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Scenarios to 2030 of energy use and CO_2 emissions in EU industry

A top-down study based on regression analysis of time series data

Thesis for the Degree of Master of Science in Industrial Ecology

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Abstract

The energy use and associated carbon dioxide emissions from EU industry is the main focus of this study. This sector accounts for about 30% of total energy use and 23% of total carbon dioxide emissions (including emissions from electricity generation) in the EU25. Due to the climate change effects caused by anthropogenic greenhouse gas emissions, increasing attention is being paid to the potential for mitigating emissions of carbon dioxide in industry as well as in other sectors.

The purpose of this study was to estimate energy use and carbon dioxide emissions in EU industry to 2030, assuming increasing costs for emitting carbon dioxide. Estimates were made separately for 10 industry branches, with separate estimates for old member states (EU15) and new member states (NMS10). Energy use in each branch was estimated by calculating energy use per added value as a function of energy prices, energy price elasticities and an autonomous efficiency improvement constant. Assumed values on energy price elasticities and autonomous efficiency improvement constant were based on partly literature data and partly regression analyses, carried out within this study, of time series data of energy use per added value and energy prices. Time series data on energy use and added value were taken from the Odyssee database and data on energy prices from the IEA database.

A great share of the regression analyses did not yield results of high statistical significance, most likely due to several limitations in data. First, the level of branch aggregation in the Odyssee data is relatively high, which means that possible correlation between energy price and energy use may be obscured by structural changes within the branch. Second, the length of the time series data in Odyssee is about 25 years for EU15 and only 10-15 years for NMS10, which is probably insufficient since the price impact on energy use in industry is heavily lagged, especially in capital-intensive industry branches where capital lifetime may exceed 30 years. Third, the IEA energy price data contain only average prices for the entire industry, which obviously is a source of inaccuracy since energy prices, particularly of electricity, may vary substantially between industry branches.

In the “Baseline” scenario of this study, where carbon costs are assumed to remain at current levels in the EU Emission Trading Scheme, i.e. around €25/ton CO_2, energy use in EU25 industry increases by 19% to 2030 and carbon dioxide emissions by 1.1% compared to year 2000. These results are consistent with the baseline projections of the European Commission. In the “Medium carbon cost” scenario, where emission costs are assumed to increase gradually to €60/ton CO_2 in 2030, energy use in 2030 remains at about current levels but carbon dioxide emissions fall by -15%. In the “High carbon cost “scenario, carbon costs are assumed to reach €120/ton CO_2 in 2030, and both energy use and carbon dioxide emissions drop substantially, by 14% and 29%, respectively.

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Section I

Introduction and review

I.1 Background Information

Energy is of growing importance on the political agenda of the governments throughout the world as economic growth and stability are based on this feature. Increased effort focused towards decreased consumption, increasing energy efficiency and increasing fuel flexibility is under way. This is due to a high rate of fuel dependency throughout the world, 56% in 2005 in European energy system (ECN 2004) and its combination with the steady increasing demand for energy (IEA 2005).Another reason for change in energy use is the risk that the rapid changes in the climate and the climate system are a result of human interference (IPCC 2007). All these circumstances urge the need for alternative and "cleaner" solutions for the environment without neglecting the crucial for all actions nowadays economic aspect.

The awareness for the environmental problems is growing, as the load of greenhouse gas emissions throughout the world is projected to increase significantly, more than 50% from 2003 levels by 2030 from the energy related sector (IEA 2005), if no measures will be implemented and no action taken. Accounting at around 32% of the global energy consumption (World Bank, 2004) and from 22% to 36% of the total CO_2 emission world wide (IEA 2006;IEA 2007), industrial emissions are a very significant contributor to all the consequences and the phenomena that follow this situation, such as global warming and causing changes to the natural environment.

Very similar to the global energy trend is the European, with 28% share of final energy (Eurostat 2007) or 29.3% for the year 2000 (EC 2006) when emissions share is at 15% for the same year from the same report. In the fuel mix, 79% is dependent on fossil fuels, 14% from nuclear and 7% from renewable sources (Eurostat 2007). The reason under the high share of energy use for Industry is the production of energy intensive industrial goods, which production has grown dramatically during the past decades and is projected and expected to continue growing as a result of population and per capita income increase in many regions around the world (IPCC 2007).

Nowadays, there is effort undergoing to find solutions. Thus, there is a trend towards cooperation between environmentalists and economists in order to deal with energy related problems as part of the effort to analyze, estimate and give economically reasonable and feasible solutions to the problems raised and connected with the use of fossil fuels. More analytically, examining carbon dioxide emissions coming from energy use from an economic perspective is of their main attention. There are studies based on econometric analysis, estimating price elasticity for different energy sources and fuels as an indicator of future trends on demand.

Based on price elasticity and other calculation methods and assumptions, models and scenarios are developed with implementation of different policies for achieving the desired emissions without compromising economic growth. For European Union (EU) industry, which is the focus of this report, projections exist for the baseline scenarios, with current trends and political circumstances applied to them, either for energy consumption or emissions.

One such report estimation predicts that emissions will increase initially up to the year 2020 by 4.6% compared to 2000 and then decline again close to 2000 levels by the year 2030 (EC 2006) from European Industrial sector, based on assumptions and some uncertainties. There is also another report with different assumptions that predicts a more significant rise of the emissions by around 18% in year 2030 relative to 1990 for Europe (Ion 2005). At the same time, energy demand is expected to rise rather significantly by 18.6 % (EC 2006) in Europe if no dramatic changes are to happen in the sector and with energy intensity gains at the rate of 1.2 % per annum up to the year 2030, while for countries being members of the Organization for Economic Cooperation and Development (OECD) the growth is 17.2% with base year the year 2004(EIA 2007).

So, due to the importance of the situation and the enhanced degree of uncertainty that is included in future predictions as well as the great differences between the projections, there is a need for more estimations and alternative scenarios that will cover more cases by alternative approaches and different situations and circumstances included. Furthermore, generally there is a lack of studies for projections for European Union industry when it comes to energy use and emissions and it is even rarer when using econometric analysis as a method and tool. Also, there are no estimations with different carbon emission costs. This is a matter that this report is trying to cover and provide results, if reasonable for the policy makers, who are the ones that have to make some very difficult decisions, with more material and estimations.

The objective of this study is to estimate future energy use and carbon dioxide emissions from EU industry, assuming increasing carbon costs at different levels, with scenarios built reaching the year 2030. This time period is split in three parts, 2010, 2020 and 2030, for better view of the process of the emissions and the energy use throughout this period. Separate scenarios were made for EU15 and NMS10 respectively (see Table 1 for region definitions). The estimates of future energy use and carbon dioxide emissions were based on energy price elasticities, which were partly estimated in this study using energy use data from the ODYSSEE database and energy price data from the International Energy Agency (IEA). From the values of the price elasticity, scenarios were built assuming different carbon costs in order to reach the wanted results; energy use and carbon dioxide emissions for the year 2030.

Table 1. List of countries in EU 15 and NMS 10

EU 15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden, United Kingdom
NMS 10	Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland Slovakia, Slovenia

Additionally to this scope, a literature review was made, from similar studies on projections as well as for values of energy price elasticities. The crucial fact, as already mentioned above, is the lack of studies for the European industry. Some regional estimates have been made, either country specific or area specific, but not covering the wanted specific area and sector. In any case, all this information can be indicative for comparisons or robustness of the results.

Moreover, a literature review on different environmental policies was carried out. Due to the complexity of this area, general policies are identified and shown in this report and some questions that arise for the future ones. Nowadays, there is a matter if there is a call for strict rules or not and which values are acceptable for the sustainability of the environment and all the perspectives of the society. This is at the same time the questions that the policy makers have to answer to and this report will, hopefully, try to help them take the best possible decision, not just for European industry, but for the well being of the European community.

I.2 Literature review of energy efficiency and CO_2 mitigation in industry

Another important feature of this report is the energy efficiency. It is very crucial to have knowledge as well as trends of it, so as to interpret this aspect to the results. At the same time, by improving energy efficiency it is a step towards carbon dioxide mitigation of the industry. But for decreasing the load of emissions, efficiency is not the nostrum. Fuel mix and consumption rate are also very significant, but not examined in this part of the report. Some information for these aspects can derive from the literature, where studies and reports for Europe and the World are made according to current and potential trends.

I.2.1 Current trends

Generally, as it is reported for 15 OECD countries, there is a very significant boost of the production volume the last decades, which is not always followed by same energy consumption trend and neither affected by energy prices for the period between 1962 to 2002 (Adeyemi 2007). This situation can be seen as a sign of improved efficiency taken place in some sectors from one point of view and at the same time the importance of energy for the society that its consumption is not affected by different prices. This situation is further explained by the declining rate of energy intensity, meaning simply the ratio of the Total Primary Energy Supply (TPES) and the Gross Domestic Product (GDP) (Smil 2003).

These historic trends on energy consumption and emissions from the "Manufacturing" industry, which is the industry that is supposedly covering the whole industry in this report, can show and indicate future tendencies. There is also the "Mining" sector, but its values are rather small compared to "Manufacturing" and this is the main reason why the latter is considered as the whole sector. In Figures 1 and 2, there are values of the past emissions and consumption, with the time period covering the years that data is available for both regions and are indicative of the trends. Separate figures are made for EU 15 and the New Member States (NMS10) for the easiness of distinguishing the lines and analyzing the trends of each region individually. In the figures, consumption of all energy sources examined in this report are shown as well as "Total", referring to the ones coming from the aggregation of: "Coal", "Oil", "Gas", "Electricity" and "Other sources" such as "Heat" and "Biomass". This assumption is followed everywhere in this report.

The main observation of Figure 1 is the smoothness of the lines between "Total Consumption" and "Total Emissions", by following almost identical trend, but with a small difference in the last years examined, where a small improvement can be identified as the two lines seem to have quite different orientations; the consumption upwards and the emissions downwards when comparing their trends in most of the years.

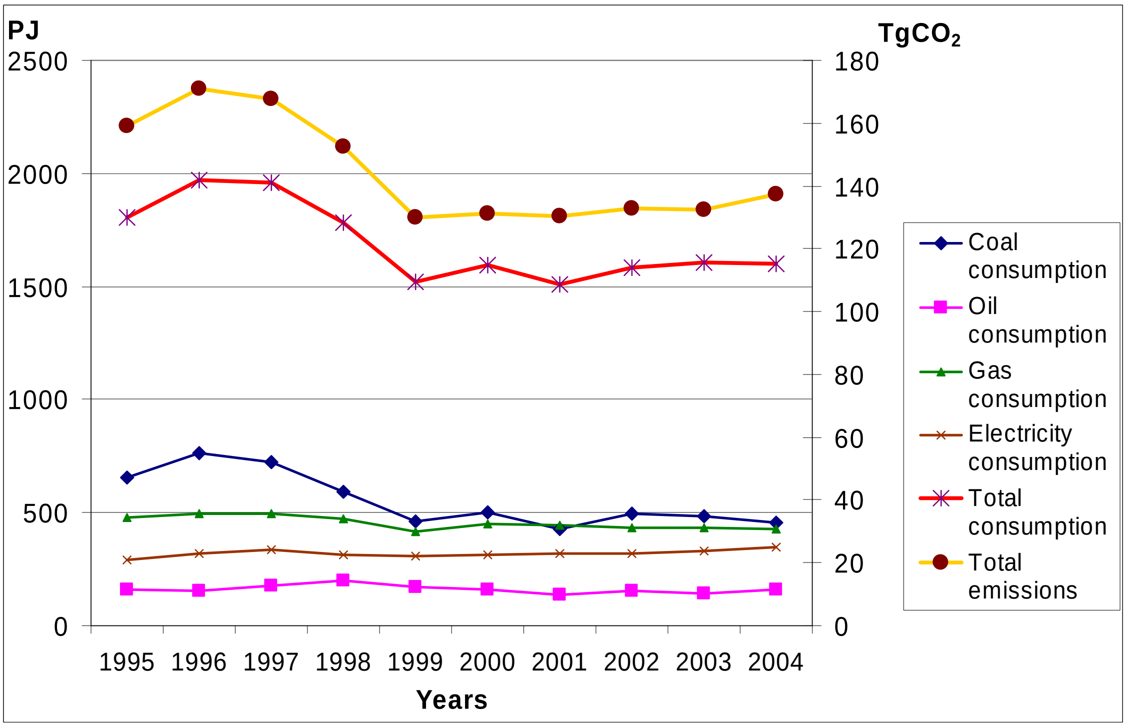

Figure 1. Total and per fuel type consumption and total emissions for NMS10 for 1995-2004 for manufacturing industry (NACE C)
Source: ODYSSEE database

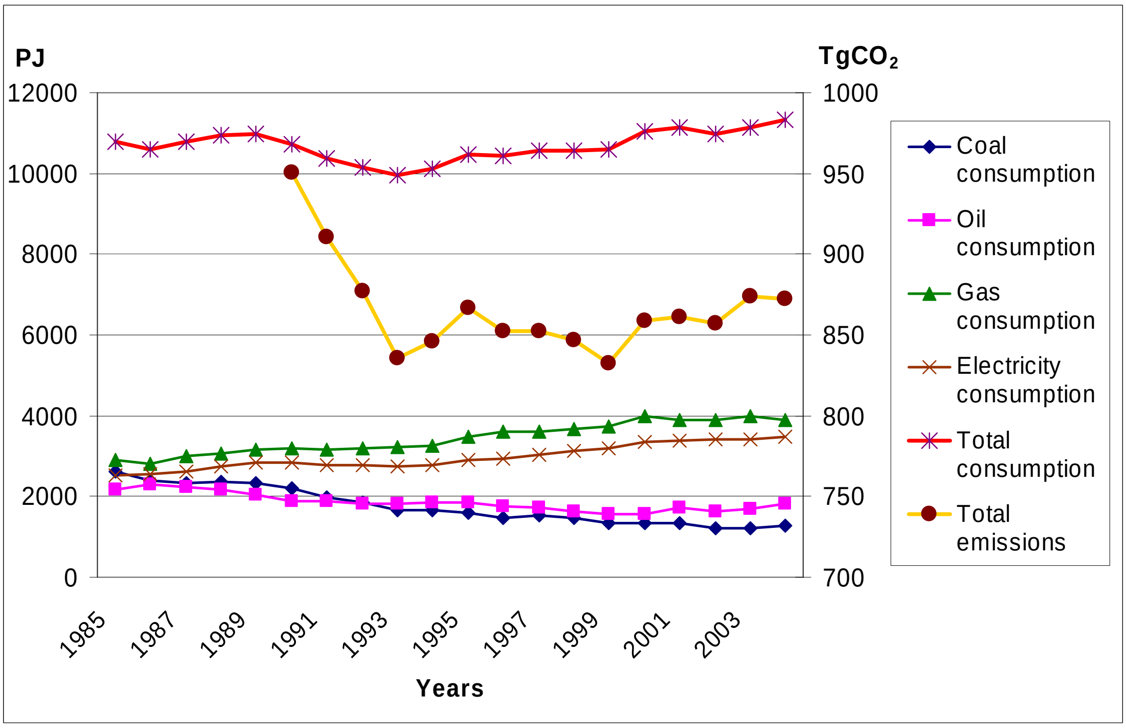

Figure 2. Total and per fuel type consumption and total emissions for EU 15 for 1985-2004 for manufacturing industry (NACE C)
Source: ODYSSEE database

For EU 15, where emissions and consumption are compared, the trend is quite different between the "Total" lines as it is obvious from the graph. Improvements appear to have taken place up to 1999 and then an increase in emissions occurs, when in parallel there is an increasing consumption trend throughout all the years. The same year, 1999, an increase in energy consumption can also be seen that can explain the alteration in the emissions trend. A general comment arising from Figure 2 is that higher energy consumption leads to higher emissions regardless of the improved energy efficiency that is visible from the more gradually increase of the emissions compared to energy use.

The historic evolution of energy consumption per "value added" for the whole industry, "Manufacturing" industry in this report, is presented in the figure below for both regions, EU 15 and NMS10, as well as for all energy types available in the ODYSSEE database, "Coal", "Gas", "Electricity", "Oil" and "Total energy" use. The time period covered once again in this graph is from 1995 to 2004, due to the limited data from the ODYSSEE database. Both regions are shown in the same figure for the easiness of the comparison of the trend between same types of energy source and between the two regions, as well as the trends of different branches in the same region. By this contrast, it is easier to identify the sectors with the most energy intensity gains, as this portion is also a measure of efficiency (EC 2006).

As it can be seen from the figure, NMS10 values are higher to those of EU 15, but a declining trend exists, indicating the transition that is taking place in this region and in some cases it is very fast. The characteristic of the values of EU 15 is that they are almost stable throughout the presented years, indicating the little variations that are taking place in this region. This situation can mostly be understood from the "Total Energy" line, where the cumulative energy use of the "Manufacturing" sector is divided by the relevant aggregated "value added" from the industry. More details are shown in Figure 3.

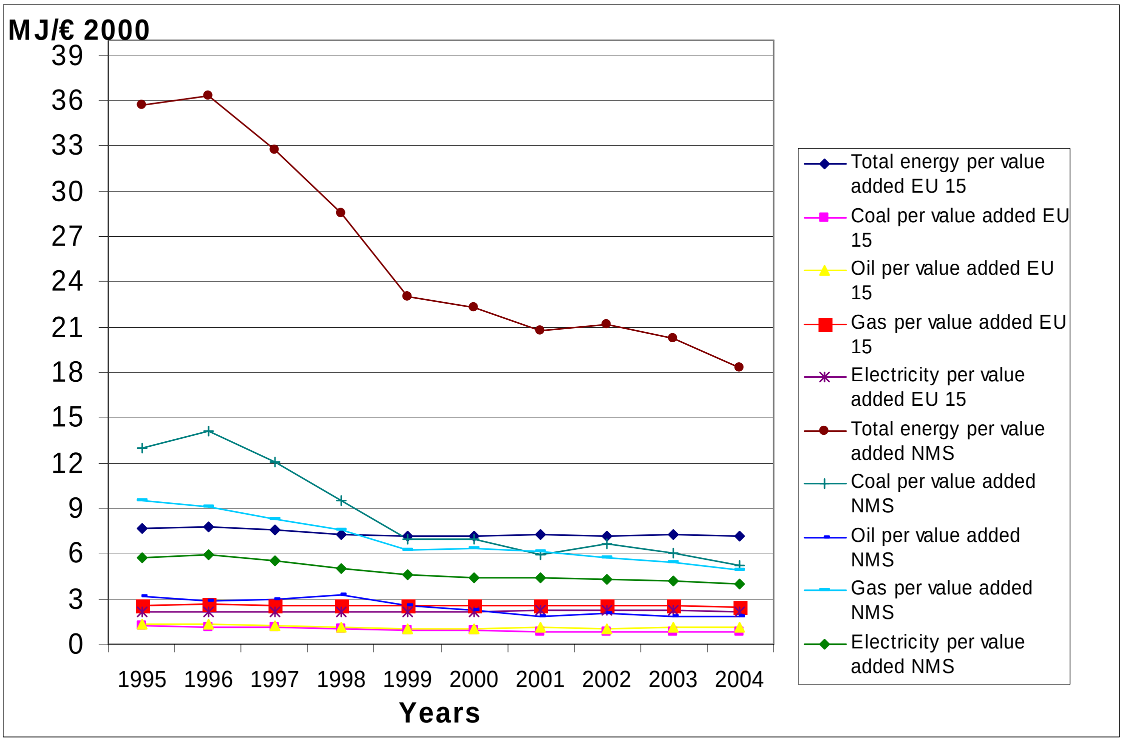

Figure 3. Energy use per value added by energy category for manufacturing industry (NACE C). Source: ODYSSEE database

It is important here to mention a detail on the currency, which is in fixed year 2000. Another significant point from this figure is the high values for "Coal" energy use for

NMS10 and the simultaneously lowest values of the graph for the same category for EU 15, verifying the great gap in the intensity in this type of energy.

Going into each branch and calculating the "consumption per value added" value for each one of them, a lot of details can be disclosed concerning each branch's individual trend and therefore their energy efficiency improvement in a way. Once more, NMS10 values are higher than EU 15 for all branches. The common characteristic is the high values in the "Primary metals" branch, where variations in the trend are also visible from the graphs. This branch, alongside with the "Chemicals" sector are very energy intensive sectors and this fact can also be verified from this graph, where their lines are having the highest values of all the other branches in almost all years presented in this graph for both regions. More details for all the branches can be seen at Figure 4.

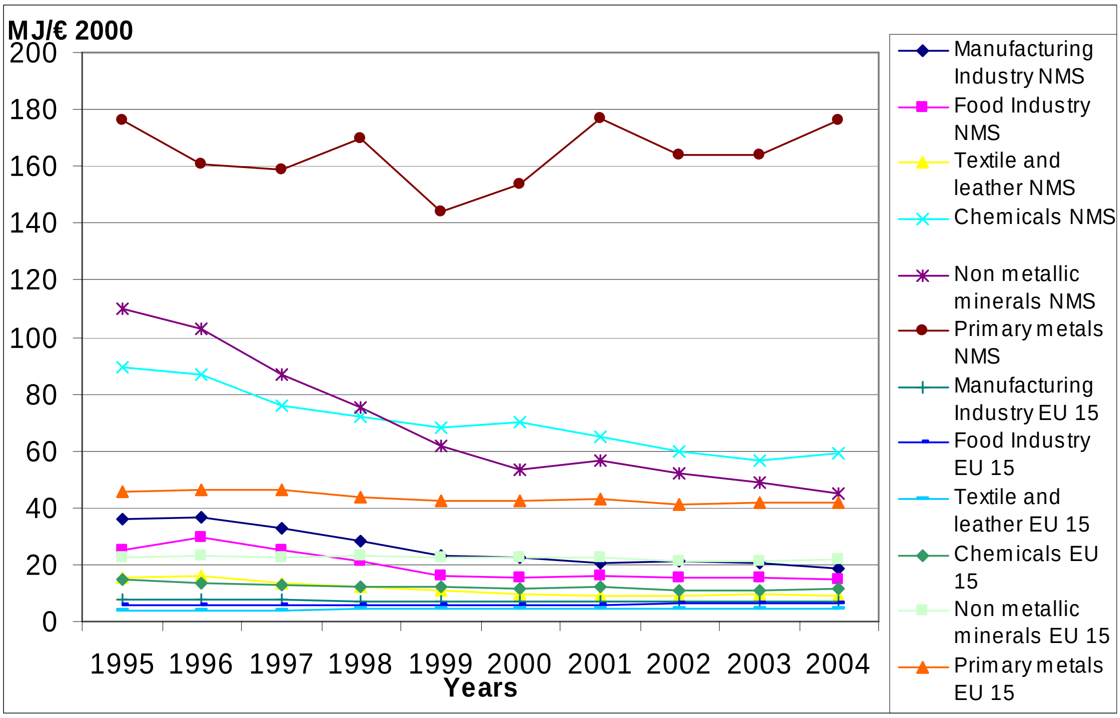

Figure 4: Energy use (total energy use) per value added for manufacturing industry and branches for EU 15 and NMS10, period 1995-2004 (NACE Rev 2). Source: ODYSSEE database

The figure of emissions per "value added" (Figure 5) for each branch separately is similarly important as it provides an overview of the sector. It is not something new to mention the higher values that are disclosed from the following figure for NMS10 in general. Going deeper in the analysis of the figure for each branch, it is quite obvious that the higher values can be seen at the "Non mineral metallic" sector at both regions, followed by "Chemicals" sector. Again, the trend is obviously declining for NMS10 and rather stable for EU 15, showing the development and the improvement that is taking place at the first region. More details can be observed and identified in Figure 5.

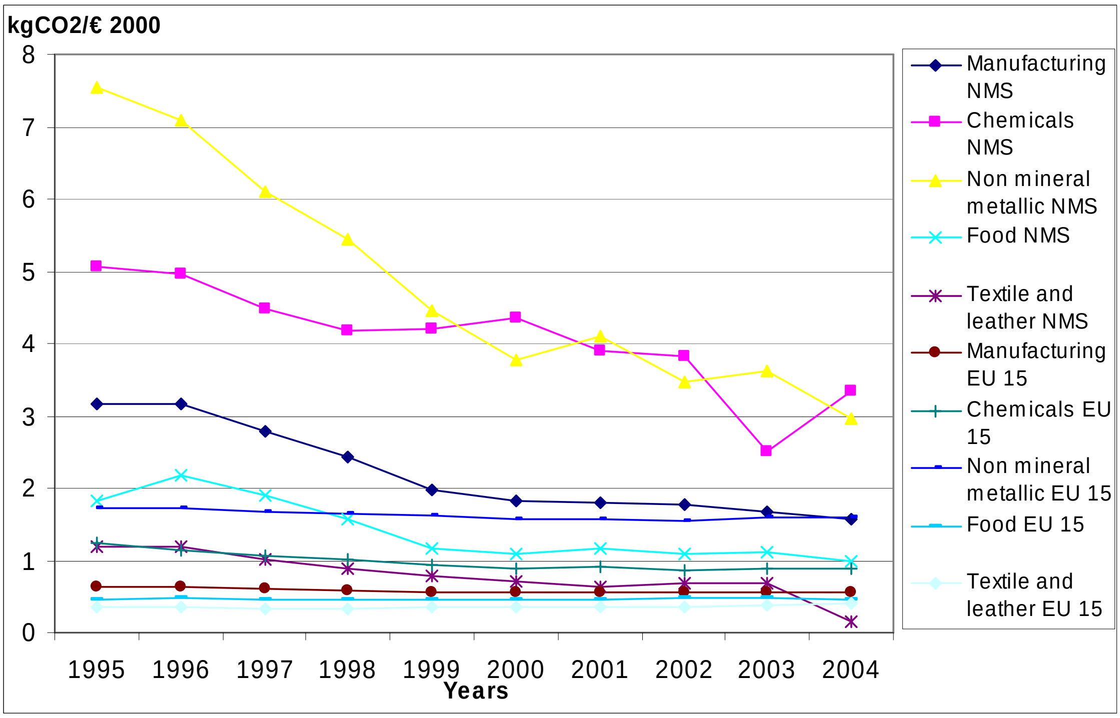

Figure 5. Emissions per value added for total and branches for EU 15 and NMS10, period 1995-2004 (NACE Rev 2). Source: ODYSSEE database

In Figure 6, energy prices are presented in Index form for whole Europe, both EU 15 and NMS10, as not separate values for each region are available from the IEA database. So, it can be assumed that the trend in energy prices is not regional and by this the presented trend is really close to the trend in prices that took place in many countries.

