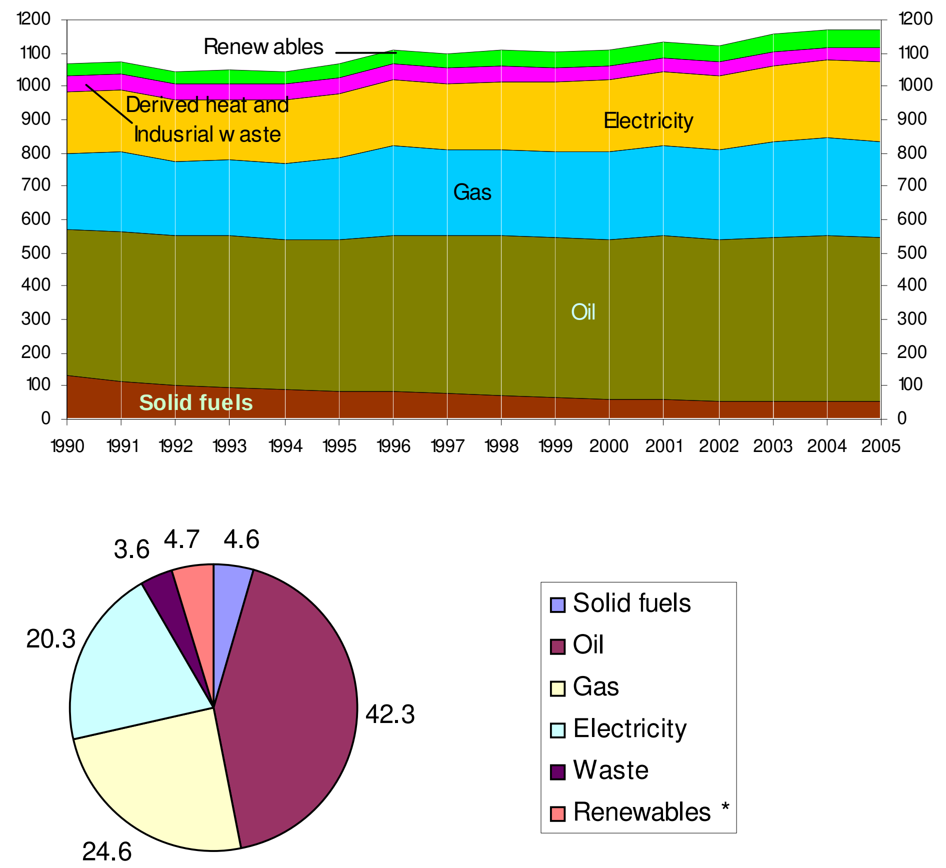

Notes: 1990=1. Source: Eurostat data.

**Figure 2 comparison of EU and the rest of the World. Gross-inland energy consumption. Year 2005**



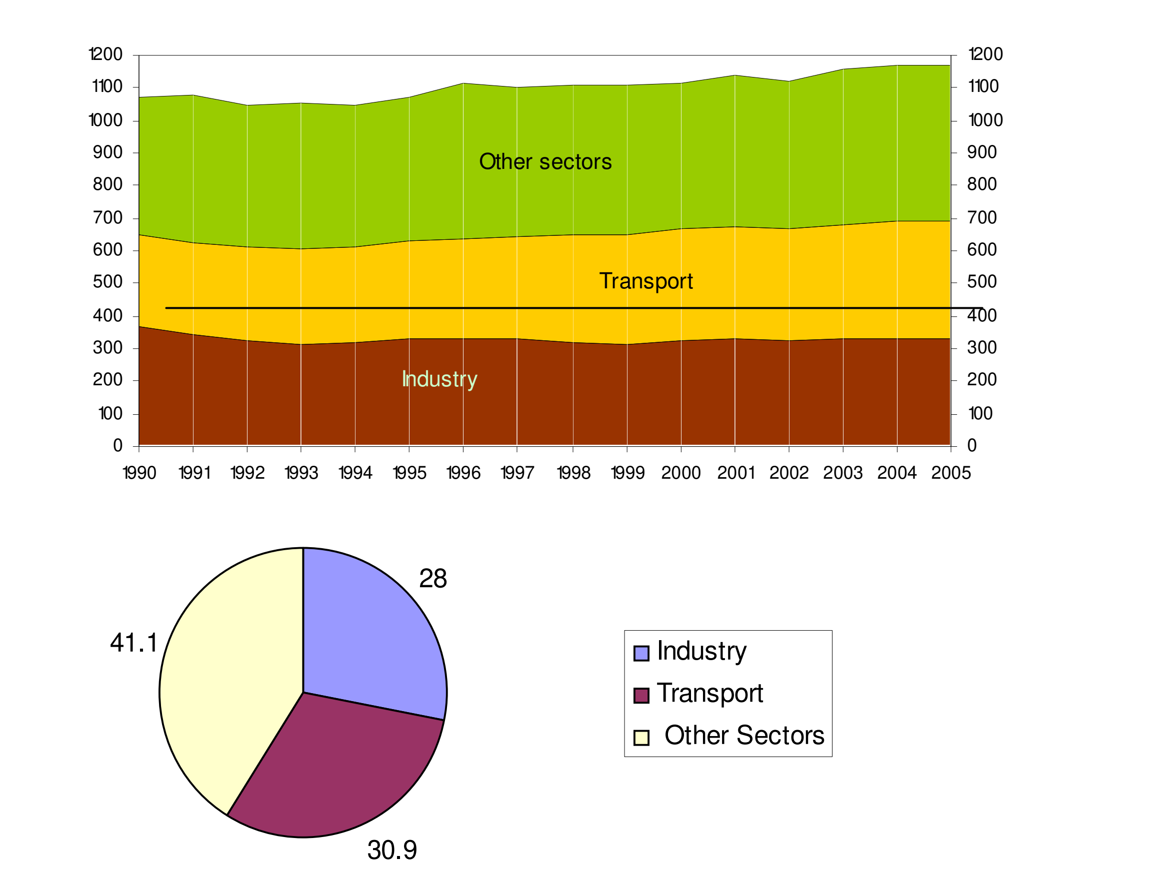

Notes: 1990=1. China, including Hong Kong. Source: Eurostat

**Figure 3 Final Energy Consumption, by fuel: EU-27. Mtoe and shares (2005)**



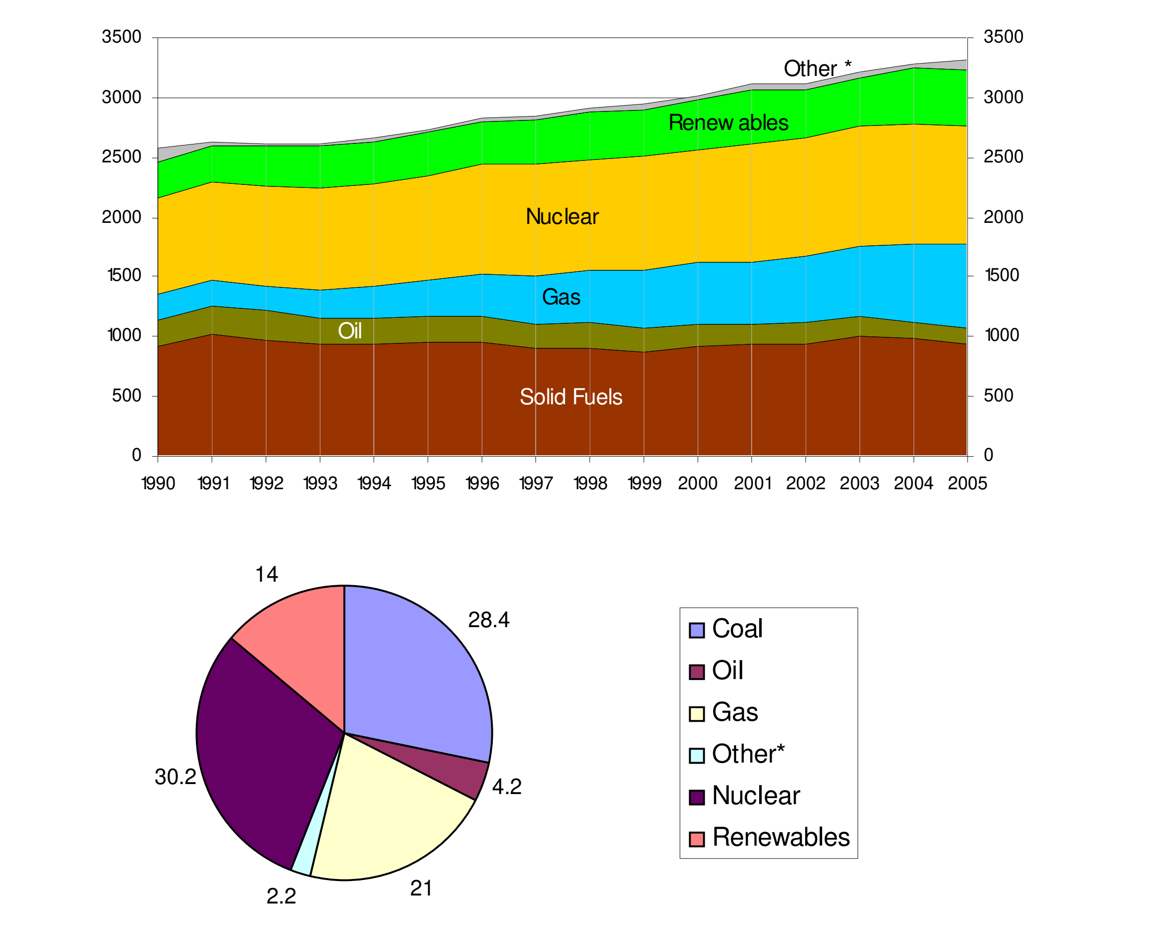

Note: * Renewable energy sources not including Electricity. Source: Eurostat

**Figure 4 Final Energy Consumption, by sector. EU-27. and shares (2005)**




Source: Eurostat

**Figure 5 Gross Electricity Generation. EU-27. TWh and shares (2005)**




Notes: * Pumped Storage Plants and Other Power Stations. Source: Eurostat

# 2. Energy indicators

## 2.1. ENERGY INTENSITY

This Section aims to provide a preliminary international comparison of energy intensity and energy efficiency indicators. Table 1 reports data on energy intensity[2] for 16 European countries. Because of data availability, we have decided to focus on the EU 15 countries and on Norway, i.e. the countries where those data are available since 1980. The countries that have recently joined the European Union have not been included in the analysis. In fact, for these countries time series are available only since 1990. In addition, because of their geographical and economic proximity, data for the EU15 nations are more easily comparable. As Table 3 shows, in 2003 the countries with the highest energy intensity were Denmark, United Kingdom and Ireland. Energy policy decisions taken by the respective authorities as well as their structure for the productive sector is concerned have allowed these countries to reach good results in terms of energy intensity achievements.
Noticeable evidence that results from Table 1 is that, between 1992 and 2003, energy efficiency has increased significantly in countries like United Kingdom, Ireland, Norway and France. As for Italy, although, in absolute terms, energy intensity in this country has slightly increased, in 2003 the country is ranked only sixth.
Finally, Table 1 illustrates also a general trend regarding the Energy Intensity of European countries. The average value for the EU15 countries plus Norway decreases progressively, (approximately by 18 percent). In addition, even the median decreases significantly. The difference between the minimum value and the maximum values decreases as well (0.097 and 0.118, respectively in 2003 and 1981). This information provides additional evidence on how energy efficiency has improved (and converged) among the considered countries.
Figure 6 reports that, between 1992 to 2003, energy efficiency has increased significantly in countries like United Kingdom, Ireland, Norway and France. As for Italy, although, in absolute terms, energy intensity in this country has slightly increased, in 2003 the country is ranked only sixth.
Finally, Table 1 illustrates also a general trend regarding the Energy Intensity of European countries. The average value for the EU15 countries plus Norway decreases progressively, (approximately by 18 percent). In addition, even the median decreases significantly. In addition, the difference between the minimum value and the maximum values decreases as well (0.097 and 0.118, respectively in 2003 and 1981). This information provides additional evidence on how energy efficiency has improved (and converged) among the considered countries.
Figure 6 reports the energy intensity for selected European economies, namely France, Germany, Italy, Spain and United Kingdom. In Spain changes in relative prices of energy inputs have not been followed by rapid improvements of energy efficiency as far as productive processes are concerned. As the IEA points out, primary energy requirements grew more than the GDP. However, although during the 1981-1987 period, in this country energy intensity decreased from 0.137 to 0.126 ktoe/00$ppp[3] (by 7.88 percent), between 1975 and 2005, the index increased by 9.77 percent; over the whole period, the index increased by 28.1 percent.
On the contrary, for the other four countries, energy intensity declined over the whole period considered. In France energy intensity fell by 18.11 percent from 1975 to 2005. In United Kingdom the decrease in energy intensity can be explained by looking at the processes of fuel switching and at the relative decline of energy intensive industries.[4] Consequently, by 2005 the energy intensity index in UK was 57.11 percent of its 1975 value. As for Germany, because of improvements in energy production processes, energy intensity in this country has decreased by, approximately, 24.24 percent between 1990 and 2005.