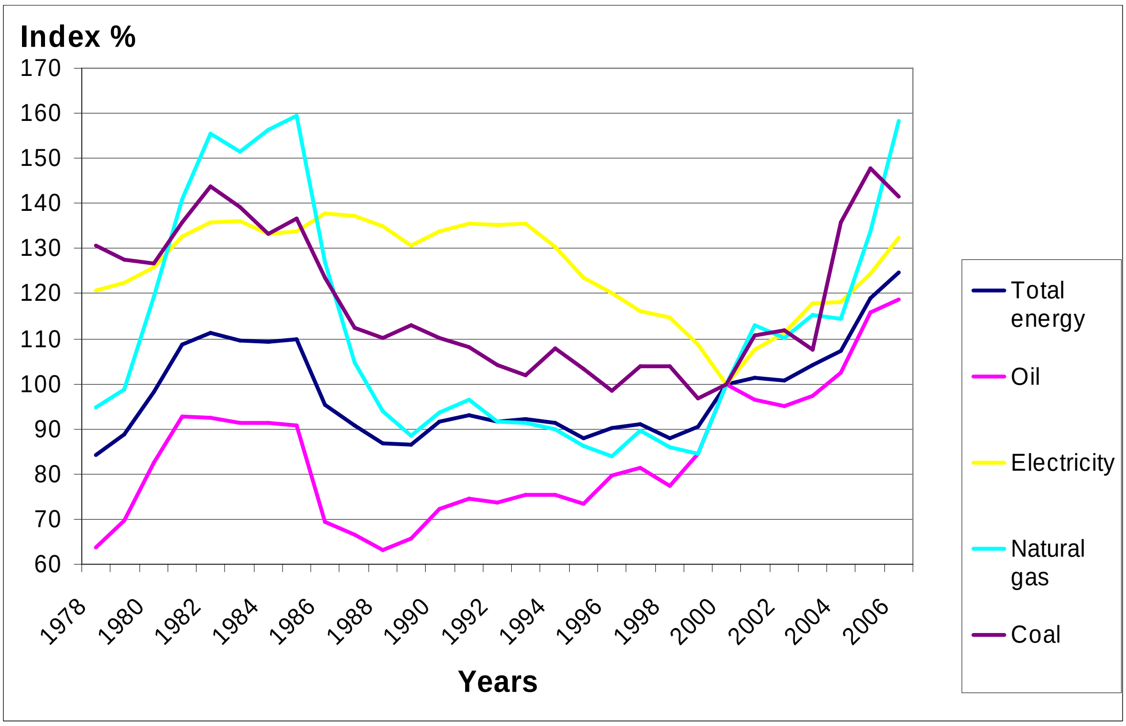

Figure 6 Energy prices by category for IEA Europe during 1978 to 2004. Index 100 = year 2000. Source: IEA database

The good point of this database is the separate prices for the different energy sources that are examined in this report and by so there is more accuracy in the results, as far as the individual prices for each fuel are concerned

From Figure 6, the great differences and variations that took place through the last decades can be seen. Especially in the first half of the 80's, a dramatic raise, which was followed by a fall, can be observed. In the early 90's, there was initially a small declining rate and then in the latest years a great increase in the prices. It is "Oil" and "Coal" that has a different, declining, trend in the early years of the new millennium, but afterwards they followed the general trend of increasing energy prices, when again in the last years "Coal" prices fall once more. These are the years where there is an "explosion" in gas prices and these opposite trends are maybe somehow correlated. More information can derive after observing the following figure.

Based on past and current data and trends as shown above and combined with some other assumptions such as future fuel mix, energy prices, energy efficiency and other various parameters, future energy use and therefore emissions can be projected and calculated. Such a study is carried out by European Commission (EC), (EC 2006), where projections are made for future energy demand as well as CO_2 emissions for the industry up to the year 2030. This period is also divided in three sections for altering some of the assumptions that are possible to change. The outcomes of these analyses are presented below in figures (Figures 7, 8), one just with the values of the projected consumption and emissions and the other with the latter values divided by the economic concept of "value added" value.

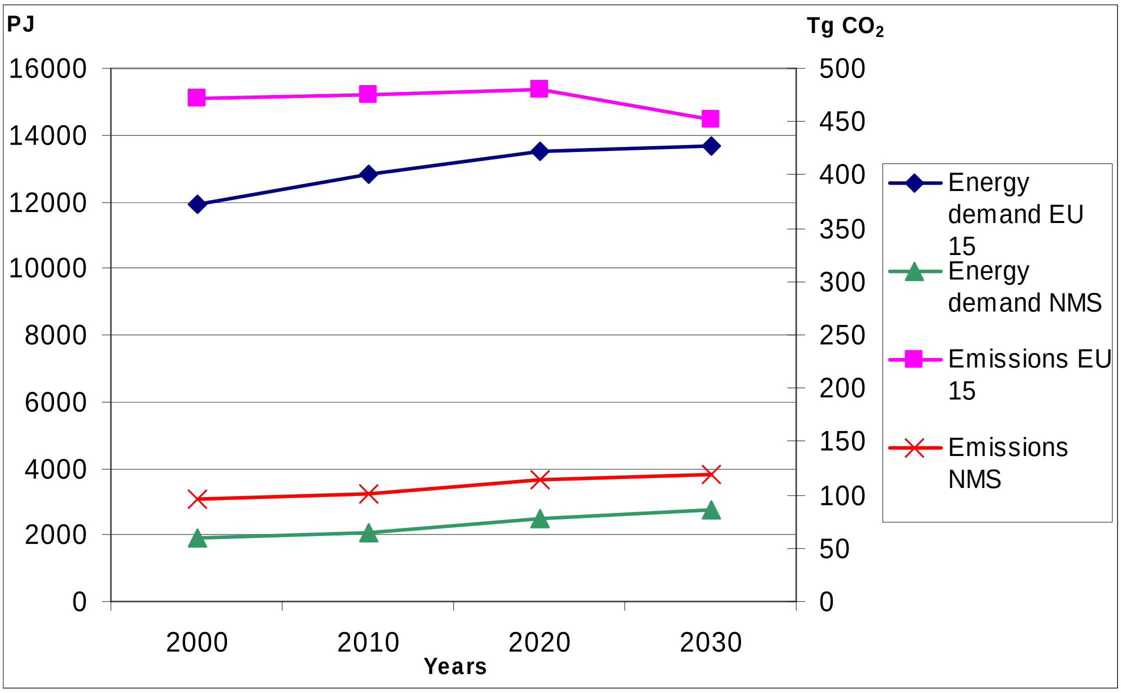

Figure 7. Projected carbon emissions and energy use in EU 15 and NMS10 in entire industry for the period 2000-2030. Source: European Commission 2006

The great difference in the volume of the emissions as well as in the final energy demand between the two regions can be very easily observed in Figure 7. At the same time, there is a similar trend in the energy demand, but not in the emissions, where there is a small decrease for EU 15 and a small increase for NMS10. Moreover, there is a difference in the rate of increase between energy demand and emissions for NMS10, where demand is growing faster than the projected emissions, indicating improvements in the efficiency. The total outcome for both regions of Figure 7 is a demand increase of 18.6% and a slight increase in the emissions by 0.4% from 2000 levels.

Maintaining the previous examples, future consumption and emissions are divided by the projected (by the same study) future "value added" so as to have an economical indication of the relevant trends. The results are shown in Figure 8.

An interesting point from Figure 8 is the almost identical trend for both regions of the "consumption per value added" with "emissions per value added"; steep declining for NMS10 (around 60%) and a smoother one for EU 15 (around 30%) for both measured values. Moreover, looking at the absolute values for NMS10 in the year 2030 they are very close to the ones of the EU 15, showing great development and improvement. This is when having in mind the initial point, where values for NMS10 are around three times the ones of EU 15 for "consumption per value added" and even more for "emissions per value added". This situation can also indicate the limited potential of improvement for countries with already established and developed infrastructure.

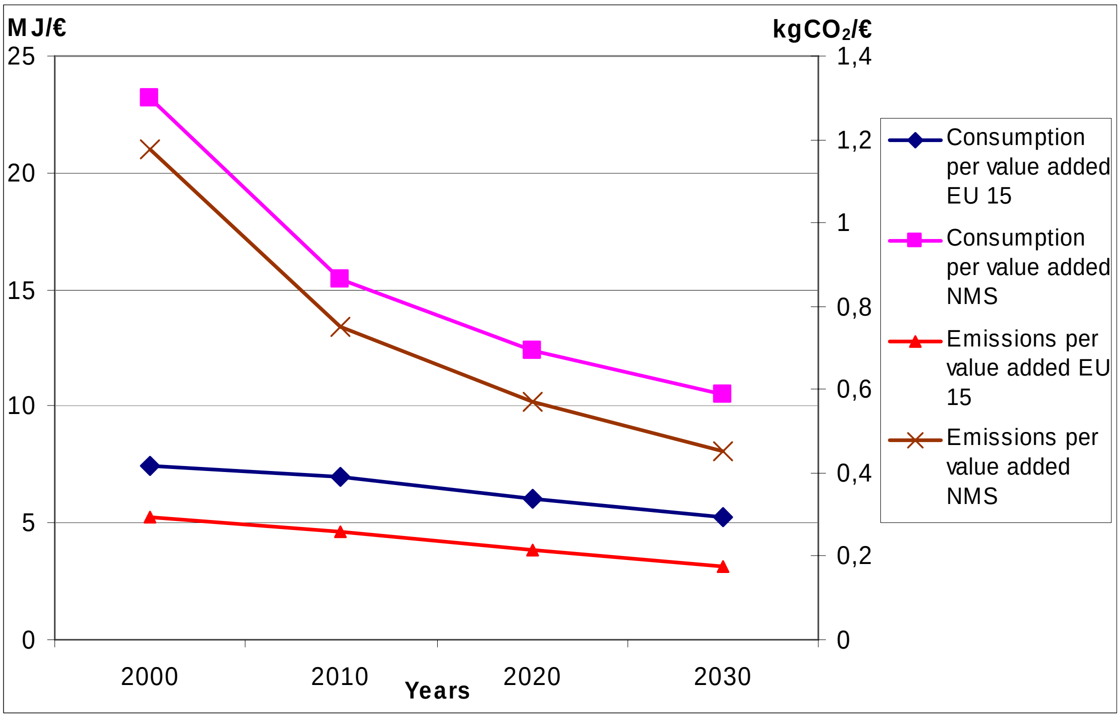

Figure 8. Projected energy use and carbon emissions per projected value added for the period 2000 to 2030. Source: European Commission 2006

When it comes to efficiency, it is important to mention the large differences that occur from region to region, from country to country or even from industry to industry (IEA 2007). At the same time, it is essential to distinguish the theoretical with the up to now feasible efficiency. As reported by IEA (2006), "The energy intensity of most industrial processes is at least 50% higher than the theoretical minimum determined by the laws of thermodynamics". Furthermore, it is reasonable that efficiency is mostly matter of decisions such as choice and optimization of the technology, operating procedures and maintenance and capacity maximization (IPCC 2007). Generally it is observed that energy efficiency tends to be lower in regions with low energy prices (IEA 2006). This situation in some extent can be attributed to regional differences in labor cost, outdated production equipment, energy subsidies, natural resource endowment and policies to limit imports (IEA 2006).

When best available technology is used, there is globally the potential for energy efficiency gains for all industries as it is reported from IEA. According to this study, the lowest improvement can be seen in the production of aluminum, varying from 6% up to 8%, due to its high electricity intensive production. In the iron and steel production, there is more room for energy savings. Starting from 9% and reaching 18% in best cases and even 30% in other study (IEA 2006), it is of great importance taking into account that it is a large consumer, around 19% of final energy use in the industrial sector. The bigger energy consumer, the chemical and petrochemical sector, which accounts to 30% of total industrial use, has an improvement of 13% to 16% if best practice of commercial technologies is applied to their processes. Here, there should also be a distinction, as the chemical industries are approaching the theoretical minimum energy use in many countries (IEA 2006).

Moreover, there is a considerable potential for the cement industry, accounting from 28% to 33%in energy savings. The contradicting phenomenon in this case is that in many countries the cement industries are approaching the theoretical minimum, whereas in for example China the industry can improve its efficiency by almost 50%. The same situation exist and in the pulp and paper industry, where globally there is a potential of 15% to 18%, but with significant differences between developed and developing countries as well as size scaled plants and techniques used. The last sector examined is the "other non metallic metals minerals and non ferrous". Despite the wide range of products, quality and resource quality and the great variety that exist from country to country in these cases, there is space for improvement that amounts from 13% to 25%, based on the available data (IEA 2007).

A simultaneously benefit from reducing energy use is the reduction in carbon dioxide emissions, if best technology is to be used in the industry. It is estimated that the mitigation reaches the level of minimum 19% globally and can even exceed to 32% in high estimates of the total industrial emissions. This is a large portion of the total share, accounting from 7.4% to 12.4% reduction from all anthropogenic emissions. The conclusion for this study is that manufacturing industry can improve its energy efficiency rather significantly by 18% to 26% and a contribution in the range of 7% to 12% reduction in global energy and process related carbon dioxide emissions. It is very significant and at the same time very promising that all these improvements are all based on current and proven technology (IEA 2007), as it "releases" optimism for further technological improvements.

A very significant contributor to succeed these levels of improvement is the high energy efficiency of modern motors and boilers, general steam processors, which are key instruments and tools in many industries, accounting to approximately 15% of global manufacturing final energy use. Numerous studies all around the world verified that there is an improvement in efficiency of the scale up to 30% (IPCC 2007) for motor systems and 10% to 15% for steam systems (IEA 2007) with the use of the latest technology. A general conclusion which can be drawn is that changes in material production and better waste treatment in general offer the highest efficiency and CO_2 emission reduction potential in Industry (Gielen 2007).

Overall, it is identified that there is a great effort undergoing for increasing the energy efficiency and therefore to decrease the volume of the emissions from industrial energy use. Especially in the high energy intensive sectors, where reduction in the use of energy is combined with less cost in the processes so greater income potential, there is a focus and research towards increasing their efficiency. Statistics for Europe of the 25 members indicate that for the period 1990 to 2003, despite the increase in primary energy needs by 6.3%, the emissions declined by 2.7%, pointing out a significant increase in the efficiency in the energy system (EC 2006).

The great question that arises is whether this effort will continue with the same rate, intensify or slow down. The only concrete answer is that with current data and rates, potential for CO_2 mitigation exist for the future even with current technology. This mitigation potential is examined in the next chapter.

I.2.2 Potential for CO_2 mitigation in medium and long term

As already said, without additional policies and incentives, the global energy related carbon dioxide emissions will continue to increase rapidly. But this situation can at the same time change, as there is potential for carbon dioxide mitigation in every sector of the industry. Technological improvements and innovations offer a great prospective on the way to redirect the current trend and situation on emissions. Also, in some sectors potential improvements can be identified in recycling and energy recovery, which are not practiced in full capacity nowadays. Furthermore, interestingly there is growing interest and somehow dependence for CO_2 reduction in Carbon Capture and Storage (CCS) technique for greater mitigation potential in some of the reports.

A summary of the literature review on mitigation potential as well as CCS potential separately is given at Table 2, when compared to the relevant in each case baseline scenario. These values are given in percentages and also the cost range is given in U.S. dollars per ton of C. Also, the year that this potential is projected to happen is included in Table 2, as well as some important assumptions that in each case the referred report is based in order to make the estimations. Furthermore, the region or country examined in each study is mentioned and the sector that this potential is to take place.

Table 2. Literature review of mitigation and carbon capture and storage potential

Reference	Area	Sector	Mitigation Potential (%)	Cost range (US$/tC)	CCS (%)(cost range in parenthesis in US$/tC)	Year projected	Assumptions
IPCC 2007(1)	OECD	Steel	15-40%	20-50	~20(<50)(a2)	2030	
IPCC 2007(1)	OECD	Primary aluminium	15-25%	<100		2030	
IPCC 2007(1)	OECD	Cement	11-40%	<50	~6(<100)	2030	
IPCC 2007(1)	OECD	Chemical Industry (3)	20-25%	<20	~100(a1) (<50)	2030	
IPCC 2007(1)	OECD	Pulp and Paper	5-40%	<20		2030	

Continue from Table 2

Reference	Area	Sector	Mitigation Potential (%)	Cost range (US$/tC)	CCS (%)(cost range in parenthesis in US$/tC)	Year projected	Assumptions
IEA 2006	Global	Power Generation	5-7%		~7	2050	From coal to gas (2)
IEA 2006	Global	Industry	5%		~2	2050	
Daniels 2005	Netherlands	Industry	16.15%			2020	Increased policy pressure

(1) IPCC 2007 literature review on CO_2 mitigation potential without including Carbon capture and storage technique
(2) Switching from coal to gas fired power generation
(3) In this report the sector is represented by “Ethylene” and “Ammonia” production
a1: In this case it is just for “Ammonia” production
a2: In this case it is both for Iron and Steel

At the same time, global and more specific (OECD countries) scenarios are made from the Intergovernmental Panel on Climate Change (IPCC), Special Report on Emission Scenarios (SRES) for up to the year 2030. The first scenario examined in this report (A1) refers to very rapid economic growth accompanied by low population growth and rapid introduction of new and more efficient technologies. The second (B2), features moderate population growth with intermediate levels of economic growth and less rapid and more diverse technological change than the latter scenario described. According to these scenarios, emissions are to increase by 23.8% and 15.7 respectively for energy related carbon dioxide emissions, including indirect emission from electricity use in the industrial sector.

In the latter scenarios, there are also regional projections including Europe divided into two areas, the Western Europe and an aggregation of the Central and Eastern Europe. The aggregated result from these two areas can be identified as the total European. Following this assumption, the outcome of the projections is rather interesting. Despite the steady increase both in the final energy consumption as well as in the primary, there is an opposite effect to the emissions. At both scenarios there is a steady decrease in energy related carbon dioxide emissions in industry. When it comes to even more regionally, for Western Europe the ratio is even higher and it is also noticeable the portion of the final energy consumption to the primary energy consumption compared to Central and Eastern Europe. This situation indicates further energy efficiency improvements possible for Central and Eastern Europe.

There is also a similar study for European Union of the 25 industrial sectors, where the future energy demand as well as energy related carbon dioxide emission from all sectors and industry is estimated (EC 2006). In this publication, which a per decade trend analysis is made, it is projected that by 2010 the emissions will increase slightly by 1.6%from the year 2000, followed by a further increase of 3% at the year 2020 (from the year 2010) and then a decline of -4.4% at the year 2030 (from the year 2020). Generally, the overall increase in the industrial emissions in the year 2030 does not exceed significantly the emissions of 2000 level, just 0.4% higher in three decades. On the contrary, energy demand for the same period increases by 18.6%. This significant difference is mostly due to structural shifts towards less energy intensive uses in the industry combined with improved energy efficiency via technological progress and changes in the fuel mix.

Looking at a regional level, energy efficiency opportunities are examined for the Dutch energy intensive industry and refineries with a time perspective up to 2020 (Daniels 2005). Based mainly on policy measures and pressure caused by them, emissions from Dutch industry seem to increase considerably at a value of 11.9% from 2000 levels when refineries as well as construction and energy sector are not included. When industrial emissions are enhanced with emissions from construction and the refineries (so covering the whole industrial sector), the increase in percentage is even higher. The rather significant raise of 16.15% is projected for the year 2020 compared with the year 2000, due to low policy pressure mainly to the power generation sector and to the industry.

Despite having all these technological improvements being technically feasible, at the same time they are not always economically reasonable to be implemented. Even more sincere is that many of the policies assumed in the scenarios above will have an effect beyond the 2030 timeframe, because of the long lifetime of the energy-using capital stock. Pinpointing this situation is that the lifespan for power plants is 40 years or more, while building structures is possible to last many years, exceeding in some cases the already said timeframe (IEA 2006). In the power sector, there is also the possibility of fuel switching, but constraints on fuel delivery systems and available generating capabilities for alternative plants are factors that are limiting this alternative solution (Söderholm 2000). However, when switching from coal fired to gas fired power generation, it contributes between 5% and 7% of the total reduction in carbon dioxide emissions globally in the baseline scenario to 2050, reported by IEA (2006). But when it comes to Europe, the share of fuels and technologies in electricity generation is projected to remain mainly unchanged at least up to 2020 (Viguier 2001).

Furthermore, it should be noted that there is very limited information on mitigation potential and cost in the industry, as there are not many available studies that include economic aspects on potential improvements. A general overview of these reports is made from IPCC (2007), where the potential cost for CO_2 mitigation is separated by product, in different meaning by industrial sector and implemented into the two scenarios of global energy use explained above, A1 and B2 and part of these results can be seen on the table above (Table 2). The main assumption of this overview is that current trends will continue until 2030 and uncertainties are the rate of technology development and diffusion, the cost of future technology, future energy and carbon prices and the level of industrial activity in 2030 and of course the policies that are to be implemented.

The first sector examined is the Iron and Steel industry. By being a very large contributor of emissions due to energy intensity of steel production and the high volume of products (IEA 2007), it is very important to investigate its mitigation potentials and its cost range. Despite the great differences in the average efficiencies around the World between OECD (Organization for Economic Co-operation and Development) and industries in China, India, Russia and Ukraine which account almost to half of the global production, there is no great difference in the cost of CO_2 reduction. The cost ranges from 74$/t C to 185$/t C and the mitigation potential is ranging from 15% to 40% for OECD countries and 25% to 40% for the rest of the world (IPCC 2007).

In this analysis, there is also another technique that is studied separately for its reduction of emissions potential. It is the Carbon Capture and Storage method (CCS), which adds to the CO_2 mitigation. With similar cost range, less than 185$/t C, it has less mitigation potential, about 20%, so it can be noted as a second option or an enhancement for further reduction.

Of higher cost and with less mitigation potential is the primary aluminium, accounting to more than half of the energy used for Non Ferrous Metals (IEA 2007). Energy use with existing technology can be reduced to 6% to 8% to some processes and even 15% in its total production compared with current best practice (IEA 2007). The CO_2 mitigation potential is on the level of 15% to 25%, with a rather significant cost that can reach 370$/t C, the highest found in this analysis (IPCC 2007). Also, in this case there is not any research on carbon capture and storage, if first of all this is possible at its processes. Something interesting from the aluminium case is the fact that there are not regional differences in the potential mitigation and an indicator of this situation is that Africa has the most energy efficient aluminium smelter worldwide. This fact is very significant if we take into account that electricity consumption in smelters amount about 3.5% of the world's total electricity use (IEA 2007).

As it is already mentioned, Cement Industry is a sector with a very high energy saving potential. This is also represented by its high mitigation potential, where values of the level 40% are shown and starting from the very low levels of 11%. However, the cost of this reduction can play a significant role as it can reach the price of 185$/t C (IPCC 2007). For this report it is a very big part of Non Metallic Minerals sub sector, consuming around 70% to 80% of the total energy used in this sub sector (IEA 2007).

For Cement Industry, there is also carbon capture and storage survey done. The results however are not very positive, as the cost is pretty high, prices of the level of 370$/t C, with very low mitigation potential on the level of around 6%. Rather disappointing when comparing with the previous methods, techniques or technologies (IPCC 2007).

Another very important sector is Chemical Industry and in this case it is shown with Petrochemical Industry. In this overview, ethylene from Petrochemical Industry and ammonia from Chemical are examined. Taking a closer look at the reason behind this choice, it is found that ethylene production alone consumes roughly 30% of the total sector's energy, while ammonia production consumes more than 1% of the world's energy and almost 20% of the energy used in Chemical Industry and 18% of the total Industrial CO_2 emissions (IEA 2006). In the combined sector the energy use is extremely high with a share of 30% of total global industrial energy end use (IEA 2007). Going into the potentials and costs, Ethylene has a mitigation potential of 20%, while Ammonia 25% with a cost at both of them below 20$/t$CO_2$ or 74$/tC (IPCC 2007).

Furthermore, another sector examined in this report (IPCC 2007), is Pulp and Paper Industry, which is the fourth largest industrial energy consumer with a share of 5,7%, despite the fact that the sector produces energy as a by-product, covering almost half of its own needs. It is also a sector that it has great mitigation potential and there is also the ability to carbon dioxide free at least theoretical (IEA 2007). This can also be the explanation for the relatively very low cost, below 74$/tC, for a high mitigation potential that can be achieved, up to 40%.

As already said and also it is very easily understood, industrial main target is the survival out of a very tough competition. In very difficult market conditions, where there is always a pressure to prices, investments on improved efficiency are not likely to be implemented, unless there is return for the investments to the companies. Unfortunately, this is the reality in many areas of the world, where public pressure, market demand and policy measures do not force the industries in cleaner solutions. So, it is clear that at least governments are the ones responsible to take policy measures in order to "force" the companies into cleaner solutions. But the question is what kind of rules and laws are needed for better results. The already implemented and in use measures are indicative in many cases of their success or incompleteness if there is long since their implementation and can be used as "drivers" towards their further development or adaptation to the different situation and conditions.

I.2.3 Policy options: Experiences and effectiveness of different policy measures

It is very difficult to identify which is the best policy measure to implement in each case and mistakes are not costless in such situations. Differences in social structures, in culture as well as power and decisiveness of governments and economical conditions of countries or regions are factors that are able to alternate the policies significantly. Despite all these peculiarities, some more "general" rules are also somehow implemented with aggregated targets so as to have a total boundary of emissions. Also, some country based and some regional measures are implemented and are presented later in this chapter. But there is great variety of policy measures that can be used at all situations and most of them fall into some of the following categories (Lund 2006), all related to social and environmental issues:

- legislative and regulatory policies
- research and technology development
- fiscal measures
- information dissemination and awareness raising
- other assisting or voluntary measures

It is more than clear that these categories are highly co-related and sometimes they can be assumed to belong to more than one category, so a general overview of all these is presented. Moreover, distinguishing the effects and by so the effectiveness and efficiency of different policies, international or domestic, from other changes in the economy is very difficult and very tricky as they are very highly correlated (Sterner 2003).

First of all very important and indicative for further actions are the global drivers-instruments such as the Clean Development Mechanism (CDM). With starting year 1997 and developed by United Nations Framework Convention on Climate Change (UNFCCC) under the Kyoto Protocol, that many countries agreed and signed, so as to have some emission reduction credits according to the ones given when they signed the

Protocol. With this tool, developed countries gain emission reduction credits when they invest to green programs that reduce Green House Gases in poor countries (IPCC 2007). Up to February 2008, more than 900 projects throughout the whole world are registered and there is also some projects requiring registration to be part of the Mechanism and gain all the benefits from the emission reduction. The total annual Carbon Emission Reductions (CERs) amounts at around 195Mt in annual average and around 1000 projects and it is expected to extend more than 3000 projects and CERs of more than 2.7 Gt of Carbon at the year 2012 (UNFCCC, 2008). Another concept mentioned by UNFCCC is the Joint Implementation (JI) for economic developed countries or even businesses that belong to these countries for reducing their Green House Gases emissions, but with less effectiveness as there is not any credit exchange up to 2008 (IPCC 2007).

Another very important policy instrument with great effect in the industries is the voluntary agreements. They can be defined as formal agreements that are essentially contracts between government and industry that include negotiated targets with time schedules and commitments on the part of all participating parties (IEA 1997). Experience from many countries and industries for many years, since the early 1990's when they were first been implemented indicate their positive effects in multiple areas, either on attitude, on market or directly for environmental benefit, especially on the latest agreements. Countries such as France and Finland were the first that implemented these policies, with less success due to lack of experience in their design for it and they were later followed by Netherland, Denmark and U.K. with great success and remarkable energy savings as well as carbon dioxide emission reductions. This effectiveness is also found on Industry sectors that applied the same method for their improvement (IPCC 2007).

Financial instruments are also used for carbon dioxide emission reduction, but there is limited experience with taxing industrial GHG emissions. The strong opposition that can be faced from the industrial sectors is a reason for the small use of this policy. Examples and experience on this policy is found from Sweden and Germany, which have tried to introduce energy taxation as part of a more general tax reform. In Sweden, the initially high taxes where lowered after the argument of the local Industries, demonstrating its lobbying power in the area. The same situation took place in Germany, where the initially tax where much higher than the ones finally implemented (Sterner 2003).

Despite this experience, examples from Sweden, Norway and Denmark indicate that carbon-energy taxation is a policy tool that can be used for decoupling of carbon emissions from economic growth. A study with the reactions of the sector of energy intensive industries is made (Enevoldsen 2007) when this policy is applied. Very important aspect is that this policy has been practiced in these countries since the early 1990, so some more clear conclusions can be made. Despite the small differences that appear in these three countries, it is clear that a carbon tax and especially in Sweden will encourage considerable reductions in the overall energy consumption. The only drawback found is the very inelastic demand for electricity and CO_2 taxes which will have only limited effects with respect to reducing electricity consumption.

Furthermore, instead of taxes, subsidies can be given to industries in order to reduce their emissions although it is considered as a "bad" instrument because it is based on a victims pay principle and is possible to be faced by strong opposition from the society (Sterner 2003). On the other hand, it can motivate companies in order to invest and develop cleaner technologies, improve their Research and Development (R&D). With different forms, fixed amounts or a percentage of the investment, are implemented in many countries with positive feedback. Evaluations indicate that subsidies in the industrial sector may lead to energy savings and GHG emission reductions and at the same time create incentives for energy efficient technologies (IPCC 2007).

Section II

Estimates of energy price elasticities in European industry

II.1 Method and data

In this section, the methodological approach for estimating energy price elasticities is presented, as well as the data used in order to make these calculations possible.

II.1.1 Method

In order to find answers to the questions on future energy demand and its emissions, an econometric analysis was carried out in order to estimate own-price energy elasticities. More specifically, a regression analysis is the tool used, including the use of energy (so it can be said at the same time as demand), the independent price in each case, the time lag that can appear in the demand after alterations in prices or any other condition that can affect the demand and also the autonomous efficiency improvement of the technology in general. Regression analysis is the analysis of the relationship between one variable called the explained or dependent variable and in this case three other variables called independent or explanatory variables (Gujarati 2006).

But it is not just elasticities the only outcome. Another important parameter calculated through this analysis is the autonomous efficiency constant. The latter expression is generally understood to describe the changes taking place in the energy demand in which technological development is a crucial factor (Yates 1995). It is also a parameter that is uncorrelated with energy prices and its changes and it is supposed to include the differences in energy use that take place after structural changes that take place in branches.

For regressions analyses including autonomous efficiency improvement constant, the analytic formula was:

(1) $\varepsilon_{i,b,r}= d_{i,b,r} * P_{i,b,r}^{\alpha} * e^{a*t}$

this takes the form of

(2) $\ln\varepsilon_{i,b,r} = \ln d_{i,b,r} + \alpha*\ln P_{i,b,r} + t*a$

and then when consumption with time lag is added to the model the formula takes the form

(3) $\ln\varepsilon_{t, i,b,r} = \ln d_{i,b,r} + \alpha*\ln P_{i,b,r} + t*a + \lambda*\ln\varepsilon_{t-1}$

Similarly, without efficiency the formulas 1, 2, 3 take the form

(4) $\varepsilon_{i,b,r}= d_{i,b,r} * P_{i,b,r}^{\alpha}$

(5) $\ln\varepsilon_{i,b,r} = \ln d_{i,b,r} + \alpha*\ln P_{i,b,r}$

(6) $\ln\varepsilon_{t, i,b,r} = \ln d_{i,b,r} + \alpha*\ln P_{i,b,r}+ \lambda*\ln\varepsilon_{t-1}$

and by so having a multiple log-linear regression model, where

ε= energy use per value added
P= energy price
t= time
a= autonomous efficiency improvement constant
d= general constant
α= elasticity (short term)
$\lambda* \ln \varepsilon_{t-1}$= lag factor
i= energy category
b= industry branch
r= region

This formula is used for all energy categories and for all branches and for both regions, EU 15 and NMS10. Also, separate regression analyses for Poland and Czech Republic are carried out, as they are the larger contributors of the New Member States and at the same time there is sufficient data available for these two countries. That situation makes the decision and selection even more convenient for further analysis and also comparison of the results between these two representatives of the New Members with the old ones, if of course it is reasonable to do so.

The time period selected for doing the regression analysis presented in this report is the decade 1980-2004, but due to data limitations regression analyses were also made for all regions from the year 1990 or from the year of the first available data in each situation. In some cases, regressions results for the period 1980-2004 were similar to the results of the period 1990-2004, as there is no data for the whole period in most of the branches and in some sectors the available data are alike the ones of the period 1990-2004.

II.1.2 Data methodology

With the use of the formula above (formula 3) and by having the data for energy use per value added, as dependent variable without time lag and as independent variable with time lag in this formula, and energy prices, independent variable, it is possible to estimate the price elasticity both the short term and the long term for all branches and regions as well as from any kind of source and electricity. The ODYSSEE database provides data for each branch and region for energy use and value added for this step of calculations. The data ranges from the period 1980 to 2004 for EU 15 and 1990 to 2004 for NMS10 and the calculations made are from this database, but due to big differences in energy prices through this period, the data used in this report starts from 1995 as the main results of this study.

Concerning the energy prices, the ones from the International Energy Association (IEA) are used as the ones from ODYSSEE database were not given in their new set of data. These values are price indexes and not prices as mention in the previous section when viewing the price variances over the years (Chapter I.2.1). This means that a reference year is selected and assumed a price of 100% and then the rest of the years are percentages of this year.

When mentioning branches, it is better to categorize them according to the NACE coding system of industries, where all similar industries are separated into larger sectors and then given a code for easiness and quickness of reading. A full representation of the branches analyzed in this report related with this system is given in Table 3.

Table 3. Branches categorized by NACE (Rev. 2) coding system in Odyssee database

No	Code	Sector	Name of Branch in Odyssee
	B	Mining and quarrying	
	C	Manufacturing	
	C 10,11,12	Manufacturing	Food
	C 13,14,15	Manufacturing	Textiles and leather
	C 17,18	Manufacturing	Paper, printing
	C 19,20,21,(22)	Manufacturing	Chemicals (Rubber and plastic)
	C 23	Manufacturing	Non metallic mineral including cement and glass
	C 24	Manufacturing	Primary metals(including steel and non ferrous metals)
	C 25,26,27,28,29,30	Manufacturing	Equipment goods including machinery, fabricated metals and transport equipment
	C 16	Manufacturing	Wood industry
	C 31,32,33	Manufacturing	Other industries

Source: Odyssee database, Eurostat

In the ODYSSEE data base, the branch denoted "Industry" seems to cover not only manufacturing and mining, but also generation and other sectors not in focus of this report and by so not presented in this table (Table 3). Furthermore, the branch named "Other industries" can be assumed that include all industries that could not be fitted in the list above and are gathered under this name and is also included in the manufacturing sector. Another point identified in this database is the unclearness of the each time named branch and what is included each time, which in this report is covered by some assumptions in each case. One of them is that the "Manufacturing" branch is assumed to be the "Total" for the purpose of this report, as it is the aggregated branch of all branches available in the ODYSSEE database, except "Mining", which values are rather small when compared with the ones of the "Manufacturing".

Another point that should be cleared from the ODYSSEE database is the concept "Total" in the energy sources. As already mentioned (Chapter I.2.1), is the aggregation of “Coal”, “Oil”, “Gas”, “Electricity”, which are examined in this report enhanced with “Biomass” and “Heat”.

Furthermore, in the analysis of the results some basic concepts of the regression analysis are mentioned in order to simultaneously present the robustness and the accuracy of the calculations and of the results. All these calculations of the regression analysis are made with Microsoft Office Excel. All the important statistics that appear in the results table in Chapter V (Appendices) of these calculations are explained below.

The first and maybe the most important concept is the R^2 (R square) or the coefficient of determination. It measures the goodness of fit, how much in percentage the one side of the equation can be expressed by the other side of the equation with the input values, the parameters and the coefficients, but by itself it does not say if the coefficients are statistically significant (Gujarati 2006).

Another important value that has to be mentioned is the P-value or the probability value and is also known as the exact significance level of the test statistic. This can be explained as the lowest significance level at which a null hypothesis can be rejected. By saying null hypothesis it is assumed the hypothesis testing done for an analysis and assumed true unless statistical test proves it wrong (Gujarati 2006).

Also, the so called T-stat or test statistic, which is the coefficient divided by the standard error and gives the level of similarity or difference between the samples. It is the one that is presented in the tables of the results on Chapter II 2. It is also important to mention that this value should be as high as possible, but each time the level depends on the number of data points, the degree of freedom and the error to reject a hypothesis when it is true (Type I error) (Gujarati 2006).

Furthermore, F value should also be mentioned and is presented in the validity of the results, as it is often used to compare the variances of two populations. It is also known as the variance ratio distribution and in simple worlds it demonstrates the times the average variation that is explained is bigger that the unexplained.

But F value can not give many details by its own, if it is not accompanied by F-significance. This value represents the chance of getting a ratio of the F value from pure chance variation. So, the closest to zero is this value, the best for the validity of the result it is. It is also a validation tool for the results and by being so it is represented in the validation analysis tables in Chapter V (Appendices) as all the values mentioned above.

II.1.3 Compilation of data sets for regression analyses

Before going to the main formula, its parameters, variables, have to be calculated in order to be placed in the formula for doing the main calculation. In this case, the estimation of price elasticity is of prior concern and the main focus of the results is based on this coefficient.

The first parameter to be calculated is the consumption that it has to be divided per its relevant “value added”. It is an economic ratio, also referred to as energy intensity and it is used for higher level of aggregation such as a whole sector in this case (WEC 2008).This is a way of measuring energy requirements and trends in the industries (UN 2003), which are the required parameter in this formula. In other cases, by dividing energy consumption with the output production of each industry there is a better view of the efficiency of the specific industry, which does not fit the purposes and the model of the formula. For the easiness of comparison and compatibility with the energy intensity of each fuel, the unit is transformed into Mega joules per euros of the price of the year of 2000(MJ/€2000).

The second parameter is the price of energy, different in each case for "Electricity", "Coal", "Gas" and "Oil" given in price indices. This means that there is a year which is selected, in this case the year 2000, and given a value of 100% and the rest of the years it is a percentage of this value. Also, in the database included there are average values for total energy, which are used for the regression analysis of the total energy consumption. These numbers were taken from the International Energy Agency (IEA) database. The drawback of this database is the lack of prices for each industry independently and independent prices for the New Member States (NMS10 10 for the purpose of this report). So, a total average for all industries for a specific fuel source is used which may imply a variation in the accuracy of the results and prices from European Union of the 15 are applied for the new member states.

The other parameter in the formula is the energy consumption that occurs after the implication of different measures, variations in prices or other circumstances like e.g. weather or expected changes in demand that may happen at industries. It includes the idea of time lag, the time needed in order to implement these changes in the production or in the product. In this report and for the well being of the results, this time lag is one year. This means that the consumption that is observed e.g. in the third year and is placed in the left part of the equation in the formula, the same consumption in the right part of the equation is counted as the fourth year. By this way, the first year of the consumption without the time lag cannot interpret in the results as there is no value for the consumption with the time lag. In case of a bigger time lag, e.g. of two or more years, more data will be needed for the regression analysis as the starting point is always the first year of the available data in all years.

The last parameter of the formula is the autonomous efficiency improvement. In terms of simplicity and due to the fact of the small impact to the results, although at the same time rather significant so it cannot be neglected but when comparing with the contribution of the rest of the variables its effect is rather small, it is assumed to have a time step relation. Each year value is the value of the previous year autonomous efficiency improvement and another unit added to it. By this way it is tried to simulate in general terms the efficiency that occurs in reality, or even better the way it changes through time.

Having completed these calculations of the parameters and by doing the regression analysis of the formula by using Microsoft Excel, all the coefficients can be calculated and are given in a table from the software used for making the analysis.

II.1.4 Calculation of short and long term own-price elasticities

A very significant and important value in this study is the own-price elasticity. It specifies how price affects the market, in this case the consumption of energy. For example, an elasticity of -0, 5 imply that the demand for the specific product is reduced by 0.5 per cent for every 1 per cent increase in the price of the same product.

This value is derived directly from the regression analysis of the formula already said in the methodology ($\ln \varepsilon_t = c + \alpha * \ln P + \lambda * \ln \varepsilon_{t-1} + t*a$) as it is the coefficient α. By being the coefficient of the natural logarithm of price, it is the slope that indicates the importance of the price in the final consumption of energy and how it is affected by different consumptions (Gujarati 2006) as it is a log-linear model and this condition only exists in double log and log-linear models.

After the calculation of the short term elasticity, the long term elasticity can also be calculated from the short term elasticity and the coefficient of the time-lag consumption, by a very simple formula ($A=\alpha / (1-\lambda)$, where A equals the long term elasticity). Although this term is very sensitive and can vary significantly over time, it is very important to know the general trend throughout the years which is expressed via this value.

II.2 Results

After completing the calculations of all the parameters, the results of the own price elasticity, the short as well as the long term, are estimated and presented in this chapter. Further analysis will follow in the next sub sections.

II.2.1 Regression analysis results: EU 15 for time series 1980-2004

The regression analysis is made by using the average values for energy prices and by having the "Total Energy" consumption from all fuels and sources with data ranging for the year 1980 to 2004 in this case. This time period is the targeted era of this report and the results from the period 1995-2004 are presented as a measure of comparison with the elasticity prices presented in this section. Also, as already said before, the time period is not fully covered in all branches and in some there is absolute coinciding with the ones of the period 1990-2004. Furthermore, when saying "Total Energy" in this report it is assumed aggregated energy from all sources available in the ODYSSEE database: "Oil", "Coal", "Gas", "Electricity", "Heat" and "Biomass". Moreover, "Manufacturing" branch can be assumed to be the "Total" when it comes to emissions and consumption as already said (Chapter II.1.2).

Going to the results, they are given in two tables (a and b respectively); the first is with efficiency improvement included and the other table is without it included in the calculations. For the easiness of the comparison, the results of the elasticity of the regions or countries are given side by side for each case. Also, T-stat value is included in each box of the table in the parenthesis for the short term elasticity and it should be reminded that the higher the T-stat value the best for the validity of the results, the absolute value of T stat (|T|) the more it deviates from zero the closest the reader is to reject the null hypothesis. It is decided to present this value in the tables in order for the reader to make a small validation analysis simultaneously when examining the results. The tables with the results are shown below.

Table 4a. Short and long term own-price elasticity of EU 15 for the time period 1980-2004 with autonomous efficiency improvement constant included in the regression analyses. T-stat is presented in the parenthesis (NACE Rev.2)

Branch (NACE codes in parenthesis)	Short term elasticity (α).T-stat in parenthesis					Long term elasticity (A).				
	Total energy	Coal	Gas	Electricity	Oil	Total energy	Coal	Gas	Electricity	Oil
Manufacturing C	0.12 (1.7)	0.4 (4.94)	-0.42 (-1.8)	0.02 (0.37)	0.41 (1.17)	0.14	0.39	-0.45	0.01	4.65
Mining B	-0.4 (-0.5)	1.4 (1.3)	-0.5 (-1.5)	-0.45 (-0.8)	0.8 (3)	-2.8	5	-1.72	-2.23	1.27
Food C10,11,12	0.23 (1.15)	0.13 (0.21)	-0.15 (-1.6)	-0.17 (-2.5)	0.006 (0.02)	0.18	0.66	-0.18	-0.17	0.008
Textile and leather C 13,14,15	0.77 (5.45)	2.2 (2.85)	-0.18 (-1.4)	-0.17 (-2.5)	0.22 (0.59)	0.59	1.78	-0.14	-0.15	0.23
Paper, printing C 17,18	0.08 (0.57)	0.53 (1.68)	-0.4 (-1.8)	-0.13 (-1.3)	0.14 (0.32)	0.07	0.66	-0.45	-0.15	0.33
Chemicals C19,20,21,22	0.556 (1.85)	2.293 (2.13)	-0.12 (-0.9)	0.055 (0.53)	1.94 (1.55)	1.02	3.8	-0.12	0.12	15.7
Non-metallic minerals C23	-0.09 (-0.5)	0.13 (0.64)	-0.06 (-0.6)	0.1 (1.23)	0.3 (1.18)	-0.08	0.12	-0.05	0.14	0.38

Continue from Table 4a

Branch (NACE codes in parenthesis)	Short term elasticity (α).T-stat in parenthesis					Long term elasticity (A).				
	Total energy	Coal	Gas	Electri city	Oil	Total energy	Coal	Gas	Electri city	Oil
Primary metals C24	0.07 (0.41)	-0.04 (-0.3)	-0.1 (-0.8)	0.08 (0.77)	-0.22 (-0.5)	0.08	-0.04	-0.11	0.09	-0.49
Steel	-0.02 (-0.0)	0.51 (1)	-0.45 (-2.2)	0.08 (0.35)	-0.42 (-0.9)	-0.02	0.6	-0.4	0.11	-0.75
Non ferrous metals	-0.18 (-0.4)	-0.21 (-0.2)	-0.39 (-2)	-0.24 (-1.2)	0.88 (1)	-0.41	-0.7	24.6	-0.55	1.14
Equipment goods C25,26,27,28,29,30	0.13 (0.72)	0.23 (0.29)	0.22 (1.81)	0.008 (0.1)	0.18 (0.53)	0.12	1.67	0.2	0.008	0.33
Other industries C31,32,33	0.46 (0.31)	0.99 (0.83)	-1.17 (-1.5)	0.09 (0.21)	0.59 (0.6)	2.41	1.07	-1.48	0.18	3.5

Similarly, the table without autonomous efficiency constant included in the calculations follows (Table 4b).

Table 4b.Short and long term own-price elasticity of EU 15 for the time period 1980-2004 without autonomous efficiency improvement constant included in the regression analyses. T-stat is presented in the parenthesis (NACE B+C)

Branch (NACE codes in parenthesis)	Short term elasticity (α).T-stat in parenthesis					Long term elasticity (A).				
	Total energy	Coal	Gas	Electri city	Oil	Total energy	Coal	Gas	Electri city	Oil
Manufacturing C	0.03 (0.34)	0.22 (1.9)	-0.06 (-0.9)	-0.07 (-1.7)	0.22 (0.68)	0.3	3.56	-0.11	-0.13	-2.62
Mining B	-0.1 (-0.3)	1.02 (1.1)	-0.57 (-1.7)	-0.34 (-0.8)	0.41 (2.5)	-0.43	6.28	-3.67	-1.79	1.12
Food C10,11,12	0.006 (0.03)	-0.12 (-0.2)	-0.06 (-0.6)	-0.17 (-1.9)	-0.74 (-2.2)	0.041	-0.462	-0.68	-0.76	-1.49
Textile and leather C 13,14,15	0.86 (7.94)	0.68 (0.57)	0.11 (0.63)	-0.25 (-1.7)	-0.3 (-1.7)	0.67	3.43	0.522	-0.53	-0.53
Paper, printing C 17,18	0.13 (0.71)	0.72 (1.9)	-0.04 (-0.4)	-0.12 (-1)	-0.21 (-0.5)	0.96	-373	-0.24	-0.74	-1.12
Chemicals C19,20,21,22	0.22 (1)	1.23 (1.2)	-0.23 (-1.5)	0.07 (0.7)	0.85 (0.84)	2.5	8.6	-0.78	0.58	-28.6
Non-metallic minerals C23	-0.37 (-2.9)	0.42 (0.98)	0.04 (0.25)	-0.02 (-0.2)	0.06 (0.8)	-0.3	-8.01	0.16	-0.13	0.11
Primary metals C24	0.07 (0.39)	-0.34 (-1.3)	-0.11 (-0.8)	0.15 (1.37)	-0.46 (-1.4)	0.69	-0.44	-0.29	0.42	-1.21
Steel	-0.19 (-0.7)	-0.24 (-0.5)	-0.32 (-1.3)	0.11 (0.66)	-0.72 (-1.6)	-0.63	-0.45	-0.81	0.2	-2
Non ferrous metals	0.17 (0.94)	0.61 (1.04)	-0.33 (-2.5)	-0.24 (-1.9)	-0.22 (-0.2)	0.28	3.9	4.8	-0.56	-1.04
Equipment goods C25,26,27,28,29,30	-0.44 (-2.5)	0.14 (0.27)	0.01 (0.11)	-0.1 (-1.5)	-0.09 (-0.3)	-0.38	1.33	0.01	-0.11	-0.69
Other industries C31,32,33	-0.56 (-0.6)	-0.3 (-0.2)	-0.63 (-1.1)	0.39 (1.2)	-0.4 (-1.1)	-1.46	-0.38	-0.86	1.2	-1.2

Another indispensable value that is shown in the next table (Table 5) is the autonomous efficiency improvement constant, which is also a part of the results of the regression analyses and its role is distinguished in order to identify its importance and if this concept is really related and correlated with changes and differences in energy use. The value of the autonomous efficiency improvement constant for this time period (1980-2004) for EU 15 is presented in the following table, Table 5, for all sources and for all branches examined in this report.

Table 5. Autonomous efficiency improvement constant for EU15 for the regression period 1980-2004 (NACE Rev 2)

Branch (NACE codes in parenthesis)	Autonomous efficiency improvement				
	Total energy	Coal	Gas	Electricity	Oil
Manufacturing C	-0.005	-0.064	0.013	0.005	-0.012
Mining B	0.006	-0.020	0.019	-0.003	-0.009
Food C10,11,12	0.009	-0.018	0.025	0.015	-0.035
Textile and leather C 13,14,15	0.002	-0.148	0.052	0.019	-0.024
Paper, printing C 17,18	0.022	-0.058	0.031	0.014	-0.020
Chemicals C19,20,21,22	-0.024	-0.099	-0.020	-0.013	-0.050
Non-metallic minerals C23	-0.005	-0.063	0.022	0.007	-0.008
Primary metals C24	-0.010	-0.016	-0.008	-0.009	-0.010
Steel	-0.015	-0.036	-0.019	-0.002	-0.024
Non ferrous metals	0.006	-0.021	0.003	3.9E-05	-0.085
Equipment goods C25,26,27,28,29,30	-0.012	-0.007	-0.009	0.004	-0.029
Other industries C31,32,33	-0.013	-0.053	0.022	-0.01	-0.026

By having this data, there is a broad overview of the results and the trends of the last decades and by so the differences with shorten but more “updated” results can be seen and analyzed.

II.2.2 Regression analysis results: EU 15 and NMS10 for time series 1995-2004

Going to the comparison of the results between the periods for this report, regression analysis is made with data from the period 1995 to 2004. It is important to mention the fact that the amount of years is not enough in order to have very realistic values. Enhanced to this condition is the fact that the actual first year included in the calculations is the year 1996, as the consumption with one year time lag is included in the formula when performing the regression analysis and which further reduces the data for the calculations. These results are indicative of more current trends than the ones of the period 1980 to 2004 but are used for comparison as it is difficult to reveal real trends and real values with short time data. The list with the results of the regression analysis of “Total Energy” for all countries and regions overviewed in this report follows.

Table 6a. Short and long term own-price elasticity for the time period 1995-2004 with autonomous efficiency improvement constant included in the regression analyses for “Total Energy”. T-stat is presented in the parenthesis (NACE Rev.2)

Branch (NACE Codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Manufacturing C	0.16 (1.55)	1.26 (1.5)	0.65 (1.94)	-0.01 (-0.02)	0.19	4.48	2.79	-0.03

Continue from Table 6a

Branch (NACE Codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Mining B	0.53 (0.96)	0.82 (0.87)	0.27 (0.35)	-1.63 (-0.7)	0.48	1.13	0.27	-1.5
Food C10,11,12	0.1 (0.4)	2.7 (1.9)	0.8 (0.74)	-0.69 (-0.35)	0.08	10.8	1.57	-0.85
Textile and leather C 13,14,15	0.36 (1.5)	0.36 (0.34)	1.1 (1.5)	-1.43 (-1.42)	0.23	0.93	2.69	-1.28
Paper, printing C 17,18	0.56 (2.6)	1.55 (1.1)	1.9 (3.5)	0.03 (0.02)	0.52	2.88	10.6	0.03
Chemicals C19,20,21,22	0.29 (0.6)	1 (2.5)	0.46 (2)	2.4 (2.6)	0.94	0.92	0.4	2.4
Non-metallic minerals C23	0.002 (0.007)	1.19 (1.3)	1.25 (1.97)	0.22 (0.3)	0.003	4.2	8.7	0.54
Primary metals C24	0.58 (2.5)	0.7 (0.75)	2.3 (1.99)	0.4 (0.32)	1.3	0.71	2.13	0.28
Steel	-0.21 (-0.42)				-0.29			
Non ferrous metals	0.059 (0.15)				0.052			
Equipment goods C25,26,27,28,29,30	0.04 (0.14)	1.42 (1.7)	0.41 (0.8)	0.32 (0.26)	0.05	11.3	1	0.55
Other industries C31,32,33	3.17 (2.3)	1.6 (0.7)	-1.24 (-0.88)	-1 (-0.48)	14.3	1.2	-1.3	-1

Table 6b. Short and long term own-price elasticity for the time period 1995-2004 without autonomous efficiency improvement constant included in the regression analyses for "Total Energy". T-stat is presented in the parenthesis (NACE Rev.2)

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Manufacturing C	0.08 (0.67)	0.83 (0.92)	0.56 (1.4)	0.03 (0.04)	-26.9	-6	-2.12	0.15
Mining B	0.62 (2.1)	-0.19 (-0.2)	-0.29 (-0.34)	-1.77 (-0.9)	0.58	-0.77	-1	-1.8
Food C10,11,12	0.27 (0.9)	0.26 (0.2)	-0.3 (-0.3)	0.53 (0.2)	0.35	7.3	-1.2	1.7
Textile and leather C 13,14,15	0.52 (1.4)	-0.16 (-0.21)	-0.07 (-0.09)	-2.3 (-1.7)	0.6	-0.9	-1.2	-6
Paper, printing C 17,18	0.68 (4.1)	-0.39 (-0.5)	0.5 (0.9)	-0.6 (-0.3)	0.8	-1	-7.8	-1.2
Chemicals C19,20,21,22	0.13 (0.51)	-1 (-1.6)	-0.53 (-1.5)	2.6 (2.7)	0.74	-1.8	-0.8	3
Non-metallic minerals C23	-0.22 (-1.8)	0.76 (0.83)	1.2 (1.65)	0.3 (0.4)	-0.31	-6.9	-3.3	1.76
Primary metals C24	0.2 (0.7)	0.2 (0.6)	1.56 (3.3)	1.35 (0.9)	-2.48	0.18	1.5	1.2
Steel	-0.38 (-1.3)				-0.6			
Non ferrous metals	0.28 (1)				0.3			

Continue from Table 6b

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Equipment goods C25,26,27,28,29,30	-0.25 (-1.8)	1.16 (1.4)	0.3 (0.52)	0.07 (0.06)	-0.32	-15.5	-8.3	0.14
Other industries C31,32,33	-0.14 (-0.1)	-1 (-1.2)	-1.8 (-2.5)	-1.93 (-0.71)	-0.6	-0.9	-1.96	-5.25

As it is most probably noticed through these tables is that the majority of the results turn out to be positive, an outcome that sounds unrealistic and unreasonable when dealing with price elasticity. This is an outcome that does not appear just to this series of the calculated results, but also at the rest of the results and can be supposed that are the majority after performing the regression analysis. Some possible explanations are given in the discussion sub chapter following (Chapter II 3.1).

Regression analyses are also made for “Coal” fuel used in the European Industry of the regions and countries mentioned above. The results of these analyses are also presented in two tables for each case of calculation method.

Table 7a. Short and long term own-price elasticity for the time period 1995-2004 with autonomous efficiency improvement constant included in the regression analyses for “Coal”. T-stat is presented in the parenthesis (NACE Rev.2)

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Manufacturing C	0.51 (4.2)	0.47 (0.71)	0.15 (0.73)	-1.23 (-1)	0.4	0.67	0.2	-1.15
Mining B	0.74 (1)	-2.1 (-1.2)	-0.6 (-0.5)	1.9 (1)	0.7	-2.7	-0.9	1.26
Food C10,11,12	-0.32 (-0.42)	0.98 (1.4)	0.4 (0.9)	-2.8 (-1.25)	-0.46	1.53	0.62	-2.4
Textile and leather C 13,14,15	1 (2.8)	0.39 (0.7)	-0.32 (-0.7)	-3 (-1.4)	0.6	0.6	-0.37	-3.6
Paper, printing C 17,18	1 (3.4)	0.67 (1)	0.7 (1.4)	0.6 (0.17)	1.9	0.62	0.71	0.7
Chemicals C19,20,21,22	2.72 (1.6)	0.27 (0.3)	-0.43 (-1)	-0.3 (-0.07)	4.5	0.25	-0.4	-0.42
Non-metallic minerals C23	0.31 (1.2)	0.61 (2.7)	0.4 (2)	0.57 (0.37)	0.44	0.68	0.7	0.54
Primary metals C24	-0.003 (-0.02)	1.4 (1.7)	0.65 (1.2)	0.9 (0.7)	-0.003	1.7	0.56	0.58
Steel	-0.15 (-0.54)				-0.15			
Non ferrous metals	-0.75 (-1.1)				-0.59			
Equipment goods C25,26,27,28,29,30	-0.01 (-0.02)	-0.14 (-0.14)	-0.2 (-0.65)	-2.2 (-0.34)	-0.02	-0.2	-0.26	-2.2
Other industries C31,32,33	-1.7 (-1.7)	-0.22 (-0.12)	-0.77 (-0.85)		-2.4	-0.19	-0.98	

Table 7b. Short and long term own-price elasticity for the time period 1995-2004 without autonomous efficiency improvement constant included in the regression analyses for "Coal". T-stat is presented in the parenthesis (NACE Rev.2)

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Manufacturing C	0.27 (1.6)	-0.22 (-0.32)	0.16 (0.33)	-2.38 (-2.1)	10.5	-2.74	-1.53	-4.52
Mining B	0.75 (1.5)	-2.6 (-1.2)	-0.4 (-0.24)	-0.75 (-0.32)	0.72	-14.3	-34	-2.7
Food C10,11,12	-0.4 (-0.69)	0.009 (0.01)	0.05 (0.1)	-4.9 (-1.6)	-0.59	0.2	5.8	-7.8
Textile and leather C 13,14,15	0.26 (0.4)	0.18 (0.24)	-0.65 (-0.82)	-4.2 (-2.2)	0.69	-4.5	-19.2	-12.1
Paper, printing C 17,18	1.14 (2.3)	-0.88 (-0.88)	-0.9 (-0.9)	-1 (-0.23)	-5.2	-3.2	-1.1	-5.8
Chemicals C19,20,21,22	1.16 (0.9)	-1.1 (-1.5)	-2.3 (-2.48)	2.94 (0.85)	5	-1	-1.8	7.3
Non-metallic minerals C23	0.35 (1.18)	0.43 (1.4)	0.44 (1.66)	-1.3 (-0.9)	-5.23	-15.7	-6.1	-5.3
Primary metals C24	-0.13 (-0.9)	1.19 (2)	0.97 (1.7)	2.37 (1.6)	-0.43	1.46	1.26	1.9
Steel	-0.25 (-1.43)				-0.28			
Non ferrous metals	-0.76 (-0.78)				-3			
Equipment goods C25,26,27,28,29,30	-0.37 (-0.76)	-0.89 (-1.72)	-0.3 (-0.85)	-5.74 (-1.5)	-1	-8.4	-86	-8
Other industries C31,32,33	-0.12 (-0.14)	-2.39 (-1.47)	-1.22 (-1.1)		-0.13	-4.49	-4.47	

In these analyses, it is noticeable that there are some results missing for Czech Republic in the "Other industries" sector. This is due to lack of data for consumption for one year, but still enough to make it difficult for the regression analysis to be made.