In Italy, between 1976 and 1986 the ratio has steadily decreased (from 0.161 to 0.122 ktoe/00$ppp). However, since 1986 it remained stable at approximately 0.120 ktoe/00$ppp. Finally, since 2003 there has been a significant increase (by 1.80 percent per annum).

[2] Estimated as energy use per unit of output.
[3] Thousands of oil equivalent tons per unit of real GDP at PPP measured in US dollar, converted using Purchasing Power Parity rates in 2000.
[4] Source: UK National Statistics.

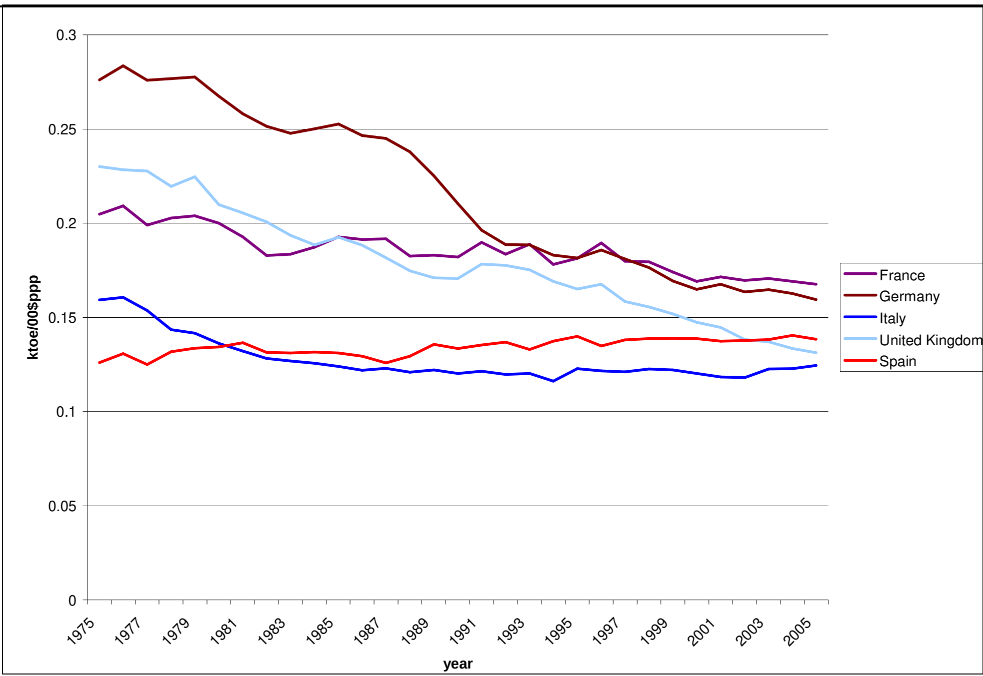
**Table 1: Energy Intensity in the EU-15 Countries and Norway. Selected Years (ktoe/00$ppp)**

ENERGY INTENSITY - Total - ( arrows show movements between quartiles over time )

| | 3-year Average Centered on 1981 | | 3-year Average Centered on 1992 | | 3-year Average Centered on 2003 | |
|---|---|---|---|---|---|---|
| 1 st Quartile | PT | 0.103 | IT | 0.121 | IE | 0.118 |
| | EL | 0.115 | PT | 0.128 | IT | 0.121 |
| | IT | 0.132 | SP | 0.135 | DK | 0.129 |
| | SP | 0.134 | AT | 0.139 | UK | 0.136 |
| 2 nd Quartile | AT | 0.156 | EL | 0.148 | AT | 0.137 |
| | DK | 0.184 | DK | 0.160 | PT | 0.138 |
| | FR | 0.192 | UK | 0.177 | SP | 0.139 |
| | UK | 0.205 | IE | 0.180 | EL | 0.140 |
| 3 rd Quartile | IE | 0.213 | FR | 0.187 | DE | 0.164 |
| | NO | 0.217 | DE | 0.191 | NO | 0.165 |
| | NL | 0.222 | NL | 0.199 | FR | 0.170 |
| | BE | 0.239 | NO | 0.201 | NL | 0.174 |
| 4 th Quartile | DE | 0.259 | BE | 0.222 | LU | 0.190 |
| | SE | 0.266 | SE | 0.254 | BE | 0.200 |
| | FI | 0.290 | LU | 0.271 | SE | 0.212 |
| | LU | 0.418 | FI | 0.284 | FI | 0.259 |
| | Average = | 0.209 | | 0.187 | | 0.162 |
| | Median = | 0.209 | | 0.184 | | 0.152 |
| | St. Dev = | 0.079 | | 0.050 | | 0.038 |
| | Minimum = | 0.103 | | 0.121 | | 0.118 |
| | Maximum = | 0.418 | | 0.284 | | 0.259 |

Notes: Countries are ordered according to their energy intensity. Arrows show significant movement between quartiles. Source: Authors' computations on IEA and WDI data.

**Figure 6: Energy Intensity 1975-2005, Selected European Countries - ktoe/00$ppp**




Source: Authors' computations on IEA and WDI data.

## 2.2 ENERGY INTENSITY BY ECONOMIC SUB-SECTORS.

### 2.2.1 Agriculture

Table 2 shows energy intensities for the agricultural sector, computed at three different points: 1981, 1992 and 2003 (three-year average). Across the countries considered, the average energy intensity of agriculture increased from 0.078 to 0.153 ktoe/00$ppp from 1981 and 2003. However, approximately 60 percent of the total increase occurred during the first part of the sample. According to Table 2, even the dispersion of countries (proxied by the standard deviation of the different values and the range between the minimum and the maximum values) increased. As far as the results of the single countries are concerned, while there were important achievements in term of energy intensity in the U.K. and France,[5] energy intensity increased significantly in the Netherlands, Norway and Ireland.

**Table 2: Energy Intensity in the EU-15 Countries and Norway. Agriculture Sector, Selected Years (ktoe/00$ppp)**

ENERGY INTENSITY - Agriculture - ( arrows show movements between quartiles over time )

| | 3-year Average Centered on 1981 | | 3-year Average Centered on 1992 | | 3-year Average Centered on 2003 | |
|---|---|---|---|---|---|---|
| 1 st Quartile | IE | 0.005 | PT | 0.045 | UK | 0.056 |
| | PT | 0.018 | IE | 0.055 | SP | 0.081 |
| | IT | 0.040 | SP | 0.056 | PT | 0.081 |
| | EL | 0.040 | UK | 0.059 | FR | 0.085 |
| 2 nd Quartile | NL | 0.045 | EL | 0.069 | EL | 0.086 |
| | FR | 0.067 | IT | 0.072 | IT | 0.091 |
| | UK | 0.068 | LU | 0.081 | IE | 0.098 |
| | SP | 0.069 | FR | 0.087 | LU | 0.104 |
| 3 rd Quartile | NO | 0.077 | AT | 0.101 | DE | 0.113 |
| | FI | 0.087 | DE | 0.139 | AT | 0.127 |
| | SE | 0.094 | FI | 0.159 | FI | 0.161 |
| | LU | 0.099 | BE | 0.160 | SE | 0.180 |
| 4 th Quartile | DE | 0.100 | SE | 0.167 | BE | 0.221 |
| | BE | 0.103 | NO | 0.178 | DK | 0.284 |
| | AT | 0.117 | DK | 0.245 | NO | 0.298 |
| | DK | 0.223 | NL | 0.302 | NL | 0.376 |
| | Average = | 0.078 | | 0.123 | | 0.153 |
| | Median = | 0.073 | | 0.094 | | 0.109 |
| | St. Dev = | 0.050 | | 0.074 | | 0.094 |
| | Minimum = | 0.005 | | 0.045 | | 0.056 |
| | Maximum = | 0.223 | | 0.302 | | 0.376 |

[5] For this country, this occurred mainly in the second part of the time period considered.

### 2.2.2 Industry

Table 3 shows the energy intensity for the industry sector for the sixteen countries considered.

**Table 3: Energy intensity in the EU-15 Countries and Norway. Industry Sector, Selected Years (ktoe/00$ppp)**

**ENERGY INTENSITY - Industry - ( arrows show movements between quartiles over time )**

| | 3-year Average Centered on 1981 | | 3-year Average Centered on 1992 | | 3-year Average Centered on 2003 | |
|---|---|---|---|---|---|---|
| 1 st Quartile | EL | 0.102 | DK | 0.104 | IE | 0.055 |
| | UK | 0.113 | UK | 0.108 | DK | 0.081 |
| | IT | 0.116 | IT | 0.111 | UK | 0.100 |
| | DK | 0.121 | SP | 0.114 | EL | 0.111 |
| 2 nd Quartile | AT | 0.122 | EL | 0.119 | IT | 0.119 |
| | SP | 0.123 | IE | 0.119 | AT | 0.122 |
| | PT | 0.128 | AT | 0.119 | SP | 0.131 |
| | FR | 0.159 | DE | 0.126 | DE | 0.132 |
| 3 rd Quartile | IE | 0.169 | FR | 0.146 | NO | 0.140 |
| | DE | 0.179 | PT | 0.166 | FR | 0.146 |
| | BE | 0.208 | NO | 0.189 | PT | 0.169 |
| | NL | 0.225 | BE | 0.210 | SE | 0.217 |
| 4 th Quartile | NO | 0.228 | NL | 0.221 | NL | 0.218 |
| | FI | 0.230 | SE | 0.264 | BE | 0.232 |
| | SE | 0.263 | FI | 0.343 | LU | 0.233 |
| | LU | 0.618 | LU | 0.385 | FI | 0.298 |
| | Average = | 0.194 | | 0.178 | | 0.157 |
| | Median = | 0.164 | | 0.136 | | 0.136 |
| | St. Dev = | 0.124 | | 0.087 | | 0.066 |
| | Minimum = | 0.102 | | 0.104 | | 0.055 |
| | Maximum = | 0.618 | | 0.385 | | 0.298 |

In contrast with the agricultural sector, energy intensity decreased on average across the countries considered. Between 1981 and 2003, the index decreased from 0.194 to 0.157 ktoe/00$ppp (or by 20.3 percent). Similarly to the previous case, the largest part of the decline occurred during the first part of the sample as the median clearly shows.
In addition, there seems to be convergence across the European countries considered: the difference between the minimum and the maximum values of the energy intensity index decreased over the period considered (from 0.516 to 0.281 and from 0.281 to 0.243 ktoe/00$ppp between 1981 and 1992 and between 1992 and 2003, respectively).
Additional evidence from Table 3 is the important results obtained in terms of energy intensity of the industrial sector by countries like Denmark, United Kingdom, Ireland and Norway. Conversely, energy intensity slightly increased in Spain and Italy with the highest increase occurring between 1992 and 2003.