Ongoing with the presentation of the results, in this case the regression analyses are made from the consumption of "Electricity" in the industrial sector, which is supposed to be primary electricity in this study, information that is not given by the ODYSSEE database but is assumed.

Table 8a. Short and long term own-price elasticity for the time period 1995-2004 with autonomous efficiency improvement constant included in the regression analyses for "Electricity". T-stat is presented in the parenthesis (NACE Rev.2)

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Manufacturing C	-0.002 (-0.04)	0.52 (2.1)	0.33 (1)	1 (0.77)	-0.003	0.44	0.84	1.36
Mining B	0.28 (0.7)	0.9 (2)	0.85 (1.4)	6.5 (1.5)	0.29	1.9	3.6	-11.2
Food C10,11,12	-0.14 (-3.5)	0.7 (1.6)	0.18 (0.19)	1.8 (1.2)	-0.16	1	0.29	1.9
Textile and leather C 13,14,15	-0.19 (-1.6)	0.59 (1.9)	0.72 (1)	-1.5 (-0.5)	-0.22	0.5	1	-1.7

Continue from Table 8a

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Paper, printing C 17,18	0.05 (1)	1.54 (3.5)	1.7 (3)	-0.67 (-0.42)	0.04	1.5	5.2	-0.5
Chemicals C19,20,21,22	0.05 (0.28)	0.21 (1)	0.8 (2.4)	-2.3 (-1.3)	0.1	0.23	1.6	-4.1
Non-metallic minerals C23	0.24 (3.5)	0.92 (4.4)	1 (2.2)	-1.5 (-0.93)	0.3	0.9	2	-4.2
Primary metals C24	0.17 (1.2)	0.95 (2.4)	2.12 (1.6)	0.8 (0.4)	0.16	0.6	1.8	0.5
Steel	-0.29 (-1)				-0.26			
Non ferrous metals	-0.3 (-1.8)				-0.21			
Equipment goods C25,26,27,28,29,30	0.08 (0.9)	1.4 (5)	0.64 (1.8)	-1.3 (-1.5)	0.06	1	1	-5.1
Other industries C31,32,33	0.6 (0.98)	-0.3 (-0.31)	-2 (-1.4)	1.9 (0.7)	0.6	-0.2	-2.3	1.9

Table 8b. Short and long term own-price elasticity for the time period 1995-2004 without autonomous efficiency improvement constant included in the regression analyses for "Electricity". T-stat is presented in the parenthesis (NACE Rev.2)

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Manufacturing C	-0.02 (-0.47)	0.12 (0.4)	0.09 (0.3)	0.67 (0.94)	-0.05	0.84	-17.9	0.95
Mining B	-0.17 (-0.46)	0.85 (2.1)	0.26 (0.53)	1.3 (0.97)	-1	1.7	-87	-0.6
Food C10,11,12	-0.05 (-0.74)	0.93 (1.7)	-0.6 (-1)	0.4 (1)	-0.2	2.5	-1.1	0.48
Textile and leather C 13,14,15	-0.1 (-0.9)	0.38 (1.3)	-0.12 (-0.3)	-0.77 (-1)	-0.7	0.53	-0.3	-0.9
Paper, printing C 17,18	0.004 (0.03)	1.43 (2.58)	0.28 (0.62)	1.37 (2.76)	0.01	2.1	2.7	1.14
Chemicals C19,20,21,22	0.14 (1.3)	0.11 (0.37)	0.16 (0.6)	-1.4 (-1.4)	2.5	2.2	4.15	-2.2
Non-metallic minerals C23	0.18 (1.7)	0.58 (1.4)	0.33 (0.5)	-0.02 (-0.05)	0.5	5.22	-2.84	-0.05
Primary metals C24	0.08 (0.5)	0.8 (2.1)	1.6 (3)	-1 (-1.9)	0.3	0.5	1.5	-0.7
Steel	-0.24 (-1)				-0.24			
Non ferrous metals	-0.24 (-1.27)				-0.35			
Equipment goods C25,26,27,28,29,30	0.04 (0.46)	0.4 (1)	0.27 (0.6)	-0.38 (-1.2)	0.05	3.7	-2.9	-1.14
Other industries C31,32,33	0.23 (0.35)	-1.2 (-0.9)	-1.3 (-2.3)	3.74 (1.8)	0.8	-0.93	-1.4	3.7

The results missing in the steel and non ferrous metals sectors for all regions except EU 15, the only region with given data in the ODYSSEE database for these two sectors, are due to lack of data for these sectors in all parts of the calculations as it can be observed from the tables above and the ones following.

Furthermore, regression analyses are also made for the "Gas" consumption in the European industry, with and without autonomous efficiency improvement constant included in the calculations.

Table 9a. Short and long term own-price elasticity for the time period 1995-2004 with autonomous efficiency improvement constant included in the regression analyses for "Gas". T-stat is presented in the parenthesis (NACE Rev 2)

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Manufacturing C	0.11 (0.33)	0.54 (2.8)	0.09 (0.31)	0.33 (0.45)	0.1	0.88	0.17	0.46
Mining B	1.23 (1.3)	1.76 (2.4)	-0.14 (-0.3)	0.7 (0.4)	1.42	1.98	-0.33	0.52
Food C10,11,12	-0.07 (-0.5)	0.53 (0.7)	-0.35 (-0.21)	-1.43 (-1.3)	-0.1	0.82	-0.28	-2
Textile and leather C 13,14,15	0.08 (0.4)	0.32 (1)	0.26 (0.12)	-0.03 (-0.02)	0.06	0.34	0.3	-0.02
Paper, printing C 17,18	-0.24 (-0.8)	0.09 (0.1)	-0.53 (-0.4)	1 (0.7)	-0.23	0.09	-0.42	0.77
Chemicals C19,20,21,22	-0.09 (-0.4)	0.92 (1.52)	-0.18 (-0.34)	0.4 (0.4)	-0.1	1.4	-0.22	0.25
Non-metallic minerals C23	0.02 (0.1)	1 (3.2)	1 (1.8)	1.26 (1.8)	0.01	2.8	3.22	44.8
Primary metals C24	0.09 (0.48)	0.64 (2)	0.88 (0.96)	-0.76 (-0.8)	0.1	0.65	1	-0.45
Steel	-0.53 (-2)				-0.51			
Non ferrous metals	0.27 (1.3)				-0.96			
Equipment goods C25,26,27,28,29,30	0.08 (0.4)	0.47 (1.4)	0.27 (1.95)	2.15 (2.3)	0.06	1.33	0.35	-11.4
Other industries C31,32,33	0.6 (0.45)	0.29 (0.32)	1.1 (0.9)	2 (1)	0.58	0.33	1.34	4.72

Table of price elasticity, short and long term, with efficiency improvement included in calculations

Table 9b. Short and long term own-price elasticity for the time period 1995-2004 without autonomous efficiency improvement constant included in the regression analyses for "Gas". T-stat is presented in the parenthesis (NACE Rev 2)

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Manufacturing C	-0.06 (-1.13)	0.35 (1.2)	0.02 (0.06)	0.75 (0.94)	-0.06	-2.47	0.19	-13.5
Mining B	0.3 (0.8)	1 (3.3)	-0.2 (-0.4)	5.11 (1.9)	0.44	1.28	-0.55	5
Food C10,11,12	0.05 (0.4)	-0.06 (-0.18)	0.37 (0.42)	-1.7 (-1.95)	0.15	-0.08	0.3	-2.45
Textile and leather C 13,14,15	0.36 (1.8)	0.89 (4.3)	1.54 (1)	-0.9 (-0.55)	0.55	0.91	2.5	-0.88
Paper, printing C 17,18	0.07 (0.5)	0.02 (0.07)	1.52 (1.2)	1 (0.5)	0.1	0.02	2.7	119

Continue from Table 9b

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Chemicals C19,20,21,22	-0.2 (-2.04)	-0.2 (-0.19)	-0.77 (-2.44)	1 (1.3)	-0.6	-3.13	-1	0.74
Non-metallic minerals C23	0.22 (1.9)	0.44 (1)	0.32 (0.6)	1.2 (2)	0.24	-5.2	2.22	20.4
Primary metals C24	-0.13 (-0.7)	0.04 (0.19)	1.1 (2.14)	0.31 (0.32)	-0.26	0.05	1.3	0.21
Steel	-0.61 (-2.53)				-0.71			
Non ferrous metals	-0.35 (-2.56)				-8.5			
Equipment goods C25,26,27,28,29,30	0.06 (0.72)	0.2 (0.6)	-0.12 (-0.54)	1.2 (1.14)	0.05	1.88	-0.31	8.36
Other industries C31,32,33	-0.83 (-1.32)	0.49 (1.9)	0.88 (1.28)	-0.02 (-0.01)	-0.9	0.52	1	-0.18

Nothing specifically can be noticed from the listing of these results that are that different from the previous ones. Also, there is the same missing data in "Steel" and "Non ferrous Metals" branches, as in the previous tables and also the same mix of positive and negative values both in short and long term price elasticity.

Last but not least is the regression analysis made for the consumption of "Oil" and "Oil products" in European Industry and the results are presented the same way as the already showed above in this sub chapter.

Table 10a. Short and long term own-price elasticity for the time period 1995-2004 with autonomous efficiency improvement constant included in the regression analyses for "Oil". T-stat is presented in the parenthesis (NACE Rev 2)

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Manufacturing C	0.16 (0.37)	-1.1 (-2)	-0.43 (-1.95)	-1.12 (-1)	3	-1.15	-1	-0.95
Mining B	0.22 (0.64)	1.25 (0.63)	-0.53 (-0.9)	-0.46 (-0.15)	0.25	1.47	-0.71	-0.6
Food C10,11,12	-0.27 (-0.86)	0.097 (0.14)	0.24 (0.68)	-5.22 (-2.05)	-0.55	0.1	0.31	-2.4
Textile and leather C 13,14,15	-0.04 (-0.09)	-2 (-1.35)	0.23 (0.21)	-0.37 (-0.17)	-0.02	-2.33	0.17	-0.49
Paper, printing C 17,18	0.3 (0.57)	-2.74 (-4.32)	-0.62 (-0.67)	0.35 (0.1)	0.88	-1.64	-0.54	0.38
Chemicals C19,20,21,22	1 (0.54)	-1.34 (-1.33)	-1.13 (-1.7)	0.23 (0.13)	4.1	-4.6	-3.8	0.27
Non-metallic minerals C23	0.24 (1.97)	-2.33 (-2.38)	-1.97 (-2.24)	-0.32 (-0.39)	0.13	-9.7	-1.44	-0.26
Primary metals C24	0.01 (0.03)	-1.52 (-1.18)	0.69 (0.55)	-1.3 (-0.8)	0.02	-3.52	0.51	-1.8
Steel	-0.48 (-1.04)				-1.1			
Non ferrous metals	0.65 (0.48)				0.77			

Continue from Table 10a

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Equipment goods C25,26,27,28,29,30	-0.34 (-0.82)	-0.46 (-0.79)	-0.45 (-0.58)	-0.72 (-0.58)	-0.55	-0.24	-0.33	-0.4
Other industries C31,32,33	0.72 (0.58)	0.47 (0.25)	0.87 (1.4)	-2.79 (-0.43)	8.55	0.42	2.15	-4

Table 10b. Short and long term own-price elasticity for the time period 1995-2004 without autonomous efficiency improvement constant included in the regression analyses for "Oil". T-stat is presented in the parenthesis (NACE Rev 2)

Branch (NACE codes in parenthesis)	Own price short term elasticity (α).T-stat in parenthesis				Long term elasticity (A)			
	EU 15	NMS10	Poland	Czech R.	EU 15	NMS10	Poland	Czech R.
Manufacturing C	0.22 (0.69)	-1.37 (-3)	-0.29 (-4.3)	-1.3 (-1)	2.72	-1.8	-0.72	-3.4
Mining B	0.4 (1.5)	0.5 (0.56)	-0.09 (-0.44)	-2.1 (-1.02)	0.55	0.58	-0.13	-3.15
Food C10,11,12	-0.35 (-1.38)	-0.79 (-1.47)	-0.07 (-0.64)	-2.6 (-1.84)	-0.89	-1.3	-0.09	-1.6
Textile and leather C 13,14,15	-0.28 (-1.73)	-0.79 (-1.37)	0.67 (1.62)	-1.38 (-0.68)	-0.2	-0.75	0.46	-2.95
Paper, printing C 17,18	-0.04 (-0.08)	-3.36 (-6.4)	-1 (-2.15)	-2 (-0.64)	-0.22	-2.13	-0.88	-3.3
Chemicals C19,20,21,22	0.71 (0.66)	-0.32 (-0.66)	-0.39 (-1.09)	-0.85 (-0.67)	2.79	-0.94	-1.82	-1.17
Non-metallic minerals C23	0.36 (5.1)	-0.96 (-1.11)	-0.98 (-2.41)	-0.92 (-0.89)	0.2	-1.79	-0.72	-5.13
Primary metals C24	-0.15 (-0.38)	-1.03 (-1.56)	-1.1 (-1.75)	-0.71 (-0.65)	-0.74	-1.94	-0.88	-0.9
Steel	-0.49 (-1.14)				-1.47			
Non ferrous metals	-0.91 (-0.73)				-1.29			
Equipment goods C25,26,27,28,29,30	-0.38 (-1.21)	-2.69 (-1.91)	-1.61 (-2.56)	-1.96 (-0.89)	-0.69	-3.83	-1.83	-2.8
Other industries C31,32,33	0.37 (0.37)	-2 (-1.43)	-0.8 (-1.41)	-3.96 (-0.81)	32.8	-2.5	-2.3	-6.77

Another value that is important to be presented is the coefficient of the autonomous efficiency constant, as it is done for the period 1980-2004. It is a also an important coefficient despite the value which constantly remains very close to zero with very few exceptions but still not spamming significantly over zero, but still having a value that allows its interpretation in the formula. So, it is interesting and also more accurate to include this coefficient, as it is revealed in the next section from the significance statistics. It is a very interesting finding from this report to reveal the contribution of technological improvements in the final energy use as well as the changes that appear in energy use. The average efficiency improvement is also calculated for EU 15 and NMS10 and presented in Table 11a.

Table 11a. Autonomous efficiency improvement constant for EU 15 and NMS10 for regression period 1995-2004 (NACE Rev 2)

Branch (NACE codes in parenthesis)	Total energy		Coal		Oil		Gas		Electricity		Average	
	EU 15	NMS10	EU 15	NMS10	EU 15	NMS10	EU 15	NMS10	EU 15	NMS10	EU 15	NMS10
Manufacturing C												
Mining B	0.003	-0.052	0.000	-0.20	0.015	-0.033	-0.046	-0.036	0.035	0.003	0,001	-0.068
Food C10,11,12	0.011	-0.083	-0.005	-0.11	-0.008	-0.057	0.019	-0.028	0.013	-0.024	0.005	-0.055
Textile and leather C 13,14,15	0.018	-0.029	-0.125	-0.15	-0.011	0.059	0.034	0.028	0.015	-0.012	-0.021	-0.018
Paper, printing C 17,18	0.007	-0.059	-0.064	-0.14	-0.024	-0.036	0.026	-0.003	0.020	-0.023	-0.011	-0.049
Chemicals C19,20,21,22	-0.008	-0.078	-0.11	-0.063	-0.014	0.043	-0.017	-0.13	-0.013	-0.033	-0.039	-0.045
Non-metallic minerals C23	-0.006	-0.054	-0.049	-0.14	0.006	0.093	0.016	-0.070	0.007	-0.055	-0.005	-0.043
Primary metals C24	-0.018	-0.013	-0.020	-0.009	-0.032	0.029	-0.020	-0.034	-0.013	0.008	-0.021	-0.002
Steel	-0.007		-0.006		-0.009		-0.011		-0.003		-0.007	
Non ferrous metals	0.009		-0.091		-0.079		-0.034		0.012		-0.048	
Equipment goods C25,26,27,28, 29,30	-0.008	-0.039	-0.033	-0.16	0.003	-0.29	-0.001	-0.041	0.004	-0.10	-0.008	-0.15
Other industries C31,32,33	-0,088	-0,077	0,064	-0,18	-0,021	-0,15	-0,076	0,009	-0,042	0,056	-0,019	-0,065

Table 11b. Autonomous efficiency improvement constant for Poland and Czech Republic (NACE Rev 2)

Branch (NACE codes in parenthesis)	Total energy		Coal		Oil		Gas		Electricity	
	Poland	Czech R.	Poland	Czech R.	Poland	Czech R.	Poland	Czech R.	Poland	Czech R.
Manufacturing C										
Mining B	-0.10	-0.006	-0.23	-0.16	0.038	-0.085	-0.012	0.13	-0.049	0.20
Food C10,11,12	-0.091	-0.057	-0.11	-0.13	-0.028	0.069	0.043	-0.007	-0.049	0.038
Textile and leather C 13,14,15	-0.10	-0.095	-0.16	-0.13	0.032	-0.12	0.12	-0.043	-0.058	-0.020
Paper, printing C 17,18	-0.098	-0.065	-0.15	-0.18	-0.033	-0.19	0.22	-0.11	-0.094	-0.058
Chemicals C19,20,21,22	-0.074	0.015	-0.13	0.11	0.073	-0.061	-0.036	0.021	-0.063	-0.031
Non-metallic minerals C23	-0.079	-0.024	-0.13	-0.097	0.084	-0.29	-0.057	0.0021	-0.10	-0.034
Primary metals C24	-0.038	0.030	0.057	0.051	-0.16	0.031	0.013	0.029	-0.026	0.052

Continue from **Table 11b**

Branch (NACE codes in parenthesis	Total energy		Coal		Oil		Gas		Electricity	
	Pol and	Czech R.	Pol and	Czech R.	Pol and	Czech R.	Pol and	Czech R.	Pol and	Czech R.
Steel (1)										
Non ferrous metals (1)										
Equipment goods C25,26,27,28,29,30	- 0.084	-0.011	-0.22	-0.086	-0.16	-0.24	- 0.053	0.045	-0.11	-0.022
Other industries C31,32,33	- 0.034	-0.13	-0.13	(1)	-0.15	-0.11	- 0.013	-0.064	0.043	-0.052

(1)No calculations possible due to missing data from ODYSSEE database

By presenting these results, there is a complete list of all the coefficients from the regression analysis. Also, a small validation is made by showing the T-stat value for the short term elasticity, which as mentioned in the methodology section it gives the level of similarity or difference between the samples.

II.3 Discussion

II.3.1 Significance of regression analyses

When comparing the significance of the results, the first impression is the better fit and generally higher significance of elasticities when autonomous efficiency constant is included in the calculations than the ones that are made without it. This observation is a rather important outcome of this report, as it verifies that there is indeed difference in energy use due to technical development and that energy use is not affected just from the price.

Another important outcome after observing the results is that the values of the price elasticity in many cases are positive. This means in real life that when the price of the each time reference fuel increases, there is a simultaneous increase in the consumption of the same fuel due to this change in price. It is clear that it is not a normal reaction of the market, as usually a higher price of a product leads to consumption decline of the same product.

For this phenomenon, it is really difficult to find a robust and concrete explanation. An explanation for these bizarre and extraordinary results may be the significant variations in the energy prices that existed (Björner 2002). Prices throughout the whole Europe changed considerably especially during the last two decades, either increasing or decreasing. More details are shown in Figure 6 (paragraph I.2.1), where prices in the form of price index are presented. Also, correlated with this situation is that energy use per value added has decreased for all sources and for all branches the last years. This can be a sign that the regression analyses did not give significant results.

Furthermore, the Global fuel market, which directly affects the Global energy market, so as a natural result the European energy market as well, seems to be going through a transition period. New sources are entering the market, pushing from the "oil and coal era" to more sustainable produced energy and general processes as it is obvious from some studies. Especially in the high energy intensive industries, there is a trend towards less carbon intensive fuels (Enevoldsen 2007). Also, the liberalization of the market in many European countries is pressing the prices to decline or at least not increase with the rate that they increase in other countries which still have monopolies or oligopolies and by so having a variance in the exact prices from country to country.

Further analyzing this situation, in the European Union a lot of procedures are happening in order to liberalize the energy market, introducing competition and free choice of energy suppliers not just of the same energy but also between different forms of energy. These changes had a great effect on the prices, where for United Kingdom between 1995 and 2002 electricity prices fell by 27% in real terms for residential use and industrial consumers had to pay 38% less over the same period (Ferreira 2005).

Another possible reason for these results can be the lack of prices for each industrial sector, as well as for each country. It is possible for large customers-consumers to have discounts that change the total result of the analysis significantly as it possible to happen with energy intensive industries (Enevoldsen 2007). Average prices in such values are expected to alter the results even in the case of index prices, where just the changes in prices are measured and in the case of the European Union of the 15 it is supposed to be about the same for all countries.

The same situation exists to the long term elasticity, where many values are positive. In most cases, this happens simply due to the natural relationship with the short term elasticity, where the latter is positive the long term elasticity follows the same trend. But there are also some exceptions. When the coefficient of the energy consumption per "value added" with the time lag exceeds the value of one, then the long term elasticity changes sign from positive to negative or vise versa.

Also, another phenomenon that is observed from the result tables is the unrealistic values of some big prices of elasticity. This is due to the values of the consumption per "value added" with the time lag once again, where they are very close to one, so the result of the fraction is rather big compared to the normal, expected values.

Having this great load of regression analysis is very difficult to present the whole of the validation for all of the results and with the whole of the stats needed in order to identify their significance. A sample of these statistics is presented in APPENDIX A and B, including the most important of the statistics results that resulted from the regression analyses. These values are the R square (R^2), P-value, F and significance F. Also, as already shown and said in the previous chapter, Chapter II.2.1 and Chapter II.2.2, when the elasticity price is shown in the results table, T-stat is also included, so as to have a small direct validation side by side with the result. Furthermore, in the tables in the APPENDIX A and B, the P-value is the one relative to the price elasticity, as there are values for all the parameters.

Here it should also be mentioned that generally it seems that the analyses with autonomous efficiency constant included in the calculations to have slight higher values than in the calculations without this constant as already mentioned. It is believed that this phenomenon is not just due to the concept of more parameters in the formula the better the values, but a realistic change due to its importance for the formula.

Going into the results, generally it is identified the pretty high values of "P-value", when the lower they are the better for the significance. It is rather interesting to see that this statistic is in the majority of the results the value is rather close to 1, which is its upper limit and not good for the significance. This condition is a sign that the null hypothesis can be rejected at a relevant high significance level.

Continuing into the statistics, the next to be analyzed is the R^2. Although no trend can be understood and localized in the sources or regions and countries, there is a general impression of rather low values, indicating a no very good fitness, with of course exceptions that are just few and not representative of the general trend. Also, there is an impression that in total Czech Republic's values seem to be lower than the ones from Poland and the two regions, another sign of inadequate data.

Moreover, when focusing on the values of statistic F and when having in mind that the higher the values the best for the robustness of the results without having any upper or lower limits, the "feeling" is that the majority of the values are not satisfying but at most rather average when comparing the higher and the lower ones. This situation cannot be once again be distinguished between the different sources, regions and countries examined, as there is no trend identified.

The last statistic presented in the tables in the APPENDIX B is the Significance F, with upper and lower limit the values 1 and 0 respectively. Here it should be noted again that the lower the value the better for the robustness of the results. Going to the results, it has to be noted that their majority, with much less exceptions than the rest of the statistics, are rather satisfying and not spamming considerably over zero and by so having the wanted range of values.

A general comment for the results, that has to be made and it is also easily understood from the text above, is that their significance is rather low and cannot distinguish the branches generally between "good" and "bad" as long as the robustness of the results is concerned, as the values of the statistics vary greatly within the sectors, among the regions and the countries without a general trend identified. So, it is very difficult and not fair enough to evaluate the branches independently.

The analysis of the significance is based on the statistics results and their explanation given in Chapter II 1.2, where the data methodology is explained and also from literature overview of similar log linear models (Gujarati 2006). Further details can be seen in APPENDIX A and B.

II.3.2 Comparison with other elasticity estimates in literature

There are publications where price elasticity is calculated for several regions as well as sectors and time periods, using different methods and techniques for the calculations. In all cases that are published, the price elasticity values are negative, in contrast to many of the elasticity estimates in this study. This can be explained by the condition that positive price elasticity values are not reasonable so they are not published. A table with the review of published price elasticity values follows (Table 12).

Table 12. Price elasticity values from the literature

Reference	Own price elasticity literature review						
	Oil	Coal	Gas	Electricity	Other	Branch	Region-time series
Kratena	-0.24	-1.98	-0.00	-0.02		Food (C 10, 11, 12)	Austria 1976-2000
Kratena	-0.09	-	-0.2	-0.04		Textile and leather C 13, 14 ,15 (a[1])	Austria 1976-2000
Kratena	-1.18	-0.53	-0.07	-0.09		Paper, printing C 17,18	Austria 1976-2000
Kratena	-0.54	-0.77	-0.06	-0.03		Chemicals C 19, 20, 21, 22	Austria 1976-2000
Kratena	-0.69	-0.35	-0.13	-0.09		Non-metallic minerals C 23	Austria 1976-2000
Kratena	-1.66	-0.02	-0.6	-0.13		Primary metals C 24	Austria 1976-2000
Kratena	-0.44(-0.51)	0.00(-)	-0.1(-0.13)	-0.01(-0.29)		Equipment goods C 25, 26, 27, 28, 29, 30 (b[1])	Austria 1976-2000

Continue from Table 12

Reference	Own price elasticity literature review						
	Oil	Coal	Gas	Electricity	Other	Branch	Region-time series
Kratena	-1.11	-1.44	-0.22	-0.03		Other industries C 31, 32, 33	Austria 1976-2000
Kratena	-0.11		-0.09	-0.18		Wood Industry C 16	Austria 1976-2000
Enevoldsen	-0.422;-0.55;-0.57	-0.37;-0.57;-0.59	(-0.11; nc;-0.12(c²))	-0.1;-0.28;-0.16		Energy Intensive Industries	Denmark, Norway and Sweden (a²)
Bjorner				(-0.34;-0.28)a³	(-0.28;-0.22) a³ b³	Industry	Denmark 1983-1997
Ko	-3.05	-0.57	-1.46			Electricity generation	USA 1993 (a⁴)
ECN (1998)			-0.13/-0.3		-0.09/-0.11	Industry	Developed countries (a⁵)

a¹: footwear industry is also included in this sector
b¹: Transport equipment is separately estimated and is presented in the parenthesis
a²: Time series Denmark (1990-2001), Norway (1991-2002), Sweden (1997-2003)
a³: Using Translog estimation and Linear logit estimation respectively
b³: Fossil fuel
a⁴: Time series monthly data of year 1993
a⁵: Meta analysis

A sample of the own price elasticity for industrial sub-energy inputs demand is from the Scandinavian region for the time period of 1990 to 2001 for Denmark, 1991 to 2002 for Norway and 1997 to 2003 for Sweden through panel regression analysis. The aim of these calculations is to derive the various energy price elasticity values that are necessary in order to estimate the impact of CO_2 taxes on energy consumption and hence decoupling of industry from emissions in Scandinavia. These countries have been practicing carbon-energy taxation since the early 1990's, higher in Sweden and Norway and lower in Denmark.

The values of the elasticity found for "Natural gas" are; -0.11 for Denmark, not calculated price for Norway and -0.12 for Sweden, compared to 0.0097 of this report for EU 15, which is the closest to the industries of these countries compared with NMS10, Poland and Czech Republic. The price elasticity of "Gas" for Norway is not calculated as it is hardly used in this country. For the two countries that price elasticity is calculated, their values indicates that the demand is close to inelastic, close to zero, something that is also found in this report, but with a different sign. Different are the results for "Oil", where values of -0.42 -0.55 and -0.57 respectively are found and -0.21 for this report, results that are far more elastic than the ones for "Gas". The outcome for "Coal" is -0.37 -0.57,-0.59 and 0.4782 respectively, being all of them rather elastic similar to the results from "Oil". For "Electricity" the results are -0.1, -0.28 and-0.26 respectively, tending to be more inelastic than the latter fuels and closer to what is found for this report and the value is -0,037 (Enevoldsen 2007).

Here is very important to indicate the variances that occur when choosing different time periods and techniques. From a publication for the Danish Industrial companies, using micro panel data with trans-log method for the period 1983 to1997, the own price elasticity for "Electricity", which is the only common wanted result, is -0,34 when translog estimation is used and -0.28 when linear logit estimation, compared with -0,1 from the previous study (Björner 2002). However, it has to be mentioned that the weighted partial elasticity is matched with the total elasticity of the previous estimation at the value of -0.1. In the same study, there is an aggregation for "Coal", "Oil" and "Natural gas" in fossil fuel. It is also interesting to observe its price elasticity which is -0.3 and -0.22 for translog and linear logit estimation methods respectively.

Also, another study comes from Austria, where a time series data is used from 1976 to 2000, using a Generalized Leontief cost function, for several industrial sectors using time series data. Analysis of 10 industrial sectors is made, enhanced with services and households which are not of interest in this report. As it is better observed for Table 12, the values of elasticity for "Coal" and "Oil" products are higher than the ones from "Gas" and "Electricity" in almost all sectors. In this study, it is also very interesting to observe the price elasticity of different processes such as heating and cooling, steam generation, industrial processes and motors. All these can be integrated in the industrial sector. The scope is to investigate if the impact of technical change on each fuel is determined by the appliance technology. When comparing the results for the two trends, with and without deterministic trend, it is concluded that there is not much difference, so the appliance technology is not a deterministic factor for choosing fuel (Kratena 2003).

Similarly, US electricity generation sector is examined, a very important sector as it is a source in this report and is also powered by fuel. The results for the price elasticity for this sector are indicative of the share of the three fuels, "Coal" "Oil" and "Gas" in this sector. As explained at the mentioned report (Ko J. 2001), "Gas" is often used as a peaking fuel because of relatively lower capital costs but higher operating costs. So, fuel prices seem to be more important on the base load market than in the peaking market. This is the reason behind the domination of coal in the USA electricity generation and the lowest, of the three fuels, price elasticity with a value of -0.57 whereas for "Oil" is -3.05 and "Gas" -1.46. Although that these values may not be similar to the European ones, they can be indicative and informative of how the energy market usually reacts to fuel price changes at this sector.

Section III

Scenarios to 2030 of energy use and CO_2 emissions in European Industry

III.1 Method and data

III.1.1 Scenarios methodology

In this subchapter, an overview of the structure of the scenarios is presented. In order to build these scenarios, some standard prices and values are used from the year 2000, which is the base year of this report. Also, these scenarios cover the period from the year 2000 to the year 2030, split in three decades and examining the final value of energy prices including carbon cost for four years: 2000, 2010, 2020, 2030. Carbon emissions are calculated in each case with different carbon costs named as “Baseline”, “Medium Carbon Cost” and “High Carbon Cost” scenarios and analyzed separately when they come from “Gas”, “Crude oil”, “Coal”, “Marginal electricity” and “Other sources” (covering biomass, heat etc), due to different carbon content and also different marginal price excluding taxes.

It should also be mentioned that these scenarios are made for branches included in the ODYSSEE database. These branches are: Industry (sum of Manufacturing and Mining, Mining, Food industry, Textile and Leather, Paper and printing, Chemicals, Non metallic minerals, Primary metals, Steel, Non ferrous metals, Equipment Goods and Other Industries. More details for these branches and their NACE coding can be seen in Chapter II1.2. Information on the parameters as well as the equations used for the scenarios follows.

- equations for **coal (c), oil (o), gas (g)** and **electricity (e)**:

$$\varepsilon(P)_{i,b,r} = f_{i,b,r}\, e^{a \cdot t}\, P_{i,b,r}^{\alpha} \qquad (7)$$

ε = energy use per value added
a = autonomous efficiency improvement constant
f = general constant (calculated for reference year data on value added, energy use and price)
α = own price elasticity

$$P(t)_{i,b,r} = p(t)_i + pc(t)_i \qquad (8)$$

$p(t)_i$: energy price (per energy content) excluding C emission cost at time t

$pc(t)_i$: C emission cost (per energy content) at time t

$E(t)_{i,b,r} = \varepsilon_{i,b,r}\, VA(t)_{b,r}$ (9)

$E(t)_{i,b,r}$: energy use in branch and region at time t

$VA(t)_{b,r}$: production (in value added) in branch and region at time t

$C(t)_{b,r} = E_{i,b,r}\, ce_i$

$C(t)_{b,r}$: CO_2 emissions from branch and region at time t

ce_i: CO_2 emissions per energy content

- equations for “**other**” (o) energy:

$\varepsilon(t)_o = [\beta_b\, (\delta_c\, \Delta\varepsilon(t)_c + \delta_o\, \Delta\varepsilon(t)_o + \delta_g\, \Delta\varepsilon(t)_g) + \varepsilon(t_0)_o]\, [P(t)_o / P(t_0)_o - 1]\, \alpha_{oo}$

β_b : share of heat demand below 400 ^oC in branch

$\delta_{c/o/g}$: fossil-to-“other” substitution factor (coal=1, oil=0.75, gas=0.50)

$\Delta\varepsilon(t\text{-}t_0)_{c/o/g}$: decrease in fossil energy use compared to previous point of time (t_0)

C = 0 (all “other” energy assumed to be biomass or other CO_2 neutral energy)

Values on energy use in each branch and region for the starting year 2000 were based on EC-TREN (2006) and the IEA database, see Tables 18, 19 a and b.

Values on industrial production in terms of value added were based on baseline data in EC-TREN (2006), and for the year 2000 also on the ODYSSEE database, see Tables 15a-b. Industrial production in each branch was assumed to be the same in all scenarios.

Values on energy prices, carbon costs and carbon intensities were based on baseline data in EC-TREN (2006) in combination with assumptions (see Table 13 and 14).

Furthermore, the standard values on which these scenarios are based on have to be mentioned. These cover exchange rates between Dollar and Euro, which is set as 1 Euro accounts 1.25 Dollar. Furthermore, Energy and carbon content are taken as standard values. So, a barrel of oil equivalent (boe) is equal to 6.12 Giga Joules (GJ) and a ton of oil equivalent (toe) is equal to 41.87 GJ. Here there should also be mentioned the carbon content of energy, per Mega Joule (MJ) and per energy source (e.g. gas, oil…). When it comes to “Gas”, this value is set at 15 g C/MJ, for crude oil at 20 g C/MJ and for coal at 25 g C/MJ or else 0.2, 0.26 and 0.33 kg CO_2/kWh respectively. Other values are the electricity efficiency in marginal supply, which change through the years and the CO_2 reduction in “Electricity” generated by carbon when Carbon Capture and Storage (CCS) is applied and is set at 90% of the emissions from electricity produced with this method. A table with the values of electricity efficiency, carbon intensity of energy for electricity, carbon emission cost and marginal price, excluding taxes, of the sources that are used at all the scenarios is Table 13.

Table 13. Assumed energy prices, carbon emission cost and carbon intensity of electricity in scenarios

	Scenarios		2000	2010	2020	2030
Marginal prices (€/toe)	All scenarios	Coal	92	186	202	245
		Gas	171	244	263	315
		Oil	46	68.4	77.2	81.5
C emission cost (€/ton CO_2)	Baseline Carbon Cost		20	22.5	25	30
	Medium Carbon Cost		20	28	40	60
	High Carbon Cost		20	36	65	120
Carbon int. of energy for elec. (kg C/GJ)	All scenarios	EU 15	20	18	16	16.7
		NMS10	35	31	25	21
		Total	22	20	17	17
Electricity efficiency (Marginal supply)	Baseline Carbon Cost	Gas	40%	40%	50%	55%
		Coal	25%	25%	30%	40%
		Coal with CCS	n.a.	n.a.	n.a.	n.a.
	Medium Caron Cost	Gas	40%	40%	50%	55%
		Coal	25%	25%	30%	40%
		Coal with CCS	n.a.	n.a.	37%	37%
	High Carbon Cost	Gas	40%	40%	50%	55%
		Coal	25%	25%	32.5%	n.a.
		Coal with CCS	n.a.	n.a.	37%	37%

Source: Prices excl carbon costs and carbon intensity of electricity from EC-TREN 2006 Carbon emission costs and electric efficiencies are assumptions of this study

Going into some calculations and based on marginal prices of the sources when taxes are excluded (given in $/boe), it is possible to estimate the cost of energy per GJ (€/GJ) and at the same time cost of electricity either from coal or gas, as the efficiencies and the prices are known for each fuel. When having these values, with simple calculations the cost per GJ can be found. For electricity, this same cost is just a matter of its relevant source efficiency.

Enhanced to this price is the carbon emission cost (see formula 9), which once again in terms of simplicity and compatibility with the results is expressed as carbon cost per energy unit, so again €/GJ. This is where the different scenarios appear, when it comes to "Baseline", "Medium" and "High" carbon costs, with exception the year 2000 where all carbon emission costs are set to one value. Using these values and the ones of the energy content, combined with some simple unit transformations, it will lead to having the carbon cost per energy unit which is the wanted price.

The price of each source including carbon cost can now be calculated by simply adding the carbon cost to the price excluding taxes (see formula 8). A detail that has to be mentioned is when "Marginal electricity" price is calculated, the price is always set to the highest marginal cost ((i.e. fuel cost) among the alternatives and the final price (from the marginal electricity) and is listed in Table 13. The price of "other" energy was set to be €2/GJ lower than cheapest fossil fuel (including carbon costs), but not lower than 3 €/GJ.A table with the final prices, as calculated with the procedure above, for all the scenarios and for all years is Table 14.

Table 14. Summary of assumed energy prices in scenarios

Scenarios	Source		Prices	2000	2010	2020	2030
Baseline Cost Scenario	Gas		€/GJ	3.3	5.7	6.2	7.5
	Oil		€/GJ	5.6	7.5	8.1	9.7
	Coal		€/GJ	2.9	3.7	4.1	4.7
	Electricity	Marginal	€/GJ	11.7	14.8	13.8	13.6
	Other (Heat, Biomass etc.)		€/GJ	3	3	3	3

Continue from Table 14

Scenarios	Source		Prices	2000	2010	2020	2030
Medium Cost Scenario	Gas		€/GJ	3.3	6.0	7.0	9.1
	Oil		€/GJ	5.6	7.9	9.2	11.9
	Coal		€/GJ	2.9	4.2	5.5	7.4
	Electricity	Marginal	€/GJ	11.7	16.8	18.4	18.6
	Other (Heat, Biomass etc.)		€/GJ	3	3	3.5	5.4
High Cost Scenario	Gas		€/GJ	3.3	6.4	8.4	12.4
	Oil		€/GJ	5.6	8.5	11.1	16.3
	Coal		€/GJ	2.9	4.9	7.8	12.9
	Electricity	Marginal	€/GJ	11.7	19.7	24.0	22.6
	Other (Heat, Biomass etc.)		€/GJ	3	3	5.8	10.4

Source: Compiled from Table 13

For price elasticities and the autonomous efficiency improvement constant, separate values were assumed for each branch and region (see Table 15 and 16). All values were assumed to be the same over time and for all scenarios. The assumed elasticity values are rough estimates based on the regression analyses carried out in this study and values found in literature (ECN 1999) and are in the level of -0.50. Assumed values on the autonomous efficiency improvement constant were entirely based on the regression analyses in this study. It should also be mentioned that due to the higher, in absolute terms, values of elasticities and autonomous efficiency constant found in the results of this report mainly for “Coal” and less for “Other”, the assumed values for the purpose of the scenarios are towards this direction.

Table 15. Assumed scenario values on own price elasticity and autonomous efficiency improvement constant for EU 15

Branch (NACE codes in parenthesis)	Own price short term elasticity (α)					Autonomous efficiency improvement				
	Gas	Oil	Coal	Electricity	Other	Gas	Oil	Coal	Electricity	Other
Industry (B + C)	-0.40	-0.45	-0.60	-0.40	-0.50	-0.007	-0.007	-0.010	-0.007	-0.009
Mining B	-0.50	-0.45	-0.50	-0.50	-0.50	-0.005	-0.005	-0.008	-0.005	-0.007
Food C10,11,12	-0.40	-0.50	-0.60	-0.45	-0.50	-0.005	-0.005	-0.008	-0.005	-0.007
Textile and leather C 13,14,15	-0.40	-0.45	-0.60	-0.45	-0.50	-0.005	-0.005	-0.008	-0.005	-0.007
Paper, printing C 17,18	-0.40	-0.45	-0.60	-0.45	-0.50	-0.005	-0.005	-0.008	-0.005	-0.007
Chemicals C19,20,21,22	-0.40	-0.40	-0.50	-0.45	-0.50	-0.007	-0.007	-0.009	-0.007	-0.007
Non-metallic minerals C23	-0.40	-0.45	-0.60	-0.45	-0.50	-0.005	-0.005	-0.008	-0.005	-0.007
Primary metals C24	-0.40	-0.50	-0.45	-0.45	-0.50	-0.005	-0.005	-0.008	-0.005	-0.007
Steel	-0.40	-0.50	-0.45	-0.45	-0.50	-0.005	-0.005	-0.008	-0.005	-0.007
Non ferrous metals	-0.40	-0.50	-0.45	-0.45	-0.50	-0.005	-0.005	-0.008	-0.005	-0.007
Equipment goods C25,26,27,28,29,30	-0.35	-0.45	-0.60	-0.35	-0.50	-0.005	-0.005	-0.008	-0.005	-0.007
Other industries C31,32,33	-0.50	-0.40	-0.60	-0.35	-0.50	-0.005	-0.005	-0.008	-0.005	-0.007

Table 16. Assumed scenario values on own price elasticity and autonomous efficiency improvement constant for NMS10

Branch (NACE codes in parenthesis)	Own price short term elasticity (α)					Autonomous efficiency improvement				
	Gas	Oil	Coal	Electricity	Other	Gas	Oil	Coal	Electricity	Other
Industry (B + C)	-0.40	-0.45	-0.60	-0.40	-0.50	-0.015	-0.015	-0.030	-0.015	-0.019
Mining B	-0.50	-0.45	-0.50	-0.50	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017
Food C10,11,12	-0.40	-0.50	-0.60	-0.45	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017
Textile and leather C 13,14,15	-0.40	-0.45	-0.60	-0.45	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017
Paper, printing C 17,18	-0.40	-0.45	-0.60	-0.45	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017
Chemicals C19,20,21,22	-0.40	-0.40	-0.50	-0.45	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017
Non-metallic minerals C23	-0.40	-0.45	-0.60	-0.45	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017
Primary metals C24	-0.40	-0.50	-0.45	-0.45	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017
Steel	-0.40	-0.50	-0.45	-0.45	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017
Non ferrous metals	-0.40	-0.50	-0.45	-0.45	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017
Equipment goods C25,26,27,28,29,30	-0.35	-0.45	-0.60	-0.35	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017
Other industries C31,32,33	-0.50	-0.40	-0.60	-0.35	-0.50	-0.013	-0.013	-0.025	-0.013	-0.017

Also, there are some more constants same for all the scenarios such as the percentage of possible substitution from fossil fuel to other source which are standard for the whole Industry and are 100% from "Coal", 75% from "Oil" and 50% from "Gas" to Other source. Moreover, another constant is the share of heat demand below 400^{o} C which is different for each branch but common for all the scenarios and throughout the years. It is a very important parameter, as it affects the energy intensity and indicates the percentage of energy used in branches that is suitable to be supplied through district or Combined Heat and Power (CHP) heat (Göckeler, 2007). In other words, "Other sources" such as biomass can be used for producing this energy and branches with high percentage of heat demand below 400 have greater potentials on for applying this substitution in their procedures. This condition is attributed to the different energy content and potential of each source. More details on each branch share of temperature heat demand can be seen on the table below (Table 17).

Table 17. Table of percentages of heat demand below the temperature of 400^{o} C.

Year 2000	Branches										
Share of Heat demand below 400^{o} C (%)	Industry B+C	Mining C	Food (C 10,11,12)	Textile, leather (C13,14,15)	Paper, printing (C17, 18)	Chemicals (C19, 20, 21, 22)	Non metallic minerals (C 23)	Primary metals (C 24)	Steel	Non ferrous metals	Equipment Goods (C 25-30)	Other Industries (C 31, 32, 33)
EU 15	50%	100%	100%	80%	80%	50%	10%	7.5%	5%	5%	90%	80%
NMS10	45%	100%	100%	80%	80%	50%	10%	7.5%	5%	5%	90%	80%

Source: Göckeler, 2007

Here it should also be noted the energy intensity of "value added" which is linear analog to the general constant mentioned above, the relevant decade change in the autonomous efficiency value as well as the price of the energy source in the power of the price elasticity and it is expressed in energy unit per worth, so in this case MJ/€. Special attention should be paid in this value when it comes to "Other sources". In this situation, the estimation of this value is more complicates, as it is the aggregation of the previous estimated energy intensity enhanced by the share of heat demand below 400^o C, which is multiplied by the "Fossil to Other substitute factor" concept with the relevant differences in the energy intensities of the each time referred source. This whole value is then multiplied with the autonomous energy efficiency difference from the decade and then again multiplied with the price of the "Other source" from the same year.

In any case, this is the value with which by multiplying it with the relevant "value added" price it is the energy consumption that appears as the result of this interpretation. Furthermore, energy use which for the year 2000 is presented later in this Chapter (Tables 18 and 19 a and b depending on the region) and the relative shares which come as a percentage from the total of each branch.

Other values that are used in the scenarios are the carbon intensity of "value added", which is simply emissions divided by the relevant "value added". Also, there is the carbon intensity of energy, which is emissions per consumption with appropriate in each case calculation so as to have the wanted unit and including or excluding emissions from electricity. Distinguished carbon intensity of energy is the one from electricity, which values are from EC DG-TREN (2006) and this value is used for the calculation of the emissions from this source.

After interpreting all the above parameters and values, it is now possible to calculate the total emissions coming from the branches named in the beginning of this subchapter. Including or excluding emissions coming from electricity, it is easily understood that they are directly affected by the volume of the consumption, as well as the carbon content of the relevant fuel. These are the only parameters for calculating the emissions and how to estimate consumption, which is the only parameter that has to be calculated in this case, is explained briefly in the previous paragraphs.

III.1.2 Data for the scenarios

It is essential when building a scenario to have a "base" or reference year for comparing the results and also as a starting year for implementing the different assumptions or values that the scenarios are to be based on. In the case of this report, the reference year is the year 2000.

In the following table (Table 18), energy use in a selection of branches are presented per different energy source for both regions, EU 15 and NMS10 in different tables (Tables 18a and 18b), as well as the total aggregated consumption for this year is presented. That is the "Industry" sector, which in this case for the ODYSSEE database is the aggregation from "Manufacturing" and "Mining" branches, so as to have a clear view of the existing consumption of the sector that very year. For reasons of robustness and comparison, energy use values are presented from ODYSSEE database as well as from IEA and EC DG-TREN databases, when relevant data with ODYSSEE database is available for the branches that are accessible for EU 15. The percentage of each sector is also shown in the tables (18 a and b), so as to have the "volume" of each branch compared to the total and for the easiness of the comparison between the databases. These percentages are also very important as they are the values used in the "building" of the scenarios in the Excel file.

A general comment from Table 18a is the closeness of the values in many cases even in "absolute" values or even better in percentages. Of course exceptions can be identified like in "Primary metals" and more specifically in "Coal" and "Gas" consumption, where there is a large difference between the two databases. This sector is attributed with a great percentage of the differences that appear in the "Manufacturing" sector and so to "Industry" as well, as the rest of the branches seem to have more similar values.

Table 18a. Energy use by energy category and branch for EU 15 for the year 2000 in PJ per year (NACE Rev.2)

	Total		Oil		Coal		Gas		Electricity		Other sources		Rest value	
	PJ/yr	Branch share of B+C	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Branch share of total ind.
Industry														
Odysee sum	11163	100%	1565	14.0%	1343	12.0%	4015	36.0%	3387	30.3%	851	7.7%		
IEA	10598	100%	1686	15.9%	1013	9.5%	3648	34.4%	3414	32.2%	837	7.9%		
DG-TREN	11923	100%												
This study	11158		1674	15.0%	1339	12.0%	3905	35.0%	3403	30.5%	837	7.5%		
Mining														
Odyssee	111	1.0%	10.8	9.8%	5.2	4.7%	20.2	18.2%	42.5	38.3%	0.2 (5)	0.2%	32	28.8%
IEA	113	1.0%	44.5	39.4%	5.4	4.8%	20	17.7%	42.8	37.9%	0.3	0.2%		
This study	111.6	1.0%	43.5	39.0%	5.6	5.0%	19.5	17.5%	42.4	38.0%	0.6	0.5%		
Manufacturing														
Odyssee stated	11052 (4)		1554	14%	1338	12.1%	3995	36%	3344	30.2%	851	7.7%		
Odysee sum	11052	99.0%	1553	14.1%	1337	12.1%	3994	36.1%	3272	29.6%	408	3.7%	489	4.4%
IEA calculated	10485	99.0%	1641	15.6%	1007	9.6%	3628	34.6%	3372	32.2%	837	8.0%	-	-
This study	11046.4	99.0	1630.5	14.7%	1333.4	12.1%	3885.5	35.2%	3360.6	30.4%	836.4	7.6%		
Food														
Odyssee	1080	9.7%	176	16.4%	43	4.0%	505	46.8%	318	29.5%	12	1.0%	26	2.3%
IEA	1068	10.1%	179	16.8%	40	3.7%	493	46.2%	316	29.6%	40	3.7%		

Continue for Table 18a

	Total		Oil		Coal		Gas		Electricity		Other sources		Rest value	
	PJ/yr	Branch share of B+C	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Branch share of total ind.
This study	1116	10.0%	190	17.0%	45	4.0%	508	45.5%	329	29.5%	45	4.0%		
Textile and leather														
Odyssee	356	3.2%	61	17.2%	2	0.6%	159	44.7%	129	36.2%	2	0.6%	3	0.7%
IEA	388	3.7%	60	15.5%	4	1.0%	195	50.3%	125	32.2%	4	1.0%		
This study	391	3.5%	66	17.0%	4	1.0%	176	45.0%	137	35.0%	8	2.0%		
Wood and wood products														
Odyssee	-		-	-	-	-	-	-	-	-	-	-	-	-
IEA	208	2.0%	15.6	7.5%	1.1	0.5%	13.5	6.5%	68.8	33.0%	109	52.5%		
Paper, printing														
Odyssee	1342	12.0%	91	6.8%	37	2.7%	372	27.7%	448	33.4%	12	0.9%	382	28.5%
IEA	1354	12.8%	92	6.8%	40	3.0%	376	27.7%	447	33.0%	399	29.5%		
This study	1395	12.5%	98	7.0%	42	3.0%	384	27.5%	460	33.0%	411	29.5%		
Chemicals														
Odyssee	1848	16.5%	199	10.8%	26	1.4%	866	46.8%	637	34.5%	114	6.2%	6	0.3%
IEA(1)	1972	18.6%	340	17.2%	31	1.6%	855	43.4%	637	32.3%	109	5.5%		
This study	1953	17.5%	277	14.2%	29	1.5%	855	43.8%	664	34.0%	127	6.5%		
Non-metallic minerals														
Odyssee	1483	13.3%	412	27.8%	198	13.3%	599	40.4%	242	16.3%	3.3	0.2%	28.7	2%
IEA	1527	14.4%	410	26.9%	239	15.7%	591	38.7%	245	16%	42	2.7%		
This study	1551	13.9%	419	27.0%	233	15.0%	613	39.5%	248	16.0%	39	2.5%		
Primary metals														
Odyssee	2578	23.1%	164	6.4%	956	37.1%	787	30.5%	628 (5)	24.4%	1	0.0%	42	1.6%
IEA	1821	17.2%	125	6.9%	573	31.5%	494	27.1%	627	34.4%	2	0.1%		
This study	2399	21.5%	156	6.5%	902	37.6%	691	28.8%	648	27.0%	2	0.1%		
Steel														
Odyssee	2145	19.2%	109	5.1%	931	43.4%	684	31.9%	401	18.7%	1.3	0%	18.7	0.9%
IEA	1394	13.2%	65	4.7%	549	39.4%	392	28.1%	387	27.8%	1.3	0%		
This study	1997	17.9%	104	5.2%	875	43.8%	599	30.0%	419	21.0%	0.0	0.0%		
Non ferrous metals														
Odyssee	433	3.9%	55	12.7%	25	5.8%	102	23.5%	240	55.4%	-	0%	11	2.6%
IEA	427	4.0%	60.5	14.2%	23.3	5.4%	101.5	23.8%	241	56.4%	0.7	0.2%		
This study	402	3.6%	52.1	13.0%	27.2	6.8%	91.7	22.8%	228	56.8%	2.4	0.6%		
Equipment goods														
Odyssee	1063	9.5%	138	13%	10	0.9%	430	40.5%	469	44.1%	16	1.5%		
IEA	1049	9.9%	129	12.3%	14	1.3%	421	40.1%	475	45.3%	10	1.0%		
This study	1116	10.0%	145	13.0%	17	1.5%	435	39.0%	502	45.0%	17	1.5%		
Other industries														
Odyssee	1302		312		65		276		1101(3)		248		-700 (4)	
Odyssee corrected	1302	11.7%	312	24.0%	65	5.0%	276	21.2%	401	30.8%	248	19.0%		
IEA(2)	1096	10.3%	291	26.6%	66	6.0%	189	17.3%	428	39.0%	122	11.1%		
This study	1127	10.1%	282	25.0%	56	5.0%	225	20.0%	372	33.0%	192	17.0%		

Source: ODYSSEE database, IEA database, EC DG-TREN report

- Steel and non ferrous metals are sub-sectors of primary metals
- In ODYSSEE database in “Other source” it is mostly “Heat”, except “Manufacturing” and “Other Industries” where it is enhanced by “Biomass”
- In IEA database, “Other source” include: “Heat”, “Combustible Renewables and Waste Total”, “Crude Oil, NGL(Natural Gas Liquids) and Feedstocks Total” sources

(1): Chemicals Industry in IEA database include Petrochemical sector
(2): In IEA database Non-specified Industries
(3): Calculation error in ODYSSEE database
(4): Error due to calculation error for the database
(5): Country sum

Similarly, a table (Table 18b) with values for all sources and for all branches follows for New Member Stated of 10, including the percentages of the relevant each time share.