### 2.2.3 Service sector.

Energy intensity for the tertiary sectors of the EU15 and Norway is reported in Table 4. Similarly to the industrial sector case, on average, the energy intensity declined significantly over the period considered. Between 1981 and 2003, the index decreased by 19.1 percent (from 0.194 to 0.157 ktoe/00$ppp).
Over the period considered, significant improvements were achieved by the U.K. and Germany (in both cases the index decreased by, approximately, 45 percent).
In addition, energy intensity is particularly low in the Southern countries (Portugal, Spain, Greece and Italy) reflecting particularly favourable climate conditions that allows these countries to reduce the need of energy for heating. On the contrary, Scandinavian countries (Finland, Sweden and Norway) reported high values for the index.
Finally, Table 4 also shows a partial process of convergence of energy intensities across the European countries considered in the present study. In fact, since 1975, the dispersion of values for the energy intensity indicators as well the difference between the minimum and the maximum values of the energy intensity index significantly decreased. While, between 1981 and 2003, the former declined by, approximately, 68.11 percent, the range for the energy intensity indicators decreased from 0.265 to 0.118 and from 0.118 to 0.073 ktoe/00$ppp, respectively, between 1981 and 1992 and between 1992 and 2003.

**Table 4: Energy Intensity in the EU-15 Countries and Norway. Tertiary Sector, Selected Years (ktoe/00$ppp)**

**ENERGY INTENSITY - Tertiary - ( arrows show movements between quartiles over time )**

| | 3-year Average Centered on 1981 | | 3-year Average Centered on 1992 | | 3-year Average Centered on 2003 | |
|---|---|---|---|---|---|---|
| 1 st Quartile | PT | 0.092 | PT | 0.091 | IT | 0.102 |
| | SP | 0.094 | SP | 0.099 | SP | 0.104 |
| | EL | 0.101 | IT | 0.105 | PT | 0.108 |
| | IT | 0.111 | EL | 0.122 | UK | 0.108 |
| 2 nd Quartile | AT | 0.164 | AT | 0.133 | EL | 0.116 |
| | BE | 0.177 | FR | 0.145 | FR | 0.123 |
| | DK | 0.179 | DK | 0.153 | DK | 0.125 |
| | FR | 0.189 | UK | 0.154 | AT | 0.132 |
| 3 rd Quartile | UK | 0.196 | BE | 0.155 | NL | 0.134 |
| | NL | 0.198 | NL | 0.167 | DE | 0.136 |
| | NO | 0.212 | DE | 0.168 | BE | 0.136 |
| | LU | 0.218 | NO | 0.174 | IE | 0.143 |
| 4 th Quartile | IE | 0.226 | SE | 0.188 | SE | 0.149 |
| | DE | 0.247 | LU | 0.189 | NO | 0.149 |
| | SE | 0.257 | IE | 0.205 | FI | 0.171 |
| | FI | 0.357 | FI | 0.209 | LU | 0.175 |
| | Average = | 0.189 | | 0.153 | | 0.132 |
| | Median = | 0.192 | | 0.154 | | 0.133 |
| | St. Dev = | 0.069 | | 0.036 | | 0.022 |
| | Minimum = | 0.092 | | 0.091 | | 0.102 |
| | Maximum = | 0.357 | | 0.209 | | 0.175 |

## 2.3. ENERGY EFFICIENCY

In contrast with energy intensity, (energy use per unit of output or GDP), energy efficiency is based on physical/technological measures of unit consumption. Hence, the influences of economic structural changes, as well as the impact of other factors which are not directly associated to a strict definition of energy efficiency are not considered in the construction of the indicators. Table 5 to Table 8 provide a ranking of the performances of the 16 countries considered, in terms of total energy efficiency. In this section energy efficiency indexes are computed for different economic macro-sectors. The time-span covered by the available data does not allow us to verify how energy efficiency has improved in the decades before 1980.

Table 5 to Table 8 show the percentage change in the energy efficiency index in the EU-15 and Norway between 1980-2004 by considering separately the sub-periods 1980-1992 and 1993-2004. That is, they show whether in the economic system, in general, and in the three macro-sectors, in particular, significant changes have occurred. We can notice that the ranking of these countries does not illustrate necessarily the more or less “virtuous” countries in terms of energy efficiency. On the contrary, only the countries that had the more significant changes are reported. That is, these tables show only the countries that have been able to benefit from their potential of energy efficiency improvement.

Table 5 shows that several countries have achieved significant improvements in terms of energy efficiency. In particular, in countries like Greece, Ireland and Portugal good performances are due to a strong process of modernization of their energy system. On the contrary, in countries with a more mature economy like Denmark, Sweden and Norway, improvements can be explained only if one allows for policies explicitly aimed at increasing energy savings. For instance, in Portugal, factors like the introduction of natural gas in the residential sector and a substantial renewal of the car park are responsible for the achievement of these results. In Ireland, similar changes in the domestic energy uses have occurred together with the introduction of more stringent energy standards for new buildings. In addition, energy efficiency gains can be explained also by analyzing the structural changes occurred in those economies where energy intensive industrial production have been gradually abandoned in favour of sectors with a higher value added (information technology and financial services). As a result, in the two sub-samples 1980-1992 and 1992-2004, energy efficiency in Ireland has increased by 16.0 and 14.4 percent respectively. Figure 7 illustrates the change in the total energy efficiency during the period 1980-2004 in a subset of European countries (namely, France, Germany, Italy, Spain and United Kingdom). Notice that the increasing divergence among countries is largely due to the methodology used in order to calculate the index, i.e., all countries are assumed to have a value equal to 100 in the basis year (1980). However, this does not imply that all countries had the same efficiency level in that year. In the figure we report only how the total energy efficiency has changed during the following years. Therefore, it is not possible to check whether a country has become more or less efficient with respect to the other countries. The only information that can be drawn from Figure 7 is how efficiency has increased relative to 1980 for a given country. While in Spain energy efficiency remained constant; the other countries have had only modest improvements with respect to 1990.[6]

In Italy, total energy efficiency has increased significantly during the period considered. However, the process of energy efficiency improvement has recently slowed down; in fact, the percentage change of energy efficiency in the period 1992-2004 is, approximately, 25 percent of the gain achieved during the sample 1980-1992.

Let us now focus on the economic macro-sectors (industry, household and transport). As Table 6 illustrates, changes in the energy efficiency of the industrial sector for all countries considered are not very significant. In fact, as the present structure consolidated in the 1980s, possibilities of further changes have significantly decreased during the period 1992-2004. Significant exceptions to this evidence are represented by Ireland and, to a lower extent, Germany. In Ireland, high energy-intensive productions have progressively been abandoned implying a radical change in its productive structure. Similarly, in Germany, the increase in energy intensity can be explained by looking at the advantages due to a gradual process of modernization of industries in the eastern regions.

Lower improvements that have accrued in terms of energy efficiency have been achieved by Finland, the United Kingdom (in particular, for the sample 1980-1992) and Italy. For Italy, in particular, the gains in energy efficiency of the industrial sector are in line with the general trend of the period. In fact, improvements for this country are near the median change in the efficiency registered by the other European countries.

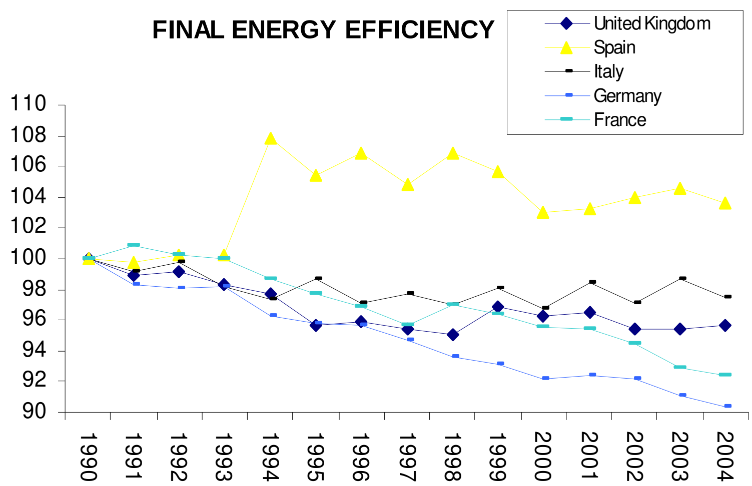
[6] In Ireland, Portugal, Denmark, Norway, Sweden and Austria (not shown), energy efficiency has increased significantly (more than 20 percentage points).

**Table 5: Percentage Change of Total Energy Efficiency in the EU-15 and Norway, 1980-2004**

| TOTAL ( % change in EE Index over period ) | | | | | |
|---|---|---|---|---|---|
| 1980 - 2004 | | 1980 - 1992 | | 1992 - 2004 | |
| EL | -30.8% | -16.8% | DK | PT | -17.9% |
| IE | -28.1% | -16.0% | IE | EL | -17.8% |
| DK | -23.7% | -15.8% | EL | IE | -14.4% |
| PT | -21.7% | -13.0% | SE | BE | -14.3% |
| SE | -21.2% | -11.2% | AT | AT | -10.0% |
| AT | -20.1% | -8.1% | DE | SE | -9.4% |
| DE | -14.9% | -5.6% | FI | NO | -9.4% |
| NO | -12.7% Median | -5.2% | FR | DK | -8.3% |
| FR | -12.4% | -5.2% | IT | FR | -7.6% |
| FI | -11.8% | -4.7% | PT | DE | -7.4% |
| IT | -6.6% | -4.1% | ES | FI | -6.6% |
| NL | -5.5% | -3.7% | NO | UK | -2.8% |
| UK | -4.9% | -2.8% | NL | NL | -2.7% |
| BE | -2.4% | -2.1% | UK | IT | -1.5% |
| ES | 0.0% | -1.0% | LU | ES | 4.3% |
| LU | 52.4% | 13.9% | BE | LU | 54.0% |
| Average = | -10.3% | -6.3% | | | -4.5% |
| Median = | -12.6% | -5.2% | | | -7.9% |
| St. Dev = | 0.191 | 0.075 | | | 0.167 |
| Minimum = | -30.8% | -16.8% | | | -17.9% |
| Maximum = | 52.4% | 13.9% | | | 54.0% |

Notes: Countries are ordered according to their energy intensity. Arrows show significant movements between quartiles over time. Source: Authors' calculations on Odyssee (ENERDATA) data.

**Figure 7: Total Energy Efficiency in Selected EU Countries, 1990-2004**




Source: Authors' calculations on Odyssee (ENERDATA) data.