Table 18b. Energy use by energy category and branch for NMS10 for the year 2000 in PJ per year (NACE Rev.2)

	Total		Oil		Coal		Gas		Electricity		Other (heat)		Rest value	
	PJ/yr	Branch share of B+C	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Share of total in branch	PJ/yr	Branch share of total ind.
Industry														
Odyssee stated	1621	100%	167	10.3%	509	31.4%	455	28.1%	321	19.8%	125	7.7%	44	2.7%
Odysee sum	1577	100%	167	10.6%	509	32.3%	455	28.8%	321	20.3%	125	8.0%		
DG-TREN	1896	100	-	-	-	-	-	-	-	-	-	-		
This study	1758	100%	185	10.5%	545	31.0%	492	28.0%	352	20.0%	185	10.5%		
Mining														
Odyssee	25	1.6%	4.5	18.0%	7.5	30.0%	3	12.0%	7	28.0%	3	12.0%	0	
This study	26.4	1.5%	4.7	18.0%	7.9	30.0%	3.2	12.0%	7.4	28.0%	3.2	12.0%		
Manufacturing														
Odyssee stated	1596		162	10.1%	502	31.5%	452	28.3%	314	19.7%	122	7.6%	44	2.8%
Odysee sum	1552	98.4%	162	10.4%	502	32.4%	452	29.1%	314	20.2%	122	7.9%		
This study	1731.6	98.5%	180.3	10.4%	537.1	31.0%	488.8	28.2%	344.6	19.9%	181.8	10.5%		
Food														
Odyssee	159	10.1%	21.8	13.7%	52.3	33.0%	38.5	24.2%	31.4	19.7%	15	9.4%	0	
This study	172	9.8%	23	13.5%	57	33.0%	41	24.0%	34	19.5%	17	10.0%		
Textile and leather														
Odyssee	49.2	3.1%	3	6.1%	11.9	24.2%	13.5	27.4%	14.6	29.7%	6.2	12.6%	0	
This study	53	3.0%	3	6.0%	13	24.0%	14.2	27.0%	16	30.0%	7	13.0%		
Paper, printing														
Odyssee stated	101		3.5	3.5%	28.5	28.3%	15.9	15.7%	23	22.7%	5.8	5.7%	24.3	24.1%
This study	109	6.2%	4	3.5%	31	28.0%	17	16.0%	25	23.0%	32	29.5%		
Chemicals														
Odyssee	308	19.5%	51.2	16.6%	96.2	31.2%	41.8	13.6%	62	20.1%	56.8	18.5%	0	
This study	334	19.0%	55	16.5%	104	31.0%	45	13.5%	67	20.0%	63	19.0%		
Non-metallic minerals														
Odyssee	190	12%	29.6	15.6%	85.1	44.8%	42	22.1%	29.8	15.7%	3.5	1.8%	0	
This study	206	11.7%	32	15.5%	92	44.5%	45	22.0%	33	16.0%	4	2.0%		
Primary metals														
Odyssee	456	28.9%	11	2.4%	183	40.1%	167	36.6%	76	16.7%	19	4.2%	0	
This study	494	28.1%	12	2.5%	195	39.5%	178	36.0%	84	17.0%	25	5.0%		
Steel														
Odyssee	402	25.5%	10	2.5%	171.8	42.7%	153.8	38.3%	54.2	13.5%	12.2	3.0%	0	
This study	434	24.7%	11	2.5%	184	42.3%	164	37.8%	59	13.6%	17	3.8%		
Non ferrous metals														
Odyssee	53.6	3.4%	1.3	2.4%	10.7	19.9%	12.7	23.7%	22	41.0%	6.9	13.0%		
This study	60	3.4%	1.5	2.5%	11.5	19.2%	13.7	22.9%	24.9	41.7%	8.2	13.7%		
Equipment goods														
Odyssee	127	8.1%	7.5	6.0%	25.8	20.3%	35.5	27.9%	42.4	33.4%	15.8	12.4%	0	
This study	137	7.8%	8	6.0%	27	20.0%	38	28.0%	46	33.5%	17	12.5%		
Other industries														
Odyssee stated	204		34.2	16.8%	19.5	9.6%	98.3	48.2%	35	17.1%	(1)		17	8.3%
This study	227	12.9%	39	17.0%	22	9.5%	109	48.0%	40	17.5%	18	8.0%		

Source: ODYSSEE database, IEA database, EC DG-TREN report

- Total energy includes and other not specified sources
- Steel and non ferrous metals are sub-sectors of primary metals
- In ODYSSEE database in “Other source” it is mostly “Heat”, except “Manufacturing” and “Other Industries” where it is enhanced by “Biomass”
- In IEA database, “Other source” include: “Heat”, “Combustible Renewables and Waste Total”, “Crude Oil, NGL(Natural Gas Liquids) and Feedstocks Total” sources

(1)Data not available

The small differences that appear in Tables 18a and 18b in "Rest value" column can be attributed to "Biomass" which is not available for NMS10 in the ODYSSEE database.

Enhanced to this data, emissions from the same year are presented in the next table (Table 19). Unfortunately, there is not available data from the ODYSSEE database for all the branches presented as it can be observed, but at least there is data for the majority of them. All of the results are presented in Table 19.

Table 19. Total emissions of branches for EU 15 and NMS10 for the year 2000 for all branches and Manufacturing (NACE Rev.2)

Year 2000	Without electricity		With electricity	
Branch	EU 15 ($TgCO_2$)	NMS10 ($TgCO_2$)	EU 15 ($TgCO_2$)	NMS10 ($TgCO_2$)
Manufacturing C	462	88.9	859	131
Food C10,11,12	45.4	8.7	83	12.43
Textile and leather(1) C 13,14,15	13.6	2.1	28.9	3.82
Paper, printing C 17,18(1)	30.2	4.66	83.3	7.39
Chemicals(1) C19,20,21,22	65.6	15	141	22.4
Steel(2)	136	25.3	183	31.7
Non ferrous metals(2)	13	1.7	41.5	4.26
Non-metallic minerals C23	82.8	14.5	111	18.1
Equipment goods C25,26,27,28,29,30	35.2	2.28	90.73	7.3

Source: ODYSSEE database
(1)Not clear from the database if the whole sector is included
(2)Part of "Primary metals" sector

As it can be observed from this table (Table 19), there are aggregations in the calculation of the emissions. Firstly, there is an aggregation on emissions coming from fossil fuel use and secondly emissions coming from fossil fuel and electricity together and is counted as total emissions.

As already said, in this study, the economic parameter is rather important in the measurements, so it is significant to present the "energy use per value added" value of the reference year, the year 2000. But before doing that, the "value added" values are presented so as to have an overview of the economic situation of different branches for the same year and by so having a "pure" economic aspect of the sector. For the robustness of the values, prices from both ODYSSEE and European Commission (EC) are presented in Table 20a. It should also be mentioned that the "value added" values used in this study are calculated for the ones of the ODYSSEE and EC DG-TREN database. At the same time, future levels of the "value added" values are also presented, projected by EC DG-TREN, and their share compared to the total industry are shown, in order of easiness of the comparison and for having a clearer view of each branches share. The years presented in this table (Table 20) are the ones that cover the period examined in this report. More details can be observed in the table (Table 20a).

Table 20a. Value added in billion euros (fixed year 2000 euros) for EU 15 for different branches and Manufacturing (NACE Rev.2)

	2000		2010		2020		2030	
	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.
Industry(a3)								
Odyssee stated	1576							
Odyssee sum	1672	100%	-	-	-	-	-	-
DG-TREN	1603.2	100%	1839.2	100%	2253.4	100%	2602.1	100%
This study	1603.2	100%	1838.7	100%	2254.6	100%	2601.1	100%
Mining								
Odyssee	42.6	2.6%	-	-	-	-	-	-
DG-TREN	-	-	-	-	-	-	-	-
This study	40.1	2.5%	44.1	2.4%	51.8	2.3%	57.2	2.2%
Manufacturing								
Odyssee stated	1534		-	-	-	-	-	-
Odyssee sum	1629	97.4%	-	-	-	-	-	-
This study	1563.1	97.5%	1794.6	97.6%	2202.8	97.7%	2543.9	97.8%
Food								
Odyssee	179	10.7%	-	-	-	-	-	-
DG-TREN(b1)	188	11.7%	218.1	11.8%	266.6	11.8%	306.8	11.8%
This study	184.4	11.5%	213.3	11.6%	261.5	11.6%	301.7	11.6%
Textile and leather								
Odyssee	82	4.9%	-	-	-	-	-	-
DG-TREN	86.6	5.4%	71.8	3.9%	70.2	3.1%	70	2.7%
This study	83.4	5.2%	71.7	3.9%	69.9	3.1%	70.2	2.7%
Paper, printing								
Odyssee(a4)	153	9.2%	-	-	-	-	-	-
DG-TREN	151.9	9.5%	164.9	9.0%	203	9.0%	236.5	9.1%
This study	152.3	9.5%	165.5	9.0%	202.9	9.0%	236.7	9.1%
Chemicals(a2)								
Odyssee	217	13%	-	-	-	-	-	-
DG-TREN	177.7	11%	227.4	12.4%	293.5	13.0%	350.3	13.4%
This study	184.4	11.5%	233.5	12.7%	297.6	13.2%	351.1	13.5%
Non-metallic minerals								
Odyssee	71	4.2%	-	-	-	-	-	-
DG-TREN	74.3	4.6%	80.4	4.3%	92.8	4.1%	101.9	3.9%
This study	72.1	4.5%	79.1	4.3%	92.4	4.1%	101.4	3.9%
Primary metals								
Odyssee	61	3.6%	-	-	-	-	-	-
DG-TREN(b2)	60.8	3.8%	68.6	3.7%	77.2	3.4%	83	3.2%
This study	60.9	3.8%	68.0	3.7%	76.7	3.4%	83.2	3.2%
Steel								
Odyssee	n.a.							
DG-TREN	40.4	2.5%	44.2	2.4%	48.3	2.1%	50.9	2.0%
This study	40.1	2.5%	43.2	2.3%	47.3	2.1%	50.7	1.9%
Non ferrous metals								
Odyssee	n.a.		-	-	-	-	-	-
DG-TREN	20.4	1.3%	24.4	1.3%	28.9	1.3%	32.1	1.2%
This study	20.8	1.3%	24.8	1.3%	29.3	1.3%	32.5	1.2%
Engineering + other (incl. mining)								
DG-TREN	864	53.9%	1008	54.8%	1250	55.5%	1453	55.9%
Equipment goods								
Odyssee	789	49.2%	-	-	-	-	-	-

Continue from Table 20a

	2000		2010		2020		2030	
	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.
DG-TREN	-	-	-	-	-	-	-	-
This study	753.5	47.0%	878.9	47.8%%	1095.7	48.6%	1277.1	49.1%
Other industries								
Odyssee	77	4.6%	-	-	-	-	-	-
DG-TREN	171.6	10.7%	192.9	10.5%	236.6	10.5%	273.1	10.5%
This study	72.1	4.5%	84.6	4.6%	105.9	4.7%	122.2	4.7%

Source: ODYSSEE database, EC DG-TREN
(a1)Country sum
(a2)Not clear if rubber and plastic is included in EC database
(a3)Unclear which branches are included in EC database and "Manufacturing" added to "Mining" in ODYSSEE database
(a4)Pulp and Paper not included
(b1)Food, drink and tobacco included
(b2)Sum of Iron and Steel and Non ferrous metals

Generally it can be said that the majority of the values, when comparing the values of the two databases, are rather close both in terms of absolute values, either in terms of percentages. A table (Table 20b) with prices of "value added" for NMS10 is following, providing the data for the same time period examined in this report

Table 20b. Value added in billion euros (fixed year 2000 euros) for NMS10 for different branches and manufacturing industry (NACE Rev.2)

	2000		2010		2020		2030	
	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.
Industry(a1)								
Odyssee stated	77.3							
Odyssee sum	79.1	100%	-	-	-	-	-	-
DG-TREN	81.8	100%	134.8	100%	200.9	100%	261.3	100%
This study	81.8	100%	134.8	100%	200.8	100%	261.4	100%
Mining								
Odyssee	5.6(b1)	7.1%	-	-	-	-	-	-
DG-TREN	-	-	-	-	-	-	-	-
This study	5.7	7.0%	8.8	6.5%	12.0	6.0%	14.4	5.5%
Manufacturing								
Odyssee - stated	71.7		-	-	-	-	-	-
Odyssee – sum	73.5	92.9%						
This study	76.1	93.0%	126.0	93.5%	188.8	94%	247	94.5%
Food								
Odyssee	11.5	14.5%	-	-	-	-	-	-
DG-TREN(b2)	15.5	18.9%	27.2	20.2%	40.6	20.2%	52.8	20.2%
This study	14.7	18.0%	26.0	19.3%	38.8	19.3%	50.4	19.3%
Textile and leather								
Odyssee	5.3	6.7%	-	-	-	-	-	-
DG-TREN	5.9	7.2%	7.1	5.3%	8.2	4.1%	9.1	3.5%
This study	5.9	7.2%	7.1	5.3%	8.2	4.1%	9.1	3.5%
Paper, printing								
Odyssee(a3)	5.5	6.9%	-	-	-	-	-	-
DG-TREN	5.6	6.8%	9.3	6.9%	13.2	6.6%	16.1	6.1%
This study	5.6	6.8%	9.3	6.9%	13.3	6.6%	15.9	6.1%

Continue from Table 20b

	2000		2010		2020		2030	
	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.	Billion €2000/yr	Branch share of total ind.
Chemicals(a2)								
Odyssee	8.5	10.8%	-	-	-	-	-	-
DG-TREN	6.0	7.3%	9.2	6.8%	15.4	7.7%	21.3	8.1%
This study	7.0	8.5%	10.8	8.0%	18.1	9.0%	24.8	9.5%
Non-metallic minerals								
Odyssee	4.8	6.1%	-	-	-	-	-	-
DG-TREN	5.2	6.3%	8.6	6.4%	13.1	6.5%	16.6	6.3%
This study	5.2	6.3%	8.6	6.4%	13.1	6.5%	16.5	6.3%
Primary metals								
Odyssee	3.3	4.2%	-	-	-	-	-	-
DG-TREN	3.9	4.8%	4.8	3.6%	5.7	2.8%	6.3	2.4%
This study	3.9	4.8%	4.9	3.6%	5.6	2.8%	6.3	2.4%
Steel								
Odyssee	n.a.							
DG-TREN	3.0	3.7%	3.6	2.7%	4.1	2.0%	4.5	1.7%
This study	3.0	3.7%	3.6	2.7%	4.0	2.0%	4.4	1.7%
Non ferrous metals								
Odyssee	n.a.	-	-	-	-	-	-	-
DG-TREN	0.9	1.1%	1.2	0.9%	1.6	0.8%	1.8	0.7%
This study	0.9	1.1%	1.3	1.0%	1.6	0.8%	1.9	0.7%
Engineering + other (incl. mining)								
DG-TREN	39.7	48.5%	68.6	50.9%	104.6	52.1%	139	53.2%
Equipment goods								
Odyssee	29.3	37%	-	-	-	-	-	-
DG-TREN	-	-	-	-	-	-	-	-
This study	29.0	35.4%	50.5	37.4%	77.3	38.5%	104.6	40.0%
Other industries								
Odyssee	5.3	6.7%	-	-	-	-	-	-
DG-TREN	10.8	13.2%	19.3	14.3%	29.6	14.7%	39.2	15%
This study	4.8	5.9%	8.8	6.5%	14.5	7.2%	19.3	7.4%

Source: ODYSSEE database, EC DG-TREN
(a1) Unclear which branches are included in EC database and “Manufacturing” added to “Mining” in ODYSSEE database
(a2)Not clear if rubber and plastic is included in EC database
(a3) Pulp and Paper not included
(b1)Country sum
(b2)Food, drink and tobacco included

Observing Table 20b, it can be said that generally there is not much difference between the two databases, but just in cases where the branch is not exactly identical between the sources, such as “Other Industries”, where no information is given on what it is included in EC database. This can be said for both the “absolute” values and the percentages.

After presenting values of “energy use” and “value added” separately, it is time to interpret them under the “energy use per value added” concept. In Table 21, these values are presented both for EU 15 and NMS10 as well as for all sources

Table 21. Energy use per value added for EU 15 and NMS10 for the year 2000 (NACE Rev 2)

Year 2000	Coal (MJ/€)		Oil (MJ/€)		Gas (MJ/€)		Electricity (MJ/€)		Total (MJ/€)(1)	
Branch	EU 15	NMS10	EU 15	NMS10	EU 15	NMS10	EU 15	NMS10	EU 15	NMS10
Industry (B+C)(2)	0.48	4.1	0.75	1.63	1.45	3.45	1.39	3.1	4.4	13.8
Manufacturing	0.87	7	1.01	2.26	2.6	6.3	2.18	4.39	7.2	22.2
Mining B	0.1	1.3	0.5	1.0	0.3	0.6	0.6	1.8	1.6	5.5
Food C10,11,12	0.2	4.5	1.0	2.4	2.8	4.3	1.8	3.0	6.0	15.4
Textile and leather C 13,14,15	0.2	2.2	0.7	0.9	1.9	2.4	1.6	3.0	4.4	9.7
Paper, printing C 17,18	0.2	5.2	0.6	0.8	2.4	3.0	2.9	4.3	8.8	18.1
Chemicals C19,20,21,22	0.2	18.7	1.2	15.1	5.4	10.1	4.0	13.2	11.6	70.1
Non-metallic minerals C23	3.7	18.9	5.8	6.1	8.4	19.9	3.4	6.7	22.5	53.4
Primary metals C24	18.7	55.4	2.7	4.2	13.0	54.3	42.5	153.7	42.5	153.7
Steel	29.6		3.2		11.0		7.9		51.8	
Non ferrous metals	5.3		1.2		8.9		18.2		18.2	
Equipment goods C25,26,27,28,29,30	0.0	1.1	0.2	0.3	0.6	1.5	0.8	1.9	1.7	5.3
Other industries C31,32,33	0.3	4.8	4.1	6.4	3.6	18.4	14.3	6.6	16.9	38.2

Source: ODYSSEE database
(1)Except of these 4 sources, biomass and heat are also included under "Total" concept
(2)Average values from "Manufacturing" and "Mining"

Similar calculations are made for the emissions. In Table 22 there is the economic approach of the emissions, where emissions of each branch are divided with "value added" of the relevant branch and by so having a more specified value of emissions. Unfortunately, the available data either from "value added" data or from emissions from the ODYSSEE database are not sufficient so as to cover the whole of the industry examined in this report. Furthermore, it is not always clear to identify the named branch from ODYSSEE database and correlate it with NACE code system. More details in Table 22.

Table 22. Carbon emissions per value added for EU 15 and NMS10 (NACE Rev 2)

Branches Year 2000	Manufacturing C ($kgCO_2$/€)	Steel(2)	Chemicals C19,20,21,22 ($kgCO_2$/€)	Non ferrous metals(2) ($kgCO_2$/€)	Non Metallic mineral C23 ($kgCO_2$/€)	Food C10,11,12 ($kgCO^2$/€)	Textile and leather(1) C 13,14,15 ($kgCO_2$/€)	Pulp and paper* C 17,18 ($kgCO_2$/€)
EU 15	0.56	7.16	0.88	7.85	1.57	0.46	0.35	0.54
NMS10	1.83		4.35		3.76	1.08	0.71	1.33

Source: ODYSSEE database
(1)Uncertainty if the whole sector is examined when coming to emissions
(2)Part of "Primary metals" sector

By having this general overview of the base year for the branches and by having the calculated results from the previous sections, it is now possible to continue with the "building" of the scenarios, using all the data and accompanied by some assumptions and limitations which are explained in the following sections.

III.2 Results

In the previous section it was explained how the different scenarios were calculated. In this section the results from these scenarios are presented. At the same time, relative findings are also shown so as to have a broader view not just on the level of the emissions, but also observed from an economic perspective when compiled with the relevant “value added”. Also, information on the level of energy use throughout the selected period is reported. More details and information are revealed below.

Starting with the emissions and due to the very high correlation with energy use, in Figure 9 the level of both these concepts in all scenarios is presented. When taking a closer look at this it, it is easily observed the significant increase in energy use at the level of 19% (from 12916 PJ in 2000 to 15344 PJ in 2030), which is not followed by similarly analogous increase in emissions that are at the level of 1.1% (from 851 $TgCO_2$ to 860 $TgCO_2$). The same trend is observed in the Medium Carbon cost scenario, where although the general higher projected energy consumption compared to the year 2000, the emissions are always less than in the initial year, having a final decrease in the level of -14.7%, while at the same time the final increase in energy is on the level of 2.3%. Furthermore, as it is expected, in the High Carbon cost scenario there is a simultaneous drop in both values, for energy consumption falling significantly at -13.8% and in the emissions even more steep at -29% from the year 2000.

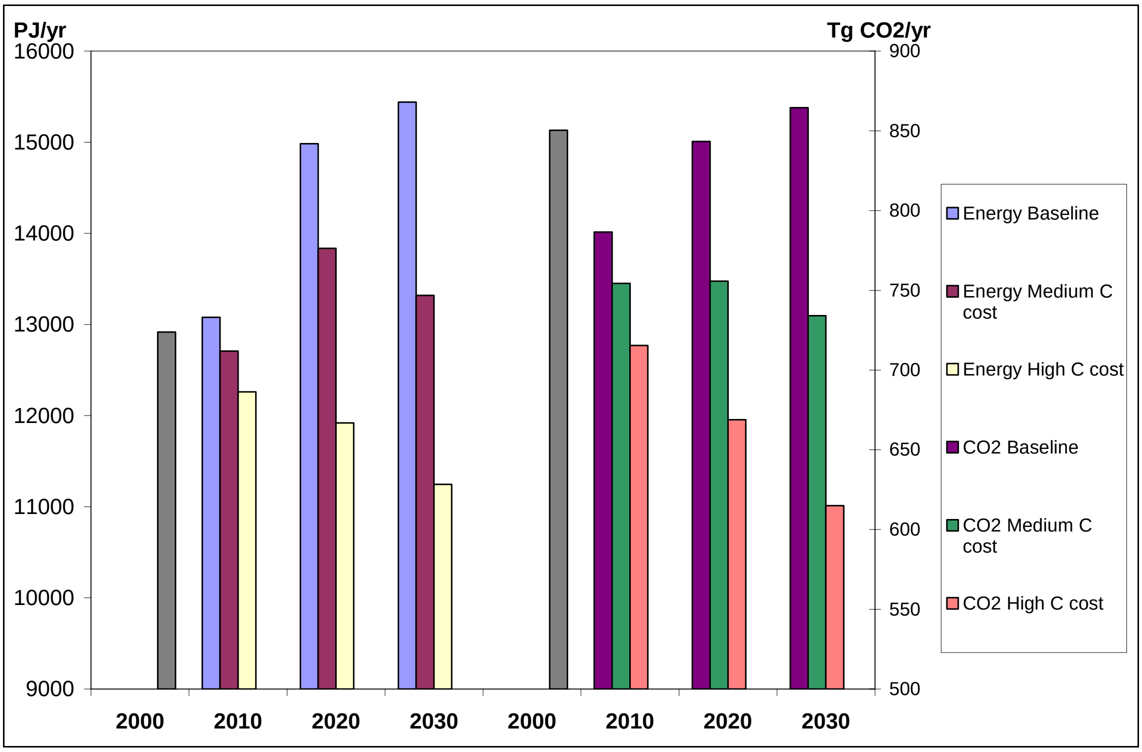

Figure 9. Energy use and carbon emissions in the scenarios for industry (NACE B+C) in EU 25

Further analyzing the findings when it comes to emissions, it is appropriate and reasonable to investigate each branch contribution and trend compared to the total emissions throughout the period examined. It is rather interesting to see the independent tendencies, the branches with the higher improvement when it comes to the Baseline scenarios and also compare this result with the result from the High Carbon cost scenarios. By doing this, it is easy to understand the potential of each branch and the effectiveness of higher carbon prices in its own procedure. In this case, figures from the Baseline (Figure 10) and the High cost scenarios (Figure 11) are presented, as they are also indicative of the Medium Carbon cost scenario which is not presented in the report.

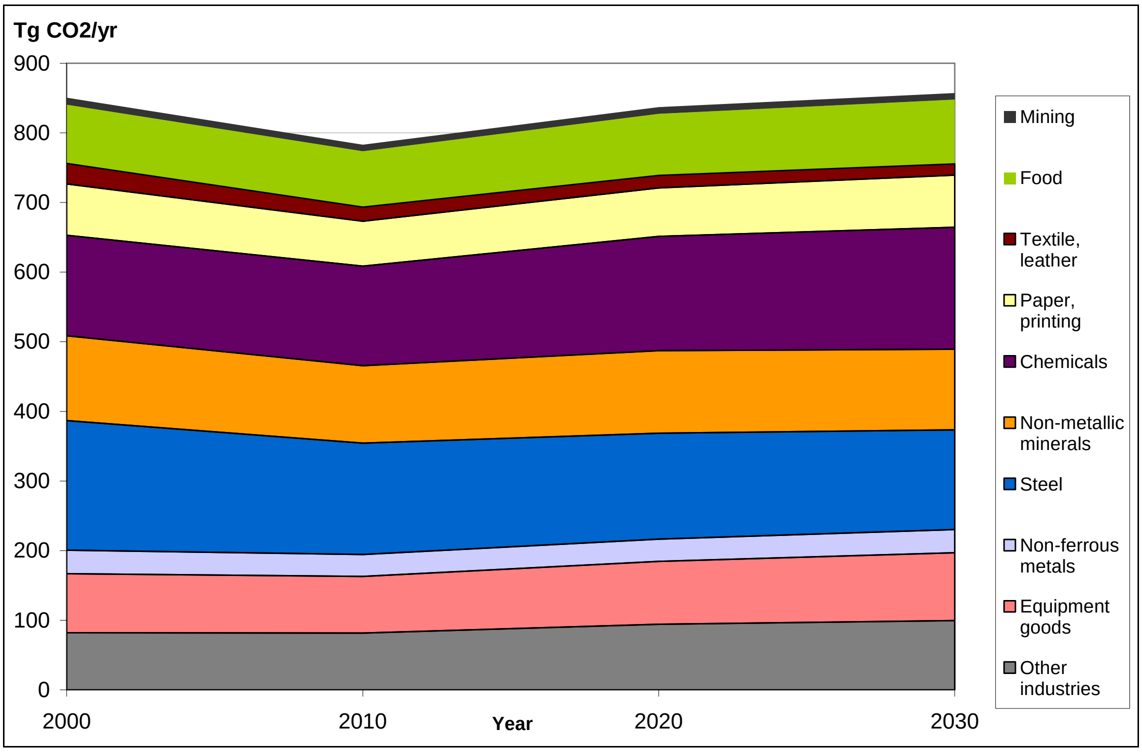

Figure 10. Carbon emissions by branch for EU 25 in the Baseline scenario (NACE Rev 2)

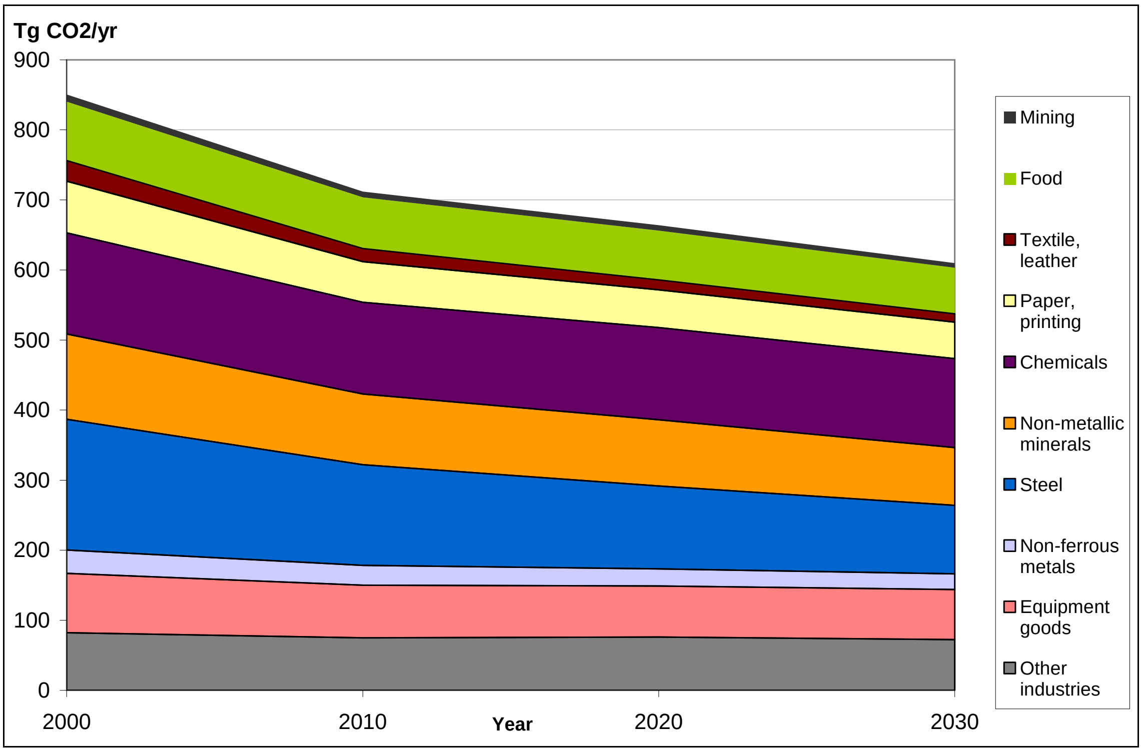

Figure 11. Carbon emissions by branch for EU 25 in the High Carbon cost scenario (NACE Rev 2)

Observing the Figures 10 and 11, it can be identified that the dominant branches are the "Steel" and "Chemicals" industries. Both of them account throughout the years around

38% of the total emissions. And this is mostly due to the decreasing trend in "Steel" industry that is projected at all scenarios and is more easily understood in High Carbon cost scenario, where the branch's emissions in 2030 are almost half (52.4%) the ones of 2000 and even in the Baseline scenario there is a fall of -23.1%. Different trend is revealed in "Chemicals" sector, where in the baseline scenario there is an increase in the emissions of 21.6% in the year 2030, reaching the share of 20.5% of the total emissions that year, whereas "Steel" share is 16.6%. The situation differs in the High Carbon cost scenario for the branch, where emissions decrease by 11.9% in the year 2030 compared to the year 2000.