Table 7 reports the percentage change of energy efficiency for the household sector in a large sample of European countries. Since data are not available for all EU15 countries, we are not able to depict an overall description of the improvements in energy efficiency for the household sector. However, statistical evidence suggests that the most significant improvements in the energy efficiency of the household

sector have been achieved by countries like Portugal and Norway. As it can be seen from this table, in Portugal, the increases in energy efficiency in the two sub-samples have been 12.9 and 42.4 percentage points, respectively. In Norway, improvements have been more impressive. Although in Norway, during the 1980-1992 period, energy efficiency has decreased by 15.8 percent, this country was able to raise energy efficiency standards. Consequently, during the 1992-2004 period, energy efficiency has increased by, approximately, 11.7 percent.
This reversal in the general trend has been argued to be due to the policies introduced by these countries in order to boost energy savings and energy conservation. The lesson that can be drawn from the experience of these countries, is that the implementation of these policies is feasible, not only in countries with high indexes of economic and social development like Norway, but also in countries that have to do efforts in order to reduce the gap they have with respect to the rest of Europe (such as Portugal).
Table 7 illustrates how great is the potential for improvement for the energy efficiency of the household sector for the less performing countries such as Italy. Despite the fact that the increase in the energy efficiency for this sector has been six times as high as of the industrial sector, the improvement in energy efficiency achieved by this sector has been equal only to 25 percent of the median change, and, approximately, a tenth of the improvement that more efficient countries (namely, Portugal and Denmark) have registered over the same period.
By contrast, performances in the energy transport sector have worsened in Spain. Improvements have been very significant in the first sub-periods with an increase in energy efficiency equal to 35.4 percent whereas in the second sub-period efficiency has decreased by 6.7 percent.
In Italy, the performance of the transport sector has been remarkable. From 1980 to 2004, energy efficiency has increased approximately by 13.4 percentage points (about the median change, twenty times higher than the increase in the efficiency of the industrial sector). However, even in this case, further improvements would be possible if appropriate policy measures and technological changes concerning the transport sector as a whole are implemented.

**Table 6: Percentage Change of Energy Efficiency in the EU-15 Countries and Norway, 1980-2004. Industrial Sector**

INDUSTRY ( % change in EE Index over period )

| 1980 - 2004 | | | 1980 - 1992 | | 1992 - 2004 | |
|---|---|---|---|---|---|---|
| IE | -19.7% | | -13.7% | IE | IE | -6.9% |
| DE | -5.8% | | -4.3% | DE | UK | -1.6% |
| FI | -4.4% | | -3.3% | FI | DE | -1.5% |
| UK | -3.7% | | -2.4% | NL | FI | -1.2% |
| NL | -3.2% | | -2.1% | UK | NL | -0.8% |
| LU | -1.3% | | -1.2% | ES | LU | -0.5% |
| NO | -1.1% | | -1.0% | NO | EL | -0.3% |
| ES | -0.8% | Median | -0.9% | LU | SE | -0.2% |
| IT | -0.6% | | -0.5% | IT | BE | -0.2% |
| AT | -0.5% | | -0.4% | AT | FR | -0.2% |
| EL | -0.2% | | -0.1% | DK | AT | -0.2% |
| BE | -0.2% | | 0.0% | BE | NO | -0.1% |
| DK | -0.2% | | 0.1% | EL | DK | -0.1% |
| SE | 0.0% | | 0.2% | SE | IT | 0.0% |
| PT | 0.5% | | 0.4% | PT | PT | 0.1% |
| FR | 1.9% | | 2.0% | FR | ES | 0.4% |
| Average = | -2.5% | | -1.7% | | | -0.8% |
| Median = | -0.7% | | -0.7% | | | -0.2% |
| St. Dev = | 0.050 | | 0.036 | | | 0.017 |
| Minimum = | -19.7% | | -13.7% | | | -6.9% |
| Maximum = | 1.9% | | 2.0% | | | 0.4% |

Notes: Countries are ordered according to their energy intensity. Arrows show significant movements between quartiles over time. Source: Authors' calculations on Odyssee (ENERDATA) data.

Table 8 shows the percentage change of energy efficiency for the transport sector. Over the whole sample (1980-2004), the countries that reported the best performances have been Ireland and Greece. Across sub-samples the most significant improvements have been achieved by the Belgian transport sector. While during the period 1980-1992, in this country, energy efficiency has decreased by 75.4 percent, in the period 1992-2004, energy efficiency has increased by 49.4 percent. Over the whole sample, the improvements in energy efficiency have been equal to 11.2 percent. On a smaller scale, France, Sweden and Norway have reported similar changes.

**Table 7: Percentage Change of Energy Efficiency in the EU-15 Countries and Norway, 1980-2004. Household**

HOUSEHOLD ( % change in EE Index over period )

| 1980 - 2004 | | | 1980 - 1992 | | 1992 - 2004 | |
|---|---|---|---|---|---|---|
| PT | -49.8% | | -31.7% | DK | PT | -42.4% |
| DK | -43.4% | | -18.0% | SE | DK | -17.2% |
| SE | -28.5% | | -12.9% | PT | AT | -16.3% |
| AT | -24.9% | | -10.3% | AT | SE | -12.8% |
| FR | -17.1% | | -10.0% | FR | NO | -11.7% |
| FI | -16.1% | Median | -7.9% | FI | FI | -8.9% |
| DE | -10.5% | | -6.9% | UK | DE | -8.5% |
| UK | -8.7% | | -2.2% | DE | FR | -7.9% |
| IT | -4.2% | | 0.5% | IT | IT | -4.7% |
| NO | 2.2% | | 15.8% | NO | UK | -1.9% |
| ES | 142.7% | | 40.5% | ES | ES | 72.7% |
| BE | n / a | | n / a | BE | BE | n / a |
| EL | n / a | | n / a | EL | EL | n / a |
| IE | n / a | | n / a | IE | IE | n / a |
| LU | n / a | | n / a | LU | LU | n / a |
| NL | n / a | | n / a | NL | NL | n / a |
| Average = | -5.3% | | -3.9% | | | -5.4% |
| Median = | -16.1% | | -7.9% | | | -8.9% |
| St. Dev = | 0.516 | | 0.188 | | | 0.280 |
| Minimum = | -49.8% | | -31.7% | | | -42.4% |
| Maximum = | 142.7% | | 40.5% | | | 72.7% |

Notes: Countries are ordered according to their energy intensity. Arrows show significant movements between quartiles over time. Source: Authors' calculations on Odyssee (ENERDATA) data.

**Table 8: Percentage Change of Energy Efficiency in the EU-15 Countries and Norway, 1980-2004. Transport Sector**

TRANSPORT ( % change in EE Index over period )

| 1980 - 2004 | | | 1980 - 1992 | | 1992 - 2004 | |
|---|---|---|---|---|---|---|
| IE | -45.0% | | -35.4% | ES | BE | -49.4% |
| EL | -43.7% | | -25.8% | IE | IE | -26.0% |
| AT | -33.2% | | -24.1% | EL | EL | -25.9% |
| ES | -31.1% | | -21.7% | AT | NO | -21.4% |
| NO | -27.4% | | -13.8% | IT | PT | -14.8% |
| PT | -24.4% | | -12.2% | DE | AT | -14.7% |
| DE | -23.1% | | -11.3% | PT | DE | -12.4% |
| DK | -16.9% | Median | -10.9% | DK | FR | -12.0% |
| IT | -13.4% | | -7.6% | NO | SE | -11.2% |
| SE | -12.8% | | -3.4% | NL | FI | -7.4% |
| FR | -12.0% | | -2.8% | LU | DK | -6.8% |
| BE | -11.2% | | -1.9% | UK | NL | -4.7% |
| NL | -7.9% | | -1.8% | SE | UK | -3.4% |
| FI | -7.5% | | -0.2% | FI | IT | 0.5% |
| UK | -5.2% | | 0.0% | FR | ES | 6.7% |
| LU | 123.5% | | 75.4% | BE | LU | 129.9% |
| Average = | -12.0% | | -6.1% | | | -4.6% |
| Median = | -15.2% | | -9.2% | | | -11.6% |
| St. Dev = | 0.382 | | 0.241 | | | 0.381 |
| Minimum = | -45.0% | | -35.4% | | | -49.4% |
| Maximum = | 123.5% | | 75.4% | | | 129.9% |

Notes: Countries are ordered according to their energy intensity. Arrows show significant movements between quartiles over time. Source: Authors' calculations on Odyssee (ENERDATA) data.

## 2.4. THE CONVERGENCE OF ENERGY INTENSITIES BETWEEN EU COUNTRIES

This section looks at the convergence of energy intensities (E.I.) across European countries (EU15 + Norway). The index, given by the ratio between final energy consumption and Gross Value Added (GVA), is an economic measure of the energy requirement that a country, or one of its industries, needs to fulfil for its production. It should be pointed out that GVA has been used only when taking into consideration industries, while as far as the economy as a whole is concerned, GDP is the variable used to measure a country's economic activity.
Data come from two sources: final and sector specific energy consumption data, measured in Million Tons of Oil Equivalent (Mtoe), have been retrieved from IEA's database, while GVA, expressed in dollars, is available from EUROSTAT. The analysis is carried out with annual data for the period 1990-2004. Basically the question of convergence is whether poorer countries will ever catch-up with richer ones. While there is a substantial literature on convergence of economic variables between countries[7], the number of studies dealing with "sustainability indicators" is still limited[8].
It is worth introducing some jargon and concepts used by growth theorists.
Income convergence has been generally thought as an implication of the neo-classical growth theory's assumption of diminishing returns (see, Ramsey (1928), Solow (1956), Cass (1965) and Koopmans (1965)). The derivation of the neoclassical equation for convergence studies, see equation 1 below, from theoretical growth models can be traced back to Barro and Sala-i-Martin (1992) and Mankiw, Romer and Weil (1992).
Two main concepts of convergence appear in the literature: β-convergence and σ-convergence. While β-convergence identifies a situation in which poorer countries are growing faster than richer ones[9], we say that a group of economies are σ-converging if the dispersion of their per-capita real GDP tends to decrease over time. Notice that the two concepts of convergence do not necessarily show up together, because they capture two different aspects of the world; β-convergence deals with the mobility of different individual economies within the given distribution of the world income, while σ-convergence relates to whether or not the cross-country distribution of income shrinks over time. The importance of these concepts can be understood by looking at what the lack of convergence across countries would imply. Such a lack of convergence says that, on one hand, the degree of cross-country GDP inequality not only fails to disappear, but it rather tends to increase over time (i.e. σ-divergence), and on the other that countries which are predicted to grow faster few years from now are the same as those that are deemed as more virtuous today (i.e. β-divergence). In summary, policy makers could in principle use convergence analysis to understand any diverging tendencies in the variable of interests, such as GDP, EI, CI and so on.
Lastly, let us formally define β and σ-convergence in order to ease the exposition.

Let $\delta_{i;\,t,t+T} \equiv ln\left( x_{i;\,t+T} / x_{i;\,t} \right)^{1/T}$ be the annualised growth rate of the variable of interest, say $x_{i;\,t}$, for country i; then if we estimate the regression,

$$\delta_{i;\,t,t+T} = \alpha + \beta ln x_{i;\,t+T} + \varepsilon_{i;\,t}, \qquad (1)$$

and we find $\beta < 0$, then we say that the set of countries is converging in the sense of β. In other words, when the estimated value of β, denoted as $\hat{\beta}$, is negative it implies that there is a negative correlation between the initial level of x and growth of *x*. Therefore it implies the tendency of poorer countries to catch up with the richer ones in terms of *x*. It can be shown that the time taken for a lower income country (*z*) to catch up to within λ% of the per capita of a higher income country (*y*) is given by:

$$T = \frac{1}{\beta}\left(\frac{\ln z_0 - \ln y_0 - \ln \lambda)}{\ln y_0 - \ln z_0}\right) \qquad (2)$$

Where per capita income in the rich country is indexed by *y* and that in the poor country by *z*.

[7] For a survey see: Islam (2003) and the references therein.
[8] For an example and references see: Markandya et al (2006).
[9] Growth theorists would actually call this concept "absolute β-convergence" as opposed to "relative β-convergence", where the latter is defined by taking into account the distance between the growth rate of a country and its own steady-state.