As far as the rest of the branches are concerned, there is a mix of reactions through the years. Starting with the Baseline scenarios, there are branches with decreasing emissions, sometimes even significantly, such as "Textile and leather" with -45%, and then less impressive such as "Mining" with -6.5%, "Non metallic Minerals" with -5% and "Non ferrous metals" with -1.6%. The rest of the branches show positive values such as "Other industries" with 21.4%, "Equipment goods" with 14.9%, "Food" with 9.9% and "Paper printing" with 1%.On the other hand, only decreasing emissions are found in High Carbon cost scenario, with rather significant percentages: "Mining" with -34.6%, "Food" with -21.4%, "Textile and leather" with -59.8%, "Paper printing" with -29.5%, "Non metallic Minerals" with -32.5%, "Non ferrous metals" with -32.8%, "Equipment goods" with -15.9%, "Other industries" with -11.7%.

Going deeper in the Baseline scenario, it is important to analyze the future energy mix and their trends throughout the years. A representation of this is shown in Figure 12.

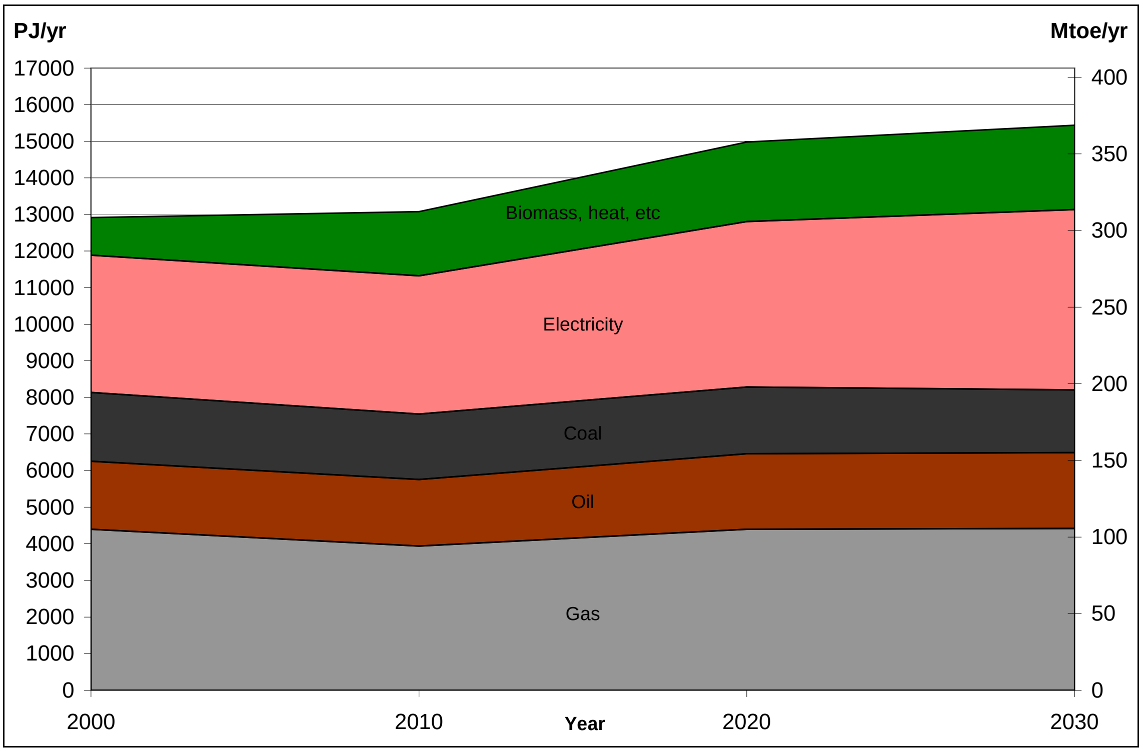

Figure 12. Energy use in industry (NACE B+C) in EU25 in the Baseline scenario

The dominant sources, as they can easily be seen from Figure 12, are "Electricity" and "Gas", when these two sources account to more than 60% of the total consumption in the whole range of the years from 2000 to 2030. It is also interesting that their share remains rather stable, around 30% each and at the same time they have increased their consumption in the scale of 1% for “Gas” and 30% for “Electricity” in the year 2030 compared to 2000. Especially for “Electricity”, just in the last decade, 2020 to 2030, the total increase in its consumption accounted at 9%, or 0.8% per year, indicating the increased demand for this source.

Similarly, “Oil” consumption share remains rather stable around 14% and with an increased consumption in year 2030 compared to 2000 in the scale of 8%, for “Coal” a share of similarly 14% and a decrease in the consumption in the scale of -7%, whereas “Biomass” share increases rather smoothly from 8% in the year 2000 to 15% in the year 2030, with an increase in its consumption of the rather astonishing but not really surprising rate of 123% compared to 2000.

Comparing these results with the ones of the High Carbon cost scenario of “Industry” (Figure 13), first of all a decrease in the total energy consumption can be seen. Declining by 13.8% from the consumption of 2000 and 27.4% when compared with the values of the Baseline scenario for the same year, the great impact of high carbon cost can be identified. Furthermore, “Electricity” and “Gas” remain dominant with a combined share of around 65%, but with different trends as “Gas” show significant signs of declining (-18% compared to 2000), while “Electricity” is the only source with positive change in the demand by 6%. Surprisingly, “Other” sources such as Biomass and Heat although the initially increased consumption, in the long run it is almost stable with a minor declining trend of -2%. “Oil” follows the same trend with “Gas”, decreasing by -15% to 2000 levels, while “Coal” consumption is significantly reduced by 50% for the same period examined, maybe due to its carbon content (25g/MJ).

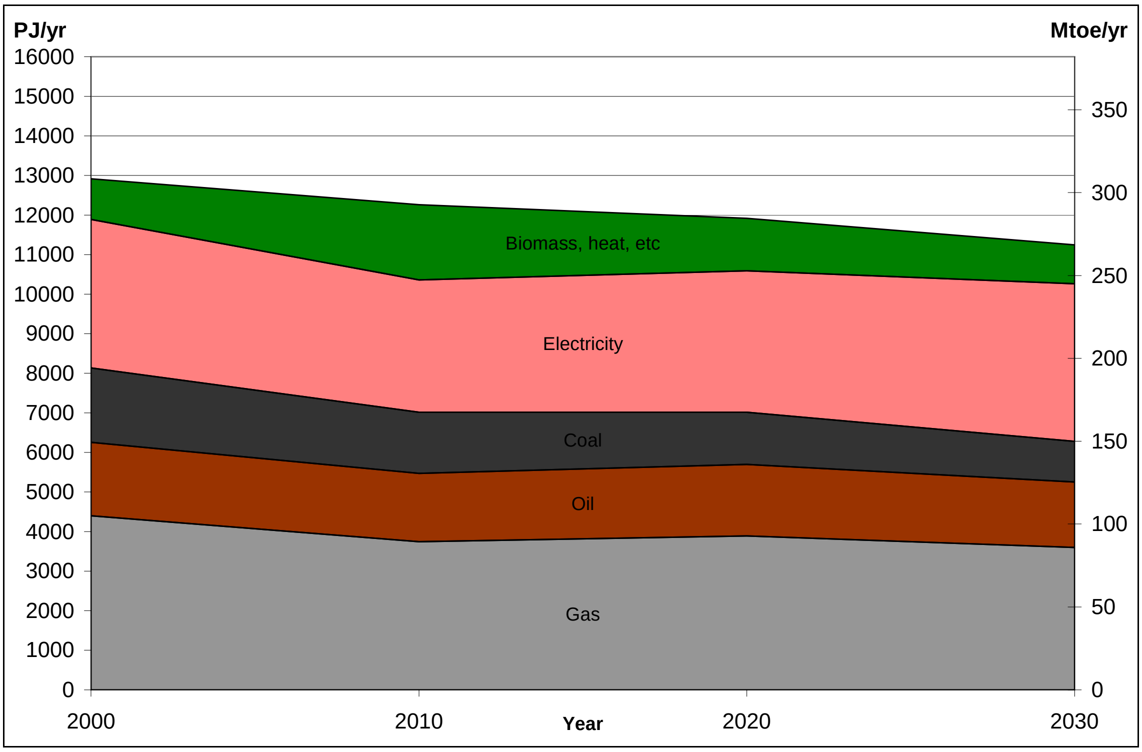

Figure 13. Energy use in industry (NACE B+C) in EU25 in the High carbon cost scenario

For further analysis, a sample of branches is selected with criteria concerning their volume of consumption and importance of the sector and for being energy intensive branches. These branches are: Food industry, Chemicals and Steel.

First to be analyzed is the Food industry, where once again “Electricity” and “Gas” are the dominant sources accounting around 60% with growing trend. In this case the latter source seems to overlap the consumption of “Electricity”, but with a by the years smaller gap, as it follows the general trend in the High Carbon cost scenario of increasing consumption in “Electricity” (11% in this branch) and decline in the rest of the sources (except “Other” sources in some cases).

The distinguishing characteristic in this branch is the higher share of “Other” sources, with a declining rate after 2010 but still having a remarkable increase of 169% raise compared to 2000 levels. Also, when it comes to “Oil” it seems to have similar trend with Industry (-12% in the consumption by the year 2030) and “Coal” in this industry has generally low values and steady declining rate the first two decades at -14% and for the last period (2020-2030) -25%, showing a total decrease of -45% in the year 2030 compared to 2000 levels. More details can be observed in Figure 14. In general, this branch shows a slightly increased consumption (0.5% compared to 2000), but having a declining rate the last decade of -4%, that can be indicative of future trend.

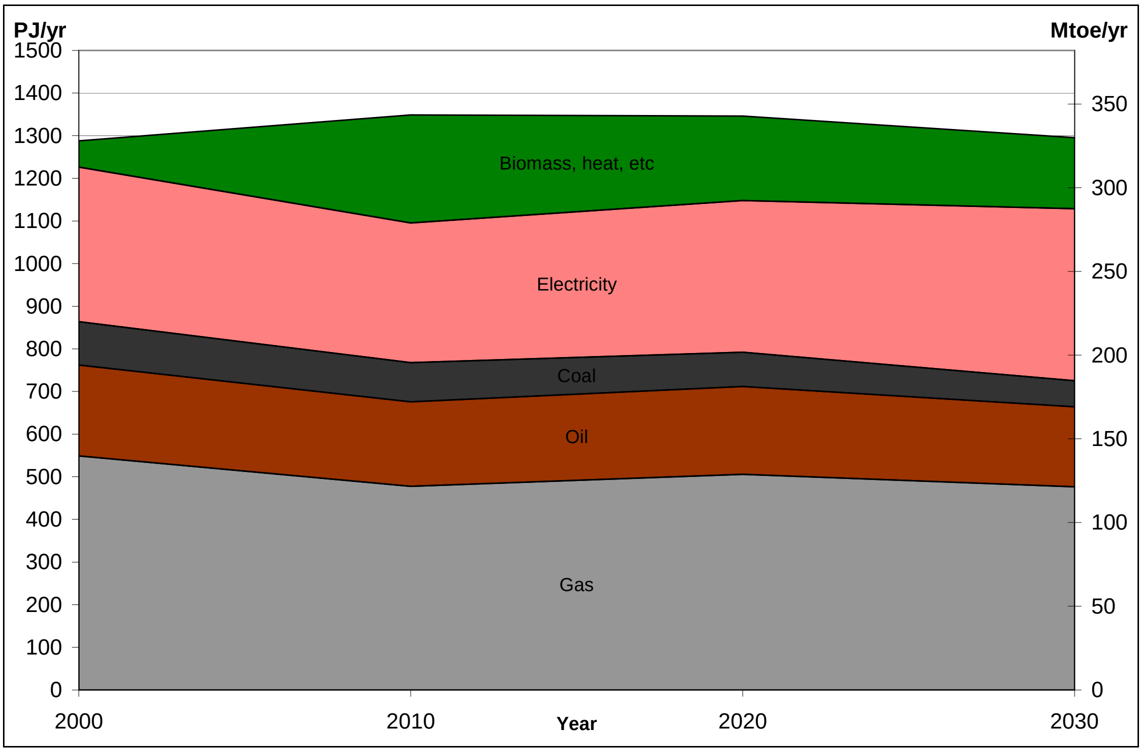

Figure 14. Energy use in the food sector (NACE C 10, 11, 12) in EU25 in the High Carbon cost scenario

Next to come is the figure from Chemicals energy mix for the same period (Figure 15)

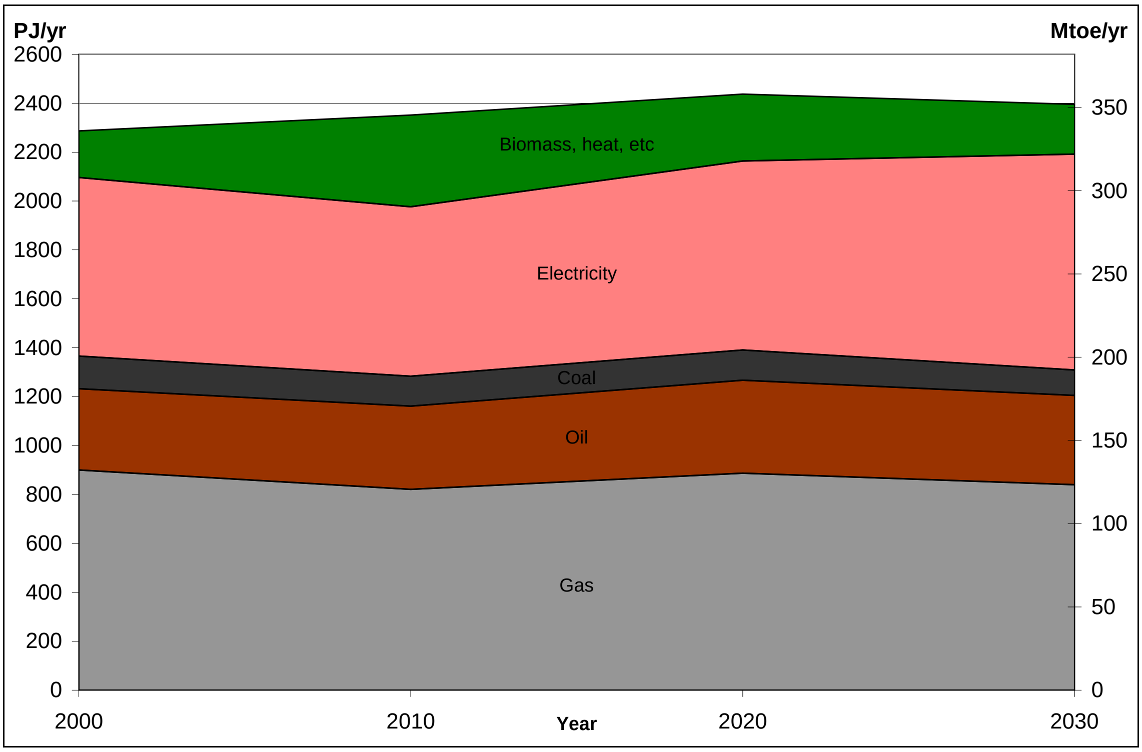

Figure 15. Energy use in the chemicals sector (NACE C 19, 20, 21,(22)) in EU25 in the High Carbon cost scenario

Observing this figure (Figure 15) it is revealed that this branch energy consumption increases by 4.8% in year 2030 compared to 2000, but again with a slight declining rate the last decade (-2%). When analyzing the sources independently, it is not difficult to identify once more the dominance role of “Electricity” and “Gas” with a combined share between 64% and 72% and again with declining trend for “Gas” (-7% from the year 2000) and growing for “Electricity” (21% from the year 2000). This general upwards trend in this branch can also be found in “Oil” (10%) and “Other” (7%). Once again “Coal” consumption is decreasing by -22% and having a final share of 4% in the branch.

A very different branch is shown at Figure 16. First of all, a very high declining rate is very obvious from the graph, getting very close to -40% (-39.9%) of the consumption of 2000 in the year 2030.This means either high improvement potential for Steel industry or high dependency on Carbon cost. Another distinguishing characteristic of the sector is that the dominant source is “Coal”, with a share ranging from 43.5% to 35%, despite the highly declining rate of -52% for the same period. Same situations exists at the rest of the sources, where “Gas” has a share of 33% but decreased consumption at the level of -37%, “Electricity’s” share at 26% and a decline of -20% and “Oil” with a share of 5% and a decline of -37%. The only source with positive change is “Other” source (8%), but with a very small share of just 1%.

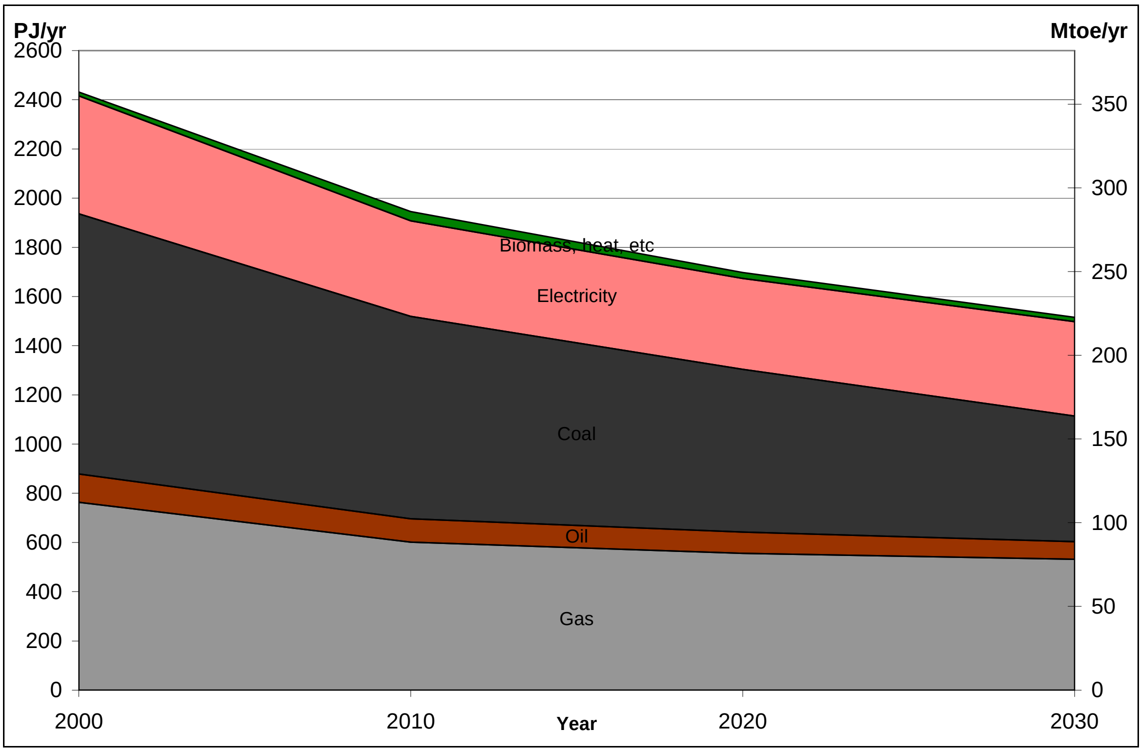

Figure 16. Energy use in the steel sector in EU25 in the High Carbon cost scenario

When it comes to emissions from these branches independently and in total, it is also important to analyze each source contribution. It is also well known that "Biomass" and "Heat" (due to double counting) do not emit any carbon or carbon substance to the atmosphere and by so "Other" sources are not included in the figures with the emissions. Information on the share of the rest of the sources in emissions is revealed in Figure.

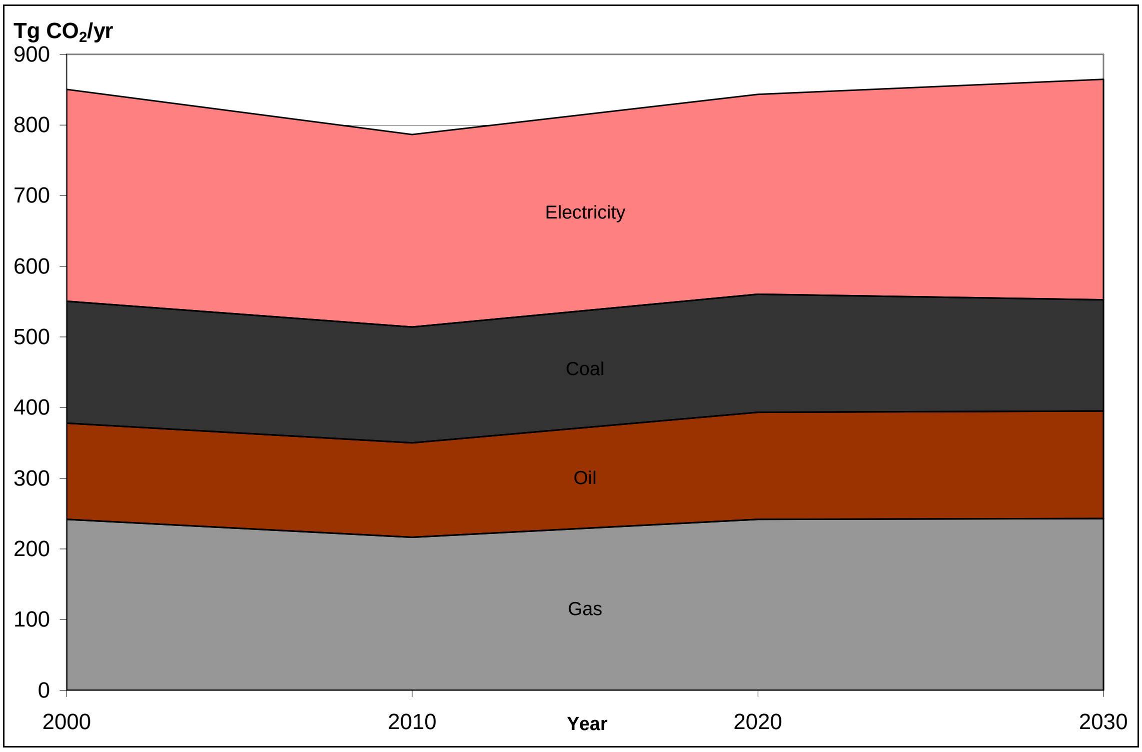

Figure 17. Carbon emissions from industry (NACE B+C) in EU 25 in the Baseline scenario

When comparing Figure 17 with Figure 12, it is easy to understand the improvements in the efficiency of each source independently, where despite the higher increase rate in energy use in total the total emissions remain pretty stable.

Before analyzing the findings from the scenarios, it is important to remind the carbon content of the sources: 15 gC/MJ for “Gas”, 20 gC/MJ for “Oil” and 25 gC/MJ for “Coal” and also carbon intensity of energy for electricity as well as electricity efficiency in marginal supply (Table 13), so as to have a broader understanding of the values presented in Figures (17, 18, 19, 20, 21).

Going to the analysis, most emissions come from “Electricity”, with a share around 35% for the whole period and final increase in the volume for the year 2030 is 3% compared to 2000 ones. This can be explained with the individual differences in the energy mix for “Electricity” as well as using the technique of CCS, where 90% of CO_2 emissions are captured. On the other hand, emissions from the rest of the sources follow exactly the same trend with the consumption in the Baseline scenario explained above. A situation that is reasonable and logical, as there is nothing that can change the emissions, except the consumption rate of the same source.

The same analysis is also made for High Carbon cost scenarios for Industry as well as for the rest of the branches shown in the energy mix figures (Figures 13, 14, 15 and 16), Food industry, Chemicals and Steel. Furthermore, similar is the trend that is observed between emissions and consumption, with exception in the “Electricity” due to the reason explained above. The figures from the analyzed emissions from Industry and the rest of the branches are shown below in Figures (17, 18, 19, 20, 21).