Lastly, σ-convergence can be expressed as follows:

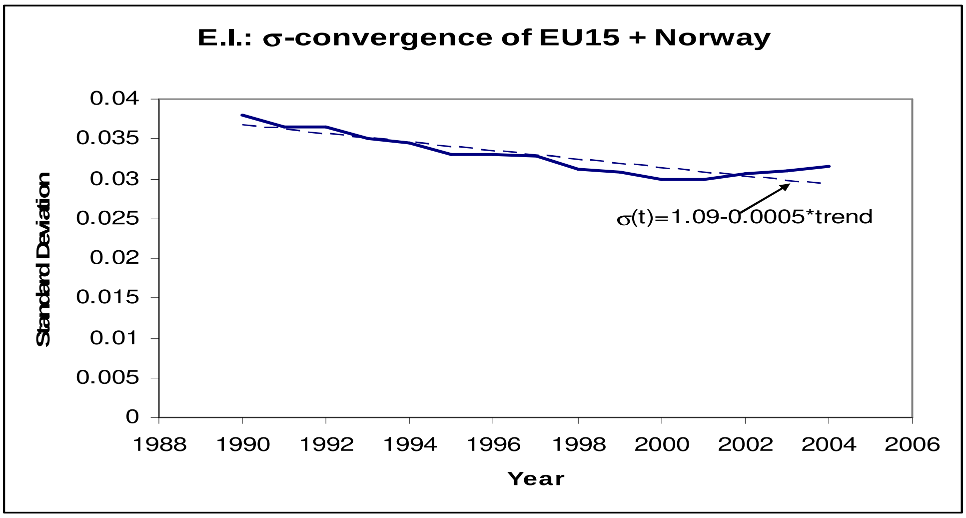
$$\sigma_{t+T} < \sigma_t, \qquad (3)$$

where $\sigma_t$ is a measure of cross-country variability, say the standard deviation or the coefficient of variation of $x_{i;t}$ measured at time *t*.

### 2.4.1 Estimating convergence in E.I.

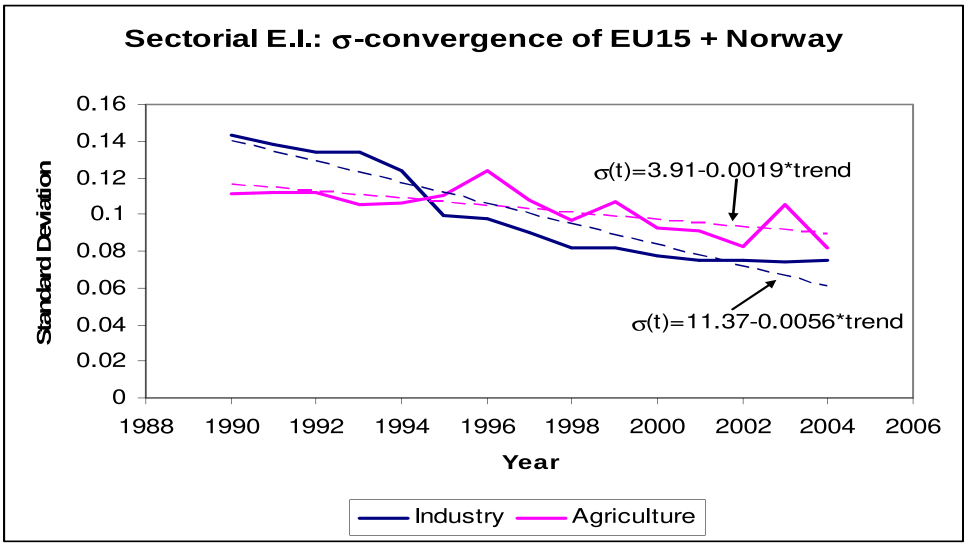
The European Union as a whole has seen its E.I. reduced by 0.78 percent per year between 1990 and 2004. Figure 8 shows that the cross-sectional dispersion of E.I. has had an overall downward trend, interrupted in the early 2000 when the standard deviation of E.I. rose briefly. Therefore in this case it is not possible to conclude that E.I. has converged in the sense of σ.
As far as β-convergence is concerned, Figure 10 indicates that for the EU15 countries and Norway the relation between growth and the initial level of E.I. is negative as depicted by the downward-sloping regression line. The estimated speed of convergence is shown in Table 9. As indicated by the negative estimates, both final E.I. and the E.I. of Industry and Agriculture have converged in the sense of β.

**Figure 8: σ-Convergence of Energy Intensity for the EU15 + Norway, 1990-2004**




Notes*:* the figure shows the cross-country standard deviations (solid line) and the fitted values (dashed line) obtained by estimating with OLS the standard deviation on a constant and a linear trend.

**Figure 9: σ-Convergence of Energy Intensity for Selected Sectors of the EU15+ Norway, 1990-2004**



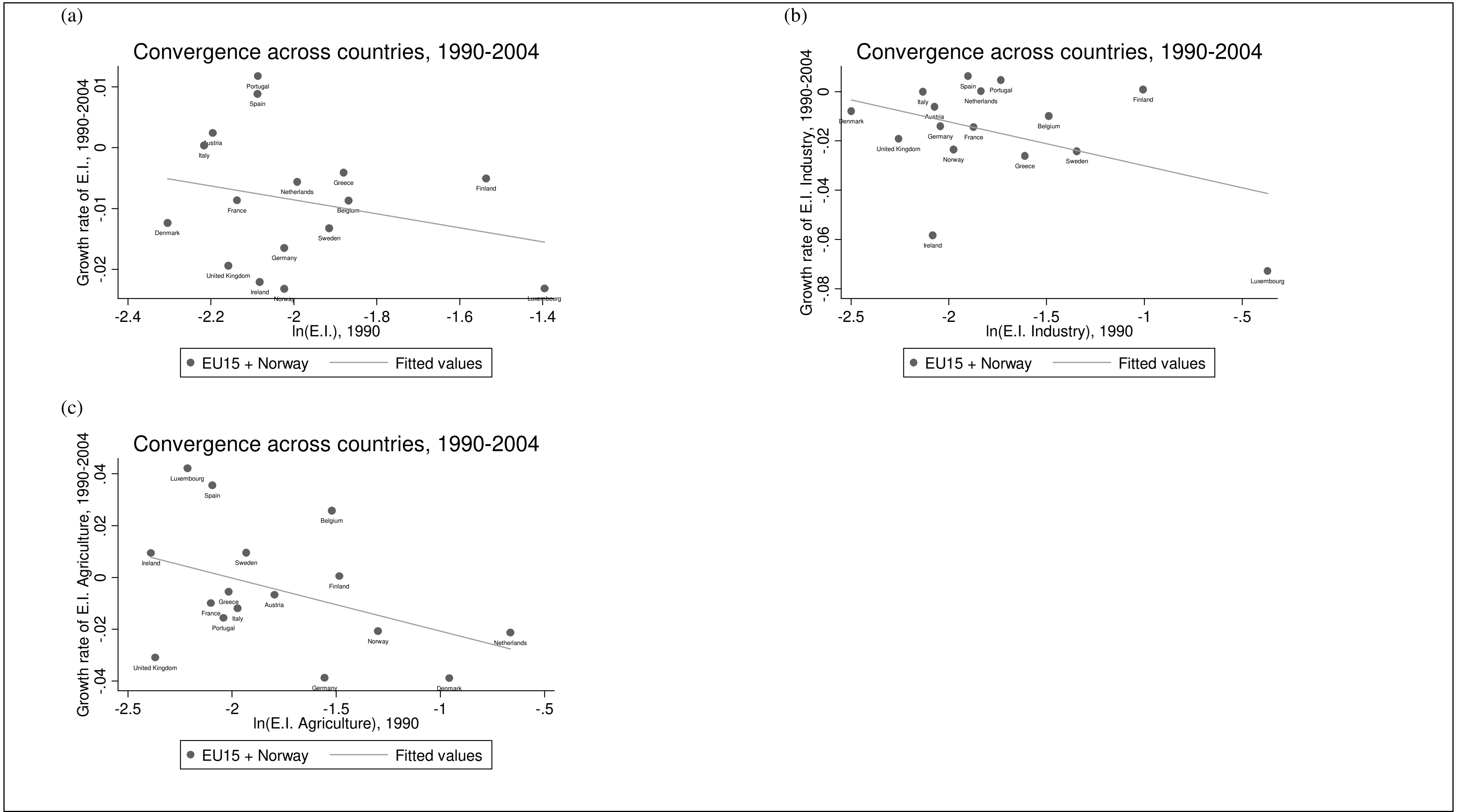

Notes*:* the figure shows the cross-country standard deviations (solid lines) and the fitted values (dashed lines) obtained by estimating with OLS the standard deviation on a constant and a linear trend.

**Table 9: Estimates of the Speeds of β-Convergence for Energy Intensity**

| Indicator | β-convergence | (p-value) |
|---|---|---|
| Energy Intensity | -0.0115 | (0.251) |
| Energy Intensity, Industry | -0.0178 | (0.220) |
| Energy Intensity, Agriculture | -0.0205 | (0.078) |

Notes*:* the regression uses OLS to estimate equations of the form: (1/T)ln('growth rate of indicator') = $\alpha + \beta *$ ln('Indicator in 1990') + $\varepsilon$. P-values are shown in "(.)". Standard errors are computed using heteroskedastic-consistent variance estimator.

**Figure 10: β-Convergence of Energy Intensity (E.I.) across EU15 Countries & Norway, 1990 E.I. and E.I. growth from 1990 to 2004**




Notes*:* Panel (a) plots final E.I., panel (b) plots E.I. of Industry panel (c) plots E.I. of Agriculture. The line(s) represents OLS fitting of E.I. growth on E.I. in 1990.

# 3. The role of EU energy policies in promoting energy efficiency in Europe.

The finding that there is at least partial evidence of convergence among EU Member States towards an improvement in the efficiency of energy use, suggests quite naturally the question of the determinants of such trends. While many factor (GDP convergence, the dynamics of international energy markets, etc.) may have played a role, in this section we investigate whether there is a significant relationship between the implementation of policy and measures directed to energy use and the improvement of energy efficiency and/or the reduction of energy intensity. Moreover, we also try and evaluate which kind of policies and measures are the most effective in determining an improvement in these indicators. Before embarking in this analysis in subsection 3.3, however, the next sub-section briefly summarise the main features of the European energy policy while subsection 3.2 looks at the main policy instruments enforced in the EU in order to influence energy efficiency.

## 3.1 TOWARDS AN EUROPEAN ENERGY POLICY

The current situation of the EU energy sector and in particular, the issues highlighted in the introduction, require Member States to reach a consensus view about a common strategy in the energy field. In the attempt to kick-start this process, The Green Paper “Energy”, adopted by the EC in March 2006, lays the basis for a European Energy Policy; this document highlights that the development of a common policy is a long-run project whose ultimate purpose is to balance three core objectives: sustainable development, competitiveness and security of supply.
As a foundation for this process the European Commission (EC) proposes establishing a Strategic EU Energy Review to be presented to the Council and Parliament on a regular basis, covering all the energy policy issues. This would help updating the European Council and Parliament monitoring progresses and identifying new challenges and responses concerning energy policy issues. Moreover, the Strategic EU Energy Review would also be a tool for achieving the first core objective, namely sustainability. Indeed, through the Strategic EU Energy Review, the EC aims at covering all aspects of energy policy, analysing all the advantages and drawbacks of different energy mixes. Although a country’s energy mix is and will remain a question of subsidiarity, its decisions have consequences for other countries and the EU as a whole, both in terms of pollution and energy security. All in all this should eventually lead to the definition of a EU’s overall energy mix to ensure security of supply and sustainability, whilst respecting the right of Member States to make their own energy choices.
A more sustainable, efficient and diverse energy mix is identified as the third priority area. The Strategic EU Energy Review is identified as the tool for defining common strategies for what concerns the choice of an environmental sustainable energy mix that could improve the security of supply, while allowing Member States to be independent on this issues.
The fourth action area is strictly related to the third one and addresses the challenges of global warming. An Action Plan on energy efficiency and a new Road Map for renewable energy sources should be adopted by the EC to select the measures necessary for the EU to save 20 percent of the energy that it would otherwise consume by 2020.
Environmental concerns are somehow addressed also in the fifth action area that aims at developing and deploying new energy technologies in order to secure energy supply and improving sustainability and competitiveness. The EC proposes to establish a strategic energy technology plan in order to develop promising energy technologies and to make them marketable. At the end of the day, what emerges from the Green Paper is that the three policy objectives, competitiveness, security of supply and sustainability, are closely interlinked and complementary.

## 3.2 ENERGY SAVING AND EFFICIENCY POLICY

In the last decades the European Community has put remarkable efforts into improving energy efficiency in all sectors and at the same time into increasing the use of renewable energies. Energy efficiency can be a key issue to improve self-sufficiency and reducing GHG emissions. In this context the Green Paper on Energy Efficiency points out that the EU could save at least 20 percent of its present energy consumption in a cost-effective manner, equivalent to EUR 60 billion per year.
In order to support a better integration of energy efficiency measures into national legislation the European Commission has proposed several directives which have been adopted and are now in force. These concern broad areas where there is significant potential for energy savings, such as:

- End-use Efficiency & Energy Services;
- Energy Efficiency in Buildings;
- Eco-design of Energy-Using Products;
- Energy Labelling of Domestic Appliances;
- Combined Heat and Power (Cogeneration).

As far as the first point is concerned, the Directive 2006/32/EC, sets an indicative energy saving target of 9 percent on total energy use, over a period of 9 years, to be reached by means of energy services and other energy efficiency improvement measures. According to the Article 14(2) of the Directive, Member States submitted their first National Energy Efficiency Action Plan (NEEAP) to the Commission in June 2007. In their NEEAPs, Member States show how they intend to reach the 9 percent indicative energy savings target by 2016.

The buildings sector offers the largest single potential for energy efficiency since it accounts for 40 percent of EU energy requirements. Among the main Community legislation for the sector are the Boiler Directive (92/42/EEC), the Construction Products Directive (89/106/EEC) and the buildings provisions in the SAVE Directive (93/76/EEC). The Directive on the energy performance of buildings (EBPD 2002/91/EC), enforced since January 2003 builds on those measures with the aim to carry out an ambitious step-ahead to increase the energy performance of public, commercial and private buildings in all Member States. In order to support the implementation of the Directive the European Commission established the EPBD Buildings Platform which provides information services for practitioners and consultants, experts in energy agencies, interest groups and national policy makers in the European Member States[10].

As far CHP is concerned, the Communities strategy outlined in the Commission's cogeneration strategy of 1997 sets an overall indicative target of doubling the share of electricity production from cogeneration to 18 percent by 2010. The indicative target was taken up in the Communication on CHP (COM(97)514 final) providing for an analysis of the barriers and strategies for is realisation. Afterwards, the Directive 2004/8/EC has been introduced. This Directive aims to reduce energy demand as a means to achieve security of energy supply, and to contribute towards the EU's carbon-saving targets. As the indicative target value from the 1997 strategy is out-dated, the Directive does not include targets but it urges Member States to carry out analyses of their potential for high efficiency cogeneration. Therefore the overall objective of the Directive is to create a framework to facilitate and support the installation and proper functioning of cogeneration where a useful heat demand exists or is foreseen.

### 3.2.1 Progress to date for energy efficiency and energy saving policies

The European Commission has set as a priority in this field the reduction in energy consumption, the improvement in energy saving and energy efficiency. In this direction the European Commission has adopted a number of policies, expressed through directives and action plans towards improving the energy efficiency in the EU energy system. The Directive 2006/32/EC on energy end-use efficiency and energy services for example indicates for its Member States an overall national indicative energy savings target of 9 percent for the ninth year of application of the Directive, which is the period 2008-2016. This target should be achieved by means of energy services and other energy efficiency improvement measures. The Directive states moreover, that each Member State should submit a National Energy Efficiency Action Plan (NEEAP) to the Commission by June 30, 2007. This NEEAPs should report how they intend to reach the 9 percent indicative energy savings target by 2016: in particular, it should describe the respective energy efficiency improvement measures, planned to meet the saving targets and their estimated impacts. Furthermore the NEEAPs should report the compliance of its Member States for the provisions of an exemplary role of the public sector as well as information and advice to final consumers. Unfortunately, given the short time

[10] The existing implemented Directives for ECO-design of energy-using products are related to ballasts for fluorescent lighting (2000/55/EC), household electric refrigerators and freezers (96/57/EC), hot-water boilers fired with liquid or gaseous fuels (92/42/EEC). These Directives have been amended in July 2005 by the article 21 of the Directive 2005/32/EC. The latter define conditions and criteria for setting requirements regarding environmentally relevant product characteristics (such as energy consumption). In principle, the Directive applies to all energy using products (except vehicles for transport) and covers all energy sources. For energy demand in households the most important Directives are the energy labelling for electric refrigerators (2003/66/EC), electric ovens (2002/40/EC), air-conditioners (2002/31/EC), dishwashers (1999/9/EC) and household lamps (98/11/EC). Others Directives are related to household dishwashers (97/17/EC) washing machines (96/89/EC), household combined washer-driers (96/60/EC) household electric tumble driers (95/13/EC) , household washing machines (95/12/EC), household electric refrigerators, freezers and their combinations (94/2/EC), household appliances (92/75/EEC).

window existing between the application of the Directive to present, no data are available on the performance in energy reduction of the single states.

The European Union has highlighted the existence of a potential energy saving of over 20 percent by 2020, which can be met removing wastes and inefficiencies. Realizing this potentials will bring to some 390 Mt of oil equivalent energy savings, along with large energy and environmental benefits. For example, it is estimated a $CO_2$ emissions reduction of 780 Mt $CO_2$ with respect to the baseline scenario, which is more than twice the EU reductions needed under the Kyoto Protocol by 2012. On basis of the policies and measures contained in the Green Paper on Energy Efficiency: “Doing More with Less”, an Action Plan has been presented in October 2006, by the European Commission. The Plan is built on the existing EU energy efficiency legislation[11] and its objective is to provide a framework, which helps achieving the 20 percent saving potentials. This framework is constituted by a list of cost-effective measures, by priority actions to be either immediately initiated or executed gradually along the Plan’s six years period. The NEEAPs will integrate well with the objectives of the Action Plan, as far as the latter represent the instruments for monitoring, reviewing and updating the plan.

The Commission has published an impact assessment report for the Action Plan for Energy Efficiency, which allow to quantify the effects of the action proposed (Tipping et al., 2006). The estimates however contain a certain degree of uncertainty, as far as a wide range of topics, at all levels of policy and decision makers, is involved. After evaluating a large set of possible instruments, some priority actions have been selected on the ground of their impact on energy savings. By far the most promising measure seem to be the extension of white certificate schemes, after evaluation of present national schemes, to all EU-countries coupled with energy efficiency obligations on energy suppliers (80Mtoe of potential savings), followed by maximum $CO_2$ emission standards for different type of cars coupled with more stringent agreements with car and truck producers after 2008-2009 (28Mtoe of potential savings) and end-user price increase to disincentivate fuel use (20Mtoe of potential savings). Taken altogether the eighteen policy options identify up to 353 Mtoe of potential primary energy savings over and above the current ‘business as usual’ projection without taking into account antagonistic or synergetic interactions (overlap) between the different policy options. Taking into account the separate policy options overlap the gross estimated aggregate energy savings potential estimate reduces by 26% to 262 Mtoe in year 2020.

An interesting study has been published by the World Energy Council, to review and evaluate some energy efficiency measures around the World[12]. The study focuses in particular on five measures - Mandatory energy audits, Energy Service Companies (ESCO's), Energy incentives for cars, Energy efficiency obligation for energy utilities, and Package of measures for solar water heaters- and it covers instutional aspects, regulations and financial measures. The analysis has been conducted by means of case studies.

Clear conclusions are stated:

- It is recognised a crucial role of pricing for the promotion of energy efficiency. A correct price signal should be provided to consumers, to build the incentives to modify their behaviour or to acquire energy efficient equipment. Fiscal and pricing policies are a strong instrument to internalise long-term costs and benefits in energy markets.
- It is emphasized that the establishment of institutions, such as agencies, is necessary to design, coordinate and evaluate programmes and measures. Moreover, they prove to be important to contract various types of stakeholders, such as companies or banks.
- Mandatory efficiency standards are another important instrument for energy efficiency. Their effect is maximized if policy makers provide both consumers and manufacturers or constructors with signals of future regulations well in advance, so that they can adapt in advance of these. Moreover, it is stated that standards should be regularly updated to be effective.
- Innovative standards for buildings are more costly than current standards, but the extra cost drops rapidly due to the externalities generated by the learning effect. Therefore the application of the most efficient appliances and buildings should be boosted by complementary policies, aiming at an increase in their market share. These efficient appliances and buildings are highly effective to reduce the cost and to make the implementation of the new regulations easier.

[11] These are the Directive on energy performance of buildings, the Directive on the promotion of cogeneration, the Directive on the taxation of energy products and electricity, the Directives on efficiency requirements for boilers, fridges and ballasts for fluorescent lighting, the Directives on the labelling of electric ovens, air conditioners, fridges and other appliances, Directive on eco-design requirements for energy-using products, Directive on energy end-use efficiency and energy services, Regulation on Energy Star labelling for office equipment.

[12] World Energy Council (2008).

- Regulations on buildings or equipment need to be enforced. In fact, enforcing the existing regulations may be as efficient as innovating the regulations.
- Energy efficiency norms for appliances and equipment contribute to differentiate between low and high efficiency equipment. Moreover they can be used for advertising incentive policies, such as tax credit or eligibility to funding schemes.
- The industry sector provides the best result in terms of energy efficiency progress, whereas passenger transport and households are the worst performing areas. On the one hand, the increased income and lifestyle changes have partially offset the technical energy efficiency gains. In this regard, technologies such as speed limiters, thermal regulation of room temperature, automatic switch off of lights and light sensors should be promoted to reduce the effect of behaviour and limit the rebound effects[13]. On the other, the bad performance of the transport sector is due to a rapid energy demand growth and the existence of limited real measures that have been implemented so far.

Other studies evaluate the impact of past energy efficiency policies and instruments. Among these, Geller et al. (2006), list the result of the evaluation of the most effective programs:

- application of energy codes;
- industrial voluntary agreements;
- pricing initiatives;
- financial incentives at national level;
- EU- wide appliance labelling and standards;
- Agreement on $CO_2$ emission intensity.

It is somehow possible to report the effective amount of energy saved, even if it may be hard to disentangle the effect of a single policy from the combination of market forces and ongoing technological changes. Therefore, the following measures should be interpred with caution.

- Thermal insulation reduced heating energy consumption per unit of floor area by 30 percent between 1978 and 1993 (Germany);
- Voluntary agreements program with industries allowed an increase in energy efficiency of 20 percent for the covered industries between 1989 and 2000 (the Netherlands);
- Taxes on carbon emission or fossil fuels are responsible for and estimated 3.3 percent reduction in $CO_2$ emission as of 2002 (Germany);
- Voluntary agreements signed by the EC and appliance manufacturers, contributed to 20 percent decrease in energy consumption of clothes and dish washers, as well as 25-35 percent reduction in standby power consumption of TVs and VCRs (various countries in Europe);
- Labelling and standards dropped the average electricity consumption of refrigerators and freezers by 27 percent between 1990 and 1999 (various countries in Europe).

[13] The rebound effect measures the tendency to "take back" potential energy savings from fuel economy improvements as increased use of energy consuming technologies (e.g. more travels on a more efficient car). See Greening and Green (1998).

## 3.3 ECONOMETRIC ANALYSIS OF THE EFFECTS OF POLICIES AND MEASURES ON ENERGY EFFICIENCY

In this section we identify the policies that better contribute to the improvement of the energy efficiency and to the reduction of energy intensity in the EU 15 countries and Norway between 1980 and 2004[14].
More specifically, we use an international panel data analysis to test the effect of energy prices and other potentially important variables in explaining energy efficiency (EE) and intensity (EI) improvements in EU15+Norway during the period between 1980 and 2004. More importantly our analysis aims to identify policies and measures (P&Ms) that proved statistically significant in improving energy efficiency (for reducing energy intensity), while controlling for other economic variables.
In order to achieve our purpose we used simple panel data regression analyses, in which we used static fixed-effect models and dynamic models. The energy efficiency and energy intensity indices were regressed against all economic variables that could potentially explain EE-EI improvements[15], and dummy variables indicating that a specific policy is in place at a country that year. We tested one and two years lags of all P&Ms, and one year lag of the main economic variables in our models.

### 3.3.1 The data

The EE-EI indices were estimated using Odyssee, Energy Information Agency (EIA), and OECD data. The indices were generated per sector: transport; household and industry, for EU15+NO countries during the period between 1980 and 2004. The economic time series per country were obtained from a range of sources, mainly the Eurostat, the World Development Indicators (WDI) and Odyssee databases.
The policies investigated were obtained from the MURE[16] database. We created dummies per policy sub-type, that is, the dummy variable equalled 1 if any of the policies of the same sub-type was in place in the country at the years of interest. For example, the P&M for the industry sector classified as a legislative-informative measure (pmint3) comprises the measure 'mandatory appointment of an energy manager' and 'mandatory audits for industrial processes'. In annex we provide a data dictionary that describes all variables and policy dummies used in our analyses.
Our strategy to pursue the model with the most significant determinants of energy efficiency followed the approach of including all potential determinants and policies with their lags and excluding from the model those variables with coefficients not statistically significant. The process was repeated until we obtained a set of statistically significant variables and policies with the expected signs. In the case of P&Ms coefficients we expect a negative sign, that is, when the policy is in place (dummy=1) it implies EE-EI improvements, which in our approach means lower values for EE-EI indices.

### 3.3.2 Results

The estimation of dynamic models did not provide stable results. In turn, we present our results using the static models. The tables in the Annex show the statistically significant variables with the 'correct' signs we obtained in each regression, separated between the economic variables and the policy variables:
The results of the regression analysis enabled us to estimate the percentage impact and elasticities of each regressor in each model. We would make the following observations:

- The price of energy has a small but significant effect on improving energy efficiency, reducing energy intensity and reducing carbon emissions in all sectors and for the aggregate level of the economy. However, the 'elasticities' are small. For example, a ten percent increase in the price of energy net of inflation increases aggregate energy efficiency by 0.16 percent only and reduces energy intensity by 0.26 percent. Effects at the sectoral level are similarly small, in some cases registering at three decimal places. The one important price elasticity we find is for households. A ten percent increase

[14] The analysis discussed in this session has been carried out by FEEM within a project on energy efficiency in Italy sponsored by the Italian industrial trade association (CONFINDUSTRIA, 2008). Given the focus of this paper and for the benefit of economy of space, we do not report on the analysis performed on $CO_2$ emission intensities and policies.
[15] Several energy prices, GDP per capita, population, R&D investments; trade balance; energy production, consumption and imports, shares of different sectors on GDP; capital formation investments; electricity generation mix; energy infrastructure and stock of vehicles.
[16] *Mesures d'Utilisation Rationnelle de l'Energie* (http://www.isis-it.com/mure).

in energy prices results in a 1.2 percent increase in energy efficiency and 0.6 percent reduction in intensity in the household sector.

- The effects of increases in GDP are mixed. In some cases GDP increases result in more efficiency and lower intensity; in other cases the reverse holds. There are about an equal number of positive effects as there are negative ones. Normally, over long periods of time GDP growth is associated with improvements in energy efficiency. In the short term, however, this relationship does not always hold; there are cyclical effects as well as special factors that can influence the relationship in the short to medium term.
- The effects of R&D expenditure on energy efficiency and intensity are disappointing. We do not generally find improvements in efficiency and intensity when R&D increases. Perhaps this reflects the general nature of the R&D included. Better measures of R&D in the energy sector should have positive effects on efficiency and intensity but we are not able to measure this effect.

As far as the policy variables are concerned we find the following:

For households: (a) regulations for heating systems, (b) grants and subsidies and tax exemptions and (c) 'cross-cutting household sector specific policies' (mainly eco-taxes) have a significant beneficial impact on this indicator. Finally cross-cutting polices in the form of (a) general programmes for energy efficiency, climate change and renewables, (b) financial measures such as $CO_2$ energy efficiency and renewable funds have a beneficial impact.
Household energy intensity is particularly influenced by soft loans and cooperative measures such as Demand Side Measures with producers of household goods.

For the transport sector the significant policy variables on energy efficiency are (a) tax exemptions and accelerated depreciation and (b) social planning such as car sharing, increased load factors for goods, commuter plans for companies etc.
In terms of energy intensity in transport tax exemptions and accelerated depreciation and modal shifts toward public transport for passengers and goods, urban traffic management are the most effective. In addition cross-cutting policies in general have an impact to reduce intensity.

For industry the significant variables on energy efficiency are: (a) mandatory standards, (b) soft loans for energy efficiency, renewables and CHP and (c) information education and training. We note, however, that the size of the impacts for industry is much smaller than for households or transport.
For energy intensity in industry, the only significant variable is information, education and training. It includes voluntary labelling, audits etc.

In terms of aggregate energy efficiency the important variables are: (a) regulations for heating systems and 'cross-cutting' household sector specific policies (mainly eco-taxes); (b) social planning in transport such as car sharing, increased load factors for goods, commuter plans for companies etc, and (c) information, education and training in industry, which includes voluntary labelling, audits etc., (d) regulations for building equipment, which includes minimum standards for boilers etc., (e) grants and subsidies in the tertiary sector, which includes investment in renewable energy sources, CHP etc. and (f) cross-cutting financial measures such as funds for renewable energy.

# 4. Conclusions

This paper has analysed energy efficiency in the EU, both in terms of reductions in energy intensity and in terms of physical indicators of energy efficiency, looking at the sectoral details and at the divergences among Member States. On this regard, in particular, we have investigated whether there is some empirical evidence that the gaps among member states are closing, by means of an econometric analysis of convergence. Our analysis points to a sensible catching–up of less performing countries in terms of reducing energy intensity, particularly in the agricultural and in the industrial sector (β-convergence). However, there is non conclusive evidence that the dispersion among countries is reducing (σ-convergence), although this holds mostly for the last 4-5 years analysed.

In view of this at least partial convergence among EU States towards more efficient energy use patterns, we have investigated whether the decisions they take in the energy field, that is, their energy policies, are playing a role in this trend and which kind of policies and measures were the most effective.
The main conclusions of the policy analysis are the following:

- in the residential sector the energy efficiency is particularly affected by heating regulation, by subsidies as well as tax reduction associated to energy policies (such as the eco-tax). Measures which apply to the production side, such as financing at low interest rate, proved to be effective;
- in the transport sector, it is worth mentioning measures such as tax reductions, incentives to eliminate old and polluting cars, car sharing, commuter plan and traffic management;
- in the industrial sector, mandatory technology standards, financing at low interest rate, information activities, education and outreach are effective.

The convergence of sustainability indicators among European countries (EU15 + Norway) can offer guidance for fine-tuning energy policies within the EU. Extending this analysis to other countries, could improve the coordination and cooperation between the EU and crucial partners. Indeed, it helps understanding how a country is ranked with respect to the other countries and whether its policies environmental and economic policies are pushing the economy in the desired direction. The panel analysis of energy policies confirms that taking action to improve energy efficiency can lead to significant improvements, and helps identifying policies with the best potential.

However, the analysis performed here can be extended and refined in several ways. In principle it would have been interesting to look to more countries, to use continuous, instead of binary, policy variables and to look at different dimensions of energy policy (such as climate change mitigation).
For the first two lines of further research, the main limitation has been data availability. In particular, policy indicators and energy efficiency indicators for new accession countries were not available or available for a decade or less of observations. For non EU countries, we could not find a policy database consistent with the MURE database used for the EU 15-States, although it was possible to find suitable data to construct energy efficiency and energy intensity indicators for the US, Japan and China. For policy variables, the MURE database is mostly qualitative, and reports the presence and the category of the policies and measures implemented in a given country, but it does not provide systematically quantitative information about these policies (such as the funds earmarked for a given policy or the financial impact of a given tax). Future analyses can be pursued by investigating the country-specific P&Ms that contributed for energy efficiency improvements. We have looked at such P&Ms at the regional level (EU-15 plus Norway), but analyses of single countries can help to understand if selected policies are more effective in different countries than others.

We did however pursue one extension mentioned above, although we did not present the results here for economy of space: the analysis of the carbon dimension of energy policy. More precisely we performed, using the methodology applied in sub-section 2.4, an analysis of convergence in carbon intensity among European countries and, similarly to sub-section 3.4 a panel analysis of the effectiveness of energy and carbon mitigation policies on the $CO_2$ emissions reductions. To summarise briefly our findings, we did found evidence of both β-convergence and σ-convergence in carbon intensity ($CO_2$ emissions per unit of gross value added) across the EU-15 and Norway in the industrial, agricultural and tertiary sectors; in terms of policy effectiveness the policies that have been most significant  for achieving $CO_2$ emissions reductions are: grants and subsidies to the household sector, (b) soft loans to the household sector, (c) taxation other than eco-taxes in the transport sector, (d) eco taxes in the transport sector.

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# ANNEX - DETAILS OF THE ECONOMETRIC ANALYSIS

## *Economic variables*

| Dependent Variables | Regressors | | | | | | |
|---|---|---|---|---|---|---|---|
| EE all sectors | Energy Price | GDP/capita | R&D | --- | --- | --- | --- |
| EE industry | Energy Price | GDP/capita | R&D | Share of industry | Energy production | Electricity from coal | --- |
| EE transport | Energy Price | --- | --- | --- | Trade | --- | --- |
| EE household | Energy Price | GDP/capita | --- | Share of service | Trade | Capital formation | --- |
| EI all sectors | Energy Price | GDP/capita | R&D | Share of industry | --- | --- | --- |
| EI industry | Energy Price | GDP/capita | R&D | Share of industry | Energy production | --- | --- |
| EI other sectors | Energy Price | GDP/capita | R&D | --- | --- | --- | --- |
| EI transport | Energy Price | GDP/capita | R&D | --- | --- | --- | --- |

*Policy variables*

| Dependent Variables | P&Ms | | | | | |
|---|---|---|---|---|---|---|
| EE all sectors | PMhhT2 | PMhhT12 | PMtrT10 | PMinT8 | PMteT2 | PMteT5 | PMccT1 |
| EE industry | PMinT2 | PMinT5 | PMinT8 | PMccT3 | PMccT7 | | |
| EE transport | PMtrT6 | PMtrT10 | | | | | |
| EE household | PMhhT2 | PMhhT6 | PMhhT8 | PMhhT12 | PMccT1 | PMccT4 | |
| EI all sectors | PMhhT6 | PMhhT7 | PMhhT11 | PMinT8 | PMteT5 | PMccT7 | |
| EI industry | PMinT1 | PMinT8 | | | | | |
| EI other sectors | PMhhT7 | PMhhT11 | PMhhT12 | PMccT7 | | | |
| EI transport | PMtrT6 | PMtrT9 | PMccT7 | | | | |

**Econometric Results of the Energy Efficiency and Energy Intensity Indicators**

All reported elasticities are statistically significant. Positive numbers indicate an improvement in efficiency or reduction in intensity and vice-versa. In the case where the variable is in percentage, the coefficient reported is the percentage change in the efficiency indicator. Years 1980-2005. Countries: EU -15+ Norway Sources: Odissee base data, IEA, WDI data

| Dependent Variables | Elec. Price | GDP capita | R&D | Share ind. | Share serv | Energy Prod. | Trade | Pop |
|---|---|---|---|---|---|---|---|---|
| units | Usc/Kwh | Us$ | M$ | % | % | Ktoe | % | mn |
| Energy efficiency index; Total (all sectors); | 0.016 | -0.079 | 0.065 | --- | --- | --- | --- | --- |
| Energy efficiency index; Industry | 0.003 | 0.044 | -0.016 | 0.001 | --- | -0.009 | --- | --- |
| Energy efficiency index; Transport sector | 0.079 | --- | --- | --- | --- | --- | 0.003 | --- |
| Energy efficiency index; Households | 0.124 | -0.337 | --- | --- | -0.009 | --- | -0.006 | --- |
| Energy intensity index; Final (all sectors) | 0.026 | 0.307 | -0.165 | 0.01 | --- | --- | --- | --- |
| Energy intensity index; Industry; | 0.038 | 0.483 | -0.24 | 0.026 | --- | 0.048 | --- | --- |
| Energy intensity index; Other sectors | 0.056 | 0.546 | -0.23 | --- | --- | --- | --- | --- |
| Energy intensity index; Transport sectors | 0.092 | -0.521 | 0.239 | --- | --- | --- | --- | --- |
| Energy intensity index; Total (all sectors) | 0.057 | 0.337 | -0.078 | -0.019 | -0.031 | --- | --- | 0.969 |

| | Transport policy variables | | | | Industry policy variables | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Dependent Variables | tr05 | tr06 | Tr09 | tr10 | in01 | in02 | in05 | in06 | In08 |
| units | % | % | % | % | % | % | % | % | % |
| Energy efficiency index; Total (all sectors); | --- | --- | --- | 3.3% | --- | --- | --- | --- | 1.8% |
| Energy efficiency index; Industry | --- | --- | --- | --- | --- | 0.4% | 1.2% | --- | 0.3% |
| Energy efficiency index; Transport sector | --- | 10.7% | --- | 7.5% | --- | --- | --- | --- | --- |
| Energy efficiency index; Households | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Energy intensity index; Final (all sectors) | --- | --- | --- | --- | --- | --- | --- | --- | 7.6% |
| Energy intensity index; Industry; | --- | --- | --- | --- | 8.4% | --- | --- | --- | 11.0% |
| Energy intensity index; Other sectors | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Energy intensity index; Transport sectors | --- | 21.6% | 6.0% | --- | --- | --- | --- | --- | --- |
| Energy intensity index; Total (all sectors) | --- | --- | --- | --- | --- | --- | --- | --- | --- |

| | Tertiary sector policies | | Cross-cutting policies | | | | |
|---|---|---|---|---|---|---|---|
| Dependent Variables | te02 | te05 | cc01 | cc02 | cc03 | cc04 | cc07 |
| Units | % | % | % | % | % | % | % |
| Energy efficiency index; Total (all sectors); | 3% | 1% | 4.6% | --- | --- | --- | --- |
| Energy efficiency index; Industry | --- | --- | --- | --- | 0.4% | --- | 0.3% |
| Energy efficiency index; Transport sector | --- | --- | --- | --- | --- | --- | --- |
| Energy efficiency index; Households | --- | --- | 11.6% | --- | --- | 39.7% | 10.4% |
| Energy intensity index; Final (all sectors) | --- | 2.8% | --- | --- | --- | --- | 3.6% |
| Energy intensity index; Industry | --- | --- | --- | --- | --- | --- | --- |
| Energy intensity index; Other sectors | --- | --- | --- | --- | --- | --- | 10.9% |
| Energy intensity index; Transport sectors | --- | --- | --- | --- | --- | --- | 6.2% |

| | Household policy variables | | | | | |
|---|---|---|---|---|---|---|
| Dependent Variables | hh02 | hh06 | hh07 | Hh08 | hh11 | hht12 |
| Units | % | % | % | % | % | % |
| Energy efficiency index; Total (all sectors); | 2.70% | --- | --- | --- | --- | 2.8% |
| Energy efficiency index; Industry | --- | --- | --- | --- | --- | --- |
| Energy efficiency index; Transport sector | --- | --- | --- | --- | --- | --- |
| Energy efficiency index; Households | 9.40% | 12.70% | --- | 6.8% | --- | 18.2% |
| Energy intensity index; Final (all sectors) | --- | 6.70% | 7.30% | --- | 7.0% | --- |
| Energy intensity index; Industry; | --- | --- | --- | --- | --- | --- |
| Energy intensity index; Other sectors | --- | --- | 8.50% | --- | 7.3% | 10.9% |
| Energy intensity index; Transport sectors | --- | --- | --- | --- | --- | --- |

**Data dictionary for the panel analysis**

The variables listed are those tested in the regressions on the basis that they had more information (less missing values) among alternative variables available in their sub-group, for the majority of countries/years.

| Variable | Description |
|---|---|
| PRgasHHus | Price in US$ of natural gas residential (incl. taxes); US$/tep. EIA |
| PRgasINDus | Price in US$ of natural gas industry (incl. taxes); US$/tep. EIA |
| PReleHHody | Price in US$ of electricity residential (incl. taxes); USC/kWh. Odyssee data |
| PReleINDody | Price in US$ of electricity industry (incl. taxes); USC/KWh. Odyssee data |
| PRgasEleUs | Price in US$ of natural gas electricity production (incl. taxes). US$/tep. ODYSSEE |
| PRgasol | Price in US$ of premium gasoline (incl. taxes); US$ per litre. |
| PRdiesel | Price in US$ of diesel (incl. taxes); US$ per litre. |
| PRdieselHH | Price in US$ of diesel (household) (incl. taxes); US$ per litre |
| PRdieselIND | Price in US$ of diesel (commercial use) (incl. taxes); US$ per litre. |
| POPwdi | Population - WDI, total (SP.POP.TOTL) WDI |
| ShINDwdi | Industry, value added (% of GDP) (NV.IND.TOTL.ZS) WDI |
| ShSERwdi | Services, etc., value added (% of GDP) (NV.SRV.TETC.ZS) WDI |
| Trade% | Trade (% of GDP) (NE.TRD.GNFS.ZS) WDI |
| R&Dpps | Total intramural R&D expenditure (GERD). Millions of PPS (Purchasing Power Standard). All sectors. |
| GDPppsCur | GDP per capita, PPP (current international $) (NY.GDP.PCAP.PP.CD) |
| CapFor% | Gross capital formation (% of GDP) (NE.GDI.TOTL.ZS) |
| Inflation | Inflation, consumer prices (annual %) (FP.CPI.TOTL.ZG) |
| EnProdWdi | Energy production (kt of oil equivalent) (EG.EGY.PROD.KT.OE) |
| EnConsWdi | Energy use (kt of oil equivalent) (EG.USE.COMM.KT.OE) |
| EnImpWdi | Energy imports, net (% of energy use) (EG.IMP.CONS.ZS) |
| EleGenCoal | Electricity production from coal sources (% of total) (EG.ELC.COAL.ZS) |
| EleGenHyd | Electricity production from hydroelectric sources (% of total) (EG.ELC.HYRO.ZS) |
| EleGenOil | Electricity production from oil sources (% of total) (EG.ELC.PETR.ZS) |
| EleGenWdi | Electricity production (GigaWh) (EG.ELC.PROD.KH) |
| EleConWdi | Electric power consumption (GigaWh) (EG.USE.ELEC.KH) |
| VehStkEur | Stock of vehicles by category at regional level; |
| PMhhT1 | P&Ms Household sector - Mandatory Standards for Buildings |

| | |
|---|---|
| PMhhT2 | P&Ms Household sector - Regulation for Heating Systems and hot water systems |
| PMhhT3 | P&Ms Household sector - Other Regulation in the Field of Buildings |
| PMhhT4 | P&Ms Household sector - Mandatory Standards for Electrical Appliances |
| PMhhT5 | P&Ms Household sector - Legislative/Informative |
| PMhhT6 | P&Ms Household sector - Grants / Subsidies |
| PMhhT7 | P&Ms Household sector - Loans/Others |
| PMhhT8 | P&Ms Household sector – Tax Exemption / Reduction |
| PMhhT9 | P&Ms Household sector – Tariffs |
| PMhhT10 | P&Ms Household sector - Information/Education |
| PMhhT11 | P&Ms Household sector - Co-operative Measures |
| PMhhT12 | P&Ms Household sector - Cross-cutting with sector-specific characteristics |
| PMtrT1 | P&Ms Transport sector - Mandatory Standards for Vehicles |
| PMtrT2 | P&Ms Transport sector - Legislative/Informative |
| PMtrT3 | P&Ms Transport sector - Grants / Subsidies |
| PMtrT4 | P&Ms Transport sector – Tolls |
| PMtrT5 | P&Ms Transport sector - Taxation (other than eco-tax) |
| PMtrT6 | P&Ms Transport sector - Tax Exemption / Reduction / Accelerated Depreciation |
| PMtrT7 | P&Ms Transport sector - Information/Education/Training |
| PMtrT8 | P&Ms Transport sector - Co-operative Measures |
| PMtrT9 | P&Ms Transport sector – Infrastructure |
| PMtrT10 | P&Ms Transport sector – Social Planning/Organisational |
| PMtrT11 | P&Ms Transport sector - Cross-cutting with sector-specific characteristics |
| PMinT1 | P&Ms Industry sector - Mandatory Demand Side Management |
| PMinT2 | P&Ms Industry sector - Other Mandatory Standards |
| PMinT3 | P&Ms Industry sector - Legislative/Informative |
| PMinT4 | P&Ms Industry sector – Grants / Subsidies |
| PMinT5 | P&Ms Industry sector - Soft Loans for Energy Efficiency, Renewable and CHP |
| PMinT6 | P&Ms Industry sector - Fiscal/Tariffs |
| PMinT7 | P&Ms Industry sector - New Market-based Instruments |
| PMinT8 | P&Ms Industry sector - Information/Education/Training |
| PMinT9 | P&Ms Industry sector - Co-operative Measures |
| PMinT10 | P&Ms Industry sector - Cross-cutting with sector-specific characteristics |

| | |
|---|---|
| PMteT1 | P&Ms Tertiary sector - Mandatory Standards for Buildings |
| PMteT2 | P&Ms Tertiary sector - Regulation for Building Equipment |
| PMteT3 | P&Ms Tertiary sector - Other Regulation in the Field of Buildings |
| PMteT4 | P&Ms Tertiary sector - Legislative/Informative |
| PMteT5 | P&Ms Tertiary sector – Grants / Subsidies |
| PMteT6 | P&Ms Tertiary sector - Soft Loans for Energy Efficiency, Renewable and CHP |
| PMteT7 | P&Ms Tertiary sector - Tax Exemption / Reduction |
| PMteT8 | P&Ms Tertiary sector - Information/Education/Training |
| PMteT9 | P&Ms Tertiary sector - Co-operative Measures |
| PMteT10 | P&Ms Tertiary sector - Cross-cutting with sector-specific characteristics |
| PMccT1 | P&Ms Cross-cutting – General Energy Efficiency / Climate Change / Renewable Programmes |
| PMccT2 | P&Ms Cross-cutting - Legislative/Normative Measures |
| PMccT3 | P&Ms Cross-cutting - Fiscal Measures/Tariffs |
| PMccT4 | P&Ms Cross-cutting - Financial Measures |
| PMccT5 | P&Ms Cross-cutting - Co-operative Measures |
| PMccT6 | P&Ms Cross-cutting - Market-based Instruments |
| PMccT7 | P&Ms Cross-cutting - Non-classified Measure Types |