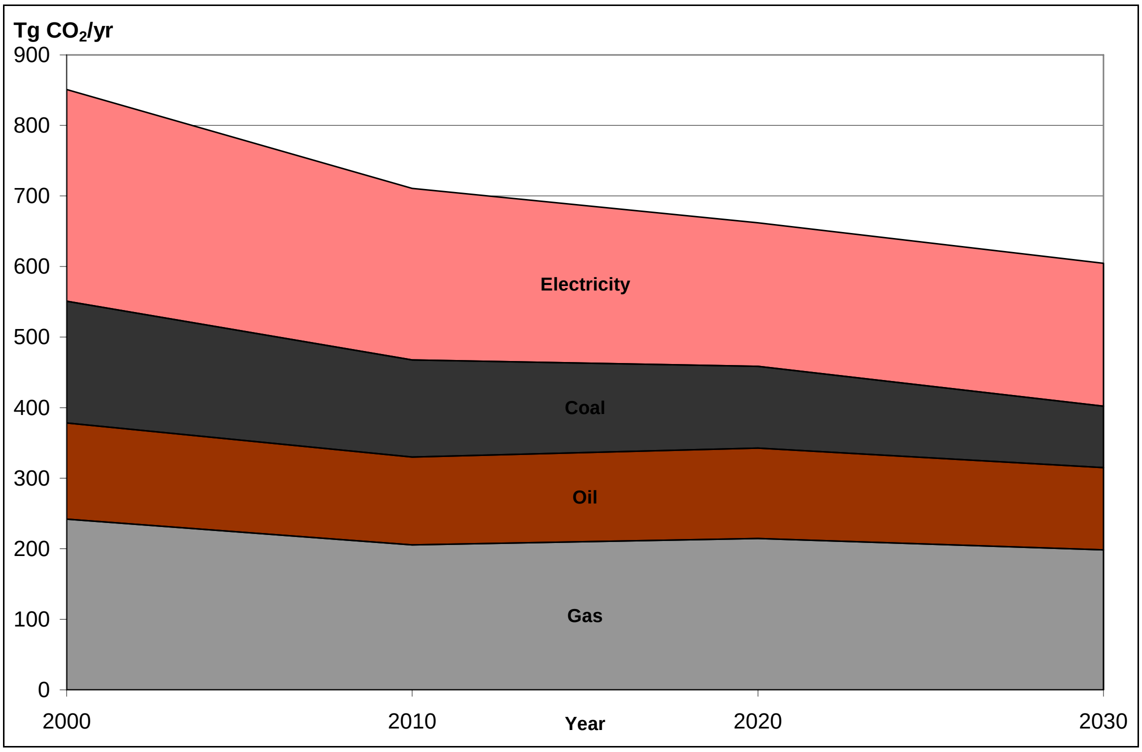

Figure 18. Carbon emissions from industry (NACE B+C) in EU 25 in the High Carbon cost scenario

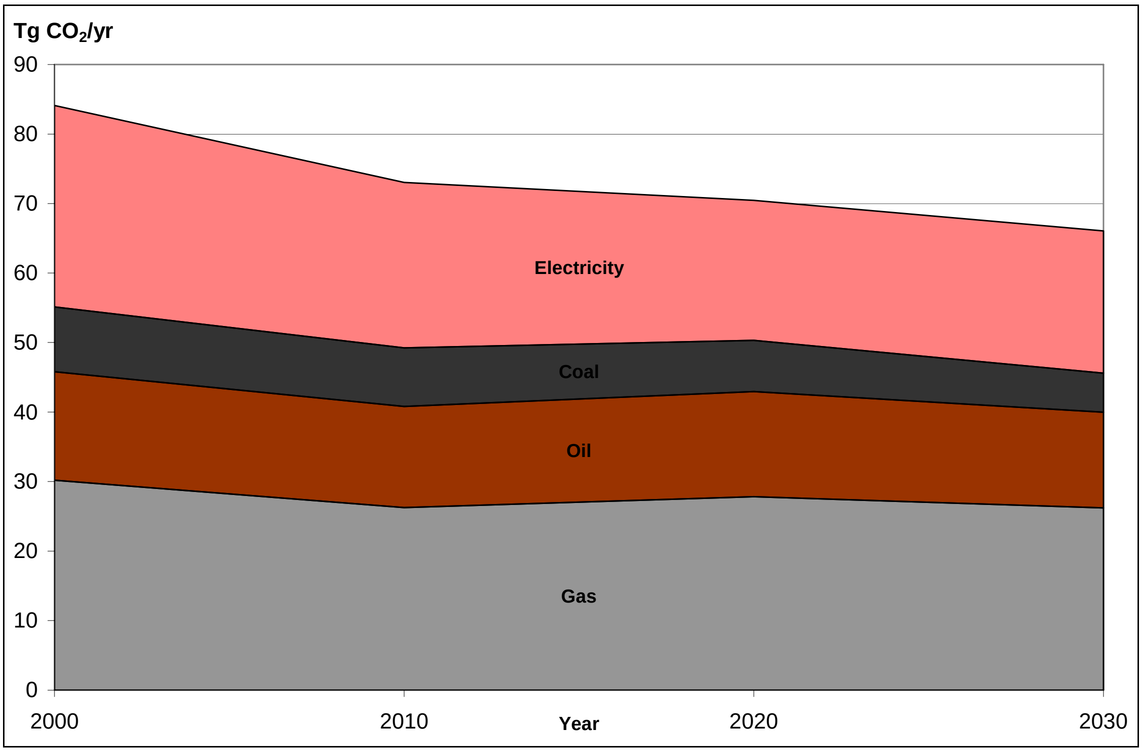

Figure 19. Carbon emissions from the food sector (NACE C 10, 11, 12) in EU 25 in the High Carbon cost scenario

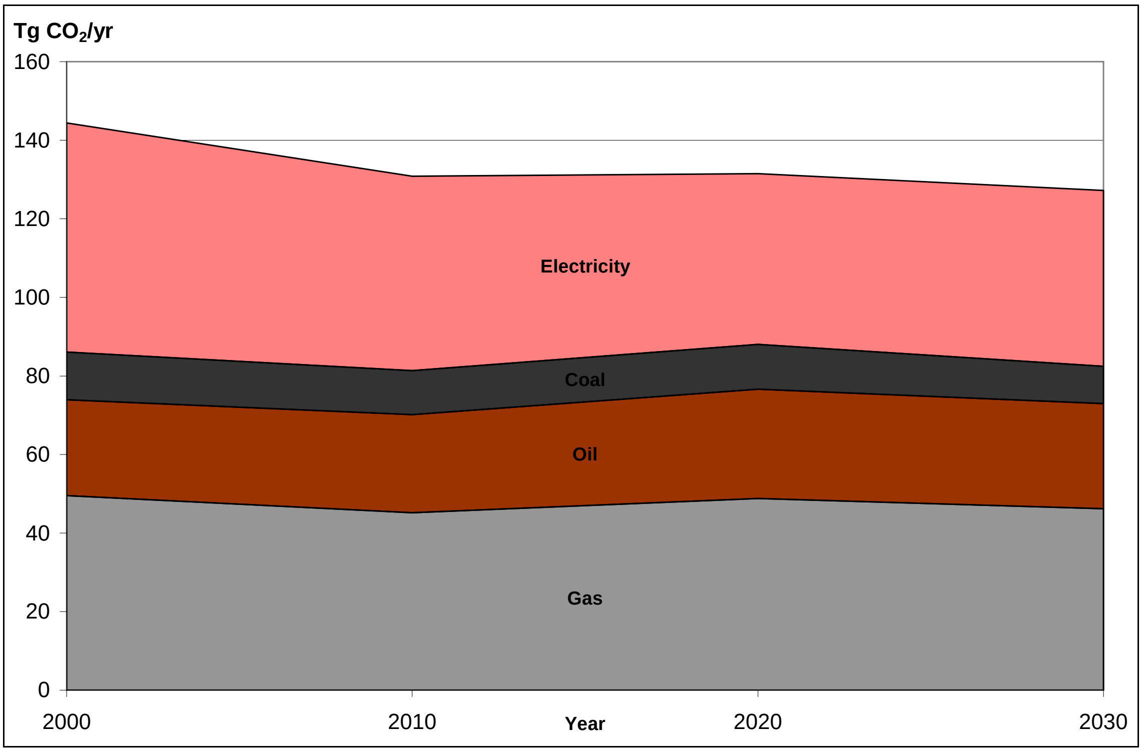

Figure 20. Carbon emissions from chemicals sector (NACE C 19, 20, 21, (22)) in EU 25 in the High Carbon cost scenario

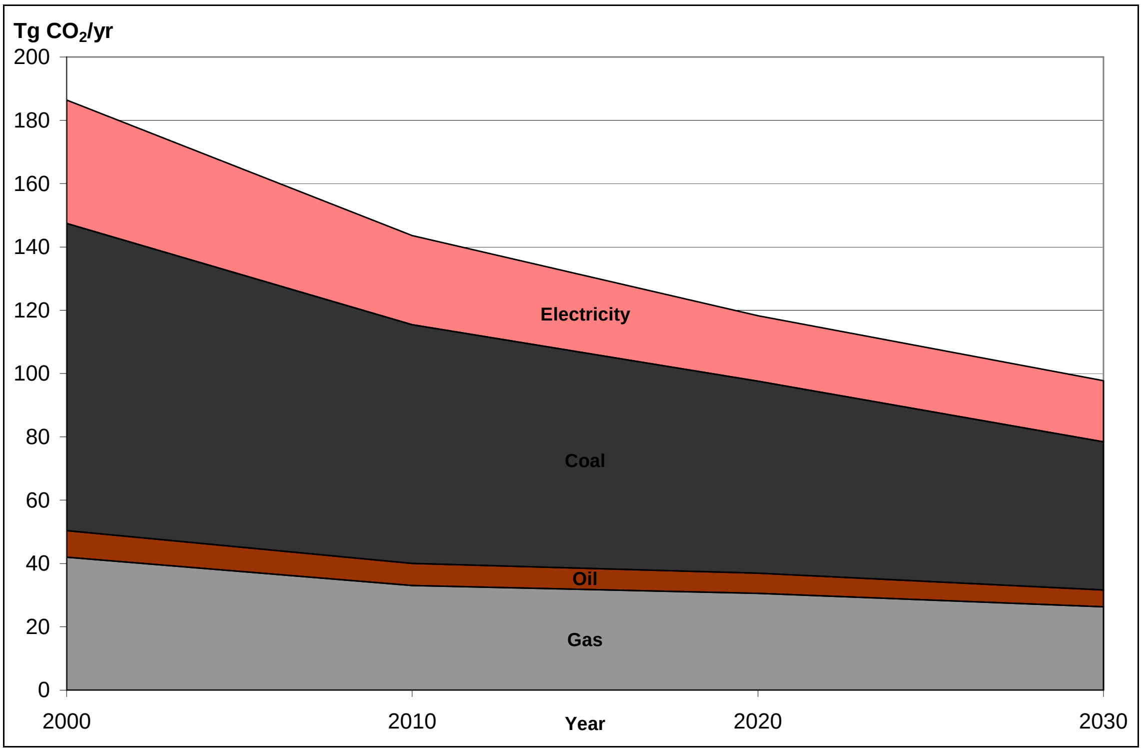

Figure 21. Carbon emissions from the steel sector in EU 25 in the High Carbon cost scenario

After presenting the findings from the scenarios, it is indicative of current and future situations of the sector to present the carbon intensity of "value added" for all the scenarios and for both regions (NMS10 and EU 15) separately. The first figure, where the carbon intensity of "value added" for Industry is presented is Figure 22.

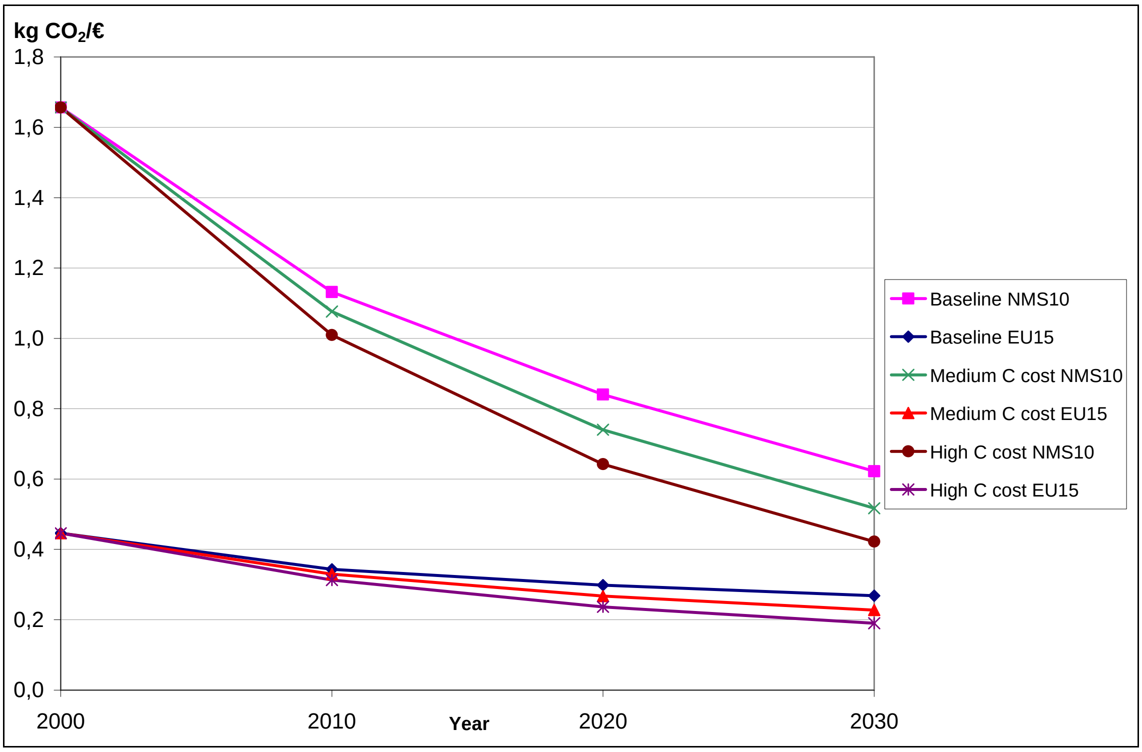

Figure 22. Carbon intensity of value added for industry (NACE B+C) in NMS10 and EU 15.

This concept reveals the relationship and the interaction of the emissions to an economic value, the "value added" value. In simple words it means the higher these value is the higher the cost of the emissions and by so more intense in the effectiveness of higher carbon costs for the branch or for Industry. This can also be understood from the unit that is used and it is kg CO_2/€. As it can be observed from Figure 22, NMS10 values are always higher than the ones from EU 15 but showing great improvement through the years, getting really close to the levels of EU 15 by the year 2030, regardless of the scenarios. On the other hand, values from EU 15 remain pretty much stable for the whole period.

Similar is the condition for Food industry, where the values in both regions are slightly better than the ones of Industry and again revealing similar improvement at all scenarios and regions.

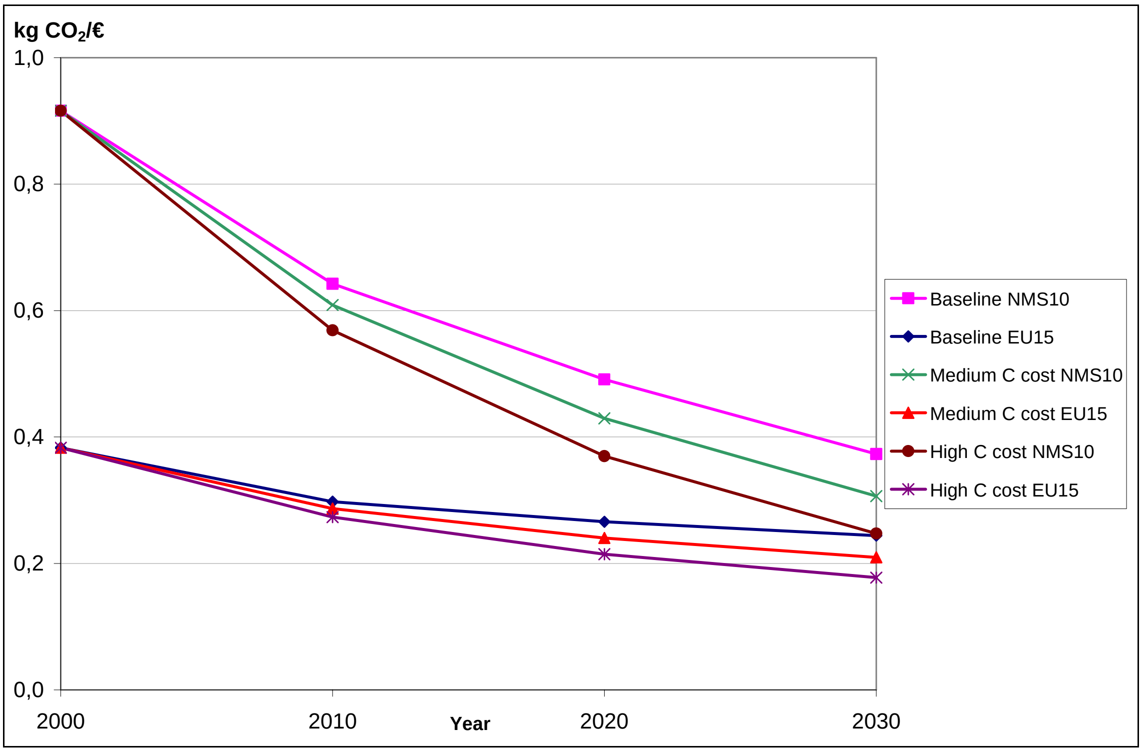

Figure 23. Carbon intensity of value added for the food sector (NACE C 10, 11, 12) in NMS10 and EU 15.

Following the same analytical method, Figures 24 and 25 for Chemicals and Steel industry follows. The higher values in both branches are expected due to their energy intense nature, especially in Steel industry where the values are the highest ones. The lower values for EU 15 indicate the great potentials that exist for the same branches in NMS10 and the levels at where this region is pointing as it can be seen from narrowing the gap by the years.

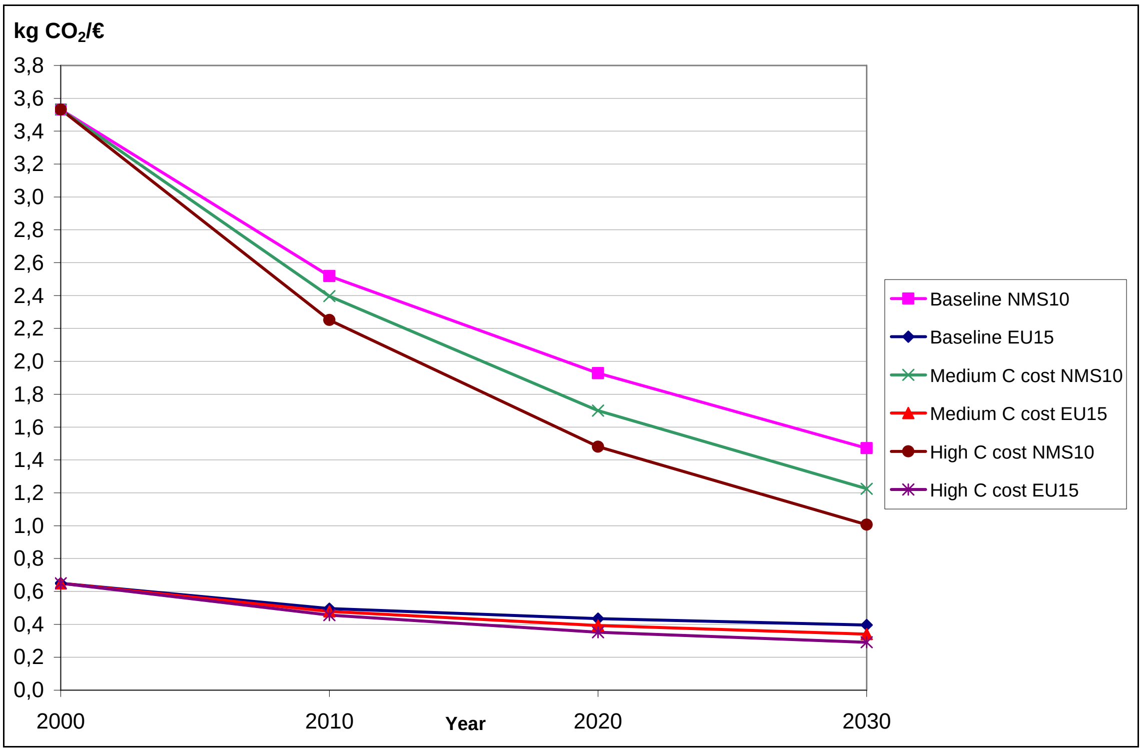

Figure 24. Carbon intensity of value added for the chemicals sector (NACE C 19, 20, 21, (22)) NMS10 and EU 15

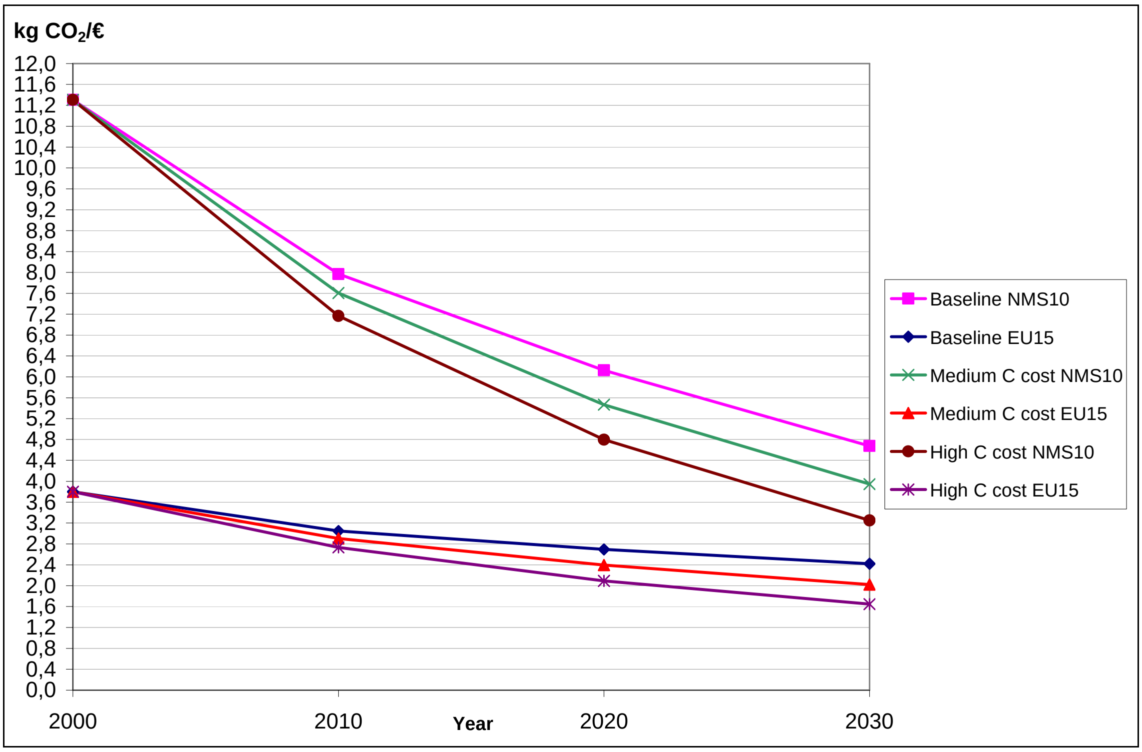

Figure 25. Carbon intensity of value added for steel sector (NACE C 24) in NMS10 and EU 15

These are the main findings from the scenarios built for the purpose of this report and limitations together with comparison with other scenarios from literature are shown in the next section.

III.3 Discussion

It is now time to reveal the uncertainties or the parameters that are not taken into account in these scenarios. Furthermore, a comparison with other scenarios from the literature is made, so as to find out the likeness or the differences with similar studies.

III.3.1 Limitations on data and method

In every study it is very important to mention its limitations so as to understand the weaknesses and the possible drawbacks for further research and possible improvements. Usually for all the reports these limitations are considered minor, at least at the time when the study is made. Moreover, there are parameters or factors that are not affecting directly the results or they make the study very complicated and this is crucial when there are time limitations.

So, for this study the most important limitation is not surprisingly the data used for doing the calculations of the regression analysis. More specifically, in the branch categories a very high level of aggregation is identified. This condition is very crucial for the results as within the same branch many different trends are possible to exist such as in value added and this may alter the results rather significantly, especially in rather big branches that included many different industries.

Same situation exists with energy prices. The prices used in this report are in the form of Index, meaning having a reference year and the rest of the years are a percentage of this year. Obviously, this data is just approximates and somehow averages of the prices that each branch is to pay for energy use for whole Europe and does not represent the real values of each branch individually and for each country, where differences are very possible to exist. This situation is enhanced by what is already mentioned in Chapter II 3.1, where big consumers may have discounts and different prices than smaller or less energy intensive branches.

Another very important limitation is once more in the database. The time series data that is available from the ODYSSEE database is very short in order to identify the trends and the price elasticities that are necessary for this report. This is because changes in energy use due to higher cost or other reasons may take several years and by so they are not represented in this database.

Also, when building the scenarios there is the uncertainty when it comes to historic variations in prices and how similar they will develop with the future ones. In the case of this report, these prices are set to very high levels and by so in this case high values for energy are expected.

Other less important parameters that are not taken into account are presented below. The first is the demographic change that may occur in Europe. Although not dramatic changes are expected to take place (EC 2006), it is a parameter that can alter significantly the results depending on the level of change. This is also enhanced by the fact or assumption that no major changes are to happen in the geopolitical situation globally, so as current economic interactions between countries are the same.

Furthermore, when it comes to policies either domestic or for Europe, some basic assumptions also exist. First of all and very important aspect is that the member countries will keep the energy efficiency measures. Moreover, not major changes are to take place in the level or rate of giving subsidies for renewable energy, so as it will be cheaper and by so more competitive in the market. Regarding energy from nuclear power plants not significant changes in their production is assumed, either positive or negative due to the phase out procedure that some countries have started.

Going further in the assumptions and the limitations, it is reasonable believed that technological improvements are to happen for improving the efficiency as well as the autonomous efficiency which is calculated for this report. The assumption in this report is that no foremost changes are to take place in the sector altering radically the situation in the energy mix and in extension in the emissions.

Other limitation is that not specific emission targets are set for Europe, so their final volume is fully decided on their economic value and the “willingness to pay” principle from the consumer point of view. This situation exist as the consumer is the one that regulates the demand and by so the whole production and is therefore the one who pays for the whole package called product and which includes costs and profit.

Moreover, resource depletion is another aspect that is not taken into consideration from an economic perspective. This means that price alterations due to shortage of supply are not considered in the final price of the source. In this study this price is fully depended on demand and emissions cost. The source that may have a different value due to depletion maybe “Gas”, but again projections for its shortage exceed our examined period.

III.3.2 Comparison with other scenarios in literature

First of all, it should be mentioned that there are no many projections on future energy use and emissions for European Industry. Results from a similar study (EC 2006) are presented in Chapter I (Chapter I.2.1), where projections on future emissions and energy use from European Industry are illustrated. So, based on the findings from this study, a robustness comparison is made in the sub-sector, presenting further details from the previously mentioned above report.

In order to have a more complete overview of the two scenarios and their results, the initial data that are based at have to be mentioned in order of compatibility and a more concrete comparison, as different initial values can give totally different impressions when simply the final conclusions are presented. Fortunately, EC DG-TREN report has as base year the year 2000, as it is in this study, so comparison is reasonable and feasible. It is important here to remind that in this report data is derived from ODYSSEE and IEA databases when it comes to calculations and regulated values from ODYSSEE, IEA and EC DG-TREN when it comes to the build up of the scenarios.

So, starting with energy consumption the first signs of different values are visible. More specifically, in EC DG-TREN the value of consumption for the year 2000 for EU 15 is 11,923 and for NMS10 1895 PJ having a total of 13,819, whereas from ODUSSEE database 11,157 and 1,758 with a total 12,916 PJ. The gap is even bigger when it comes to emissions, where from the first report (EC 2006) for EU 15 there is a volume of 471 $TgCO_2$ and for NMS10 96.1 with total 567 $TgCO_2$, whereas in this study the volume is significantly bigger reaching similarly 715 and 135 with a total of 850 $TgCO_2$ for whole Europe. This difference may be attributed to the emissions from "Electricity", where in the first case they are not included. At the other important value for this study, the "value added", a combination of the two databases is used as shown at tables 20a and 20b (Chapter III 1.2).

Going to the projected results and analyzing mostly their trends, due to the initial difference explained above, it can generally be said that when it comes to energy consumption in the long run compared with the values of 2000 the trend is almost identical, with an increase at the level of 18.6% for EC DG-TREN and 18.7% for this report reaching 16,394 PJ and 15,334 PJ respectively in the year 2030. This change is not equally reflected in the two regions, EU 15 and NMS10, where EC DG-TREN estimates indicate higher increase than this report for EU 15, 14.5% compared to 12.9%, but lower for NMS10, 44.5% compared to 55.6%.

Furthermore, it is observed that per decade changes are steeper in this report than in EC DG-TREN when results from each region individually are analyzed. During the first decade, 2000-2010, there is an increase in consumption in the scale of 7.7% for EU 15 in EC DG-TREN report and 9.6% for NMS10, while in this report for EU 15 a decline of 2.7% and for NMS10 a rise of 28.6%. Similarly for the next decade the change is 5.3% and 19.5% for the two regions in the first mentioned report above and 12.9% with 21.0% respectively in this one, while in the last period (2020-2030) 0.9% with 10.2% and 2.7 with -0.03% for EU 15 and NMS10 for the two projections respectively.

Concerning the emissions the situation is slightly different in the final result, total differences from 2000 to 2030, for the aggregated emissions from both regions (EU 25) for the relevant years. This is due to the initially big differences in values, that although the pretty similar changes for each region independently in percentage, the aggregated value (EU 25) has a difference which is higher: 0.3% increase in emissions in EC DG-TREN and 1.0% in this report. Independently for each region for the same period in the first report for EU 15 the change is -4.3% and for NMS10 23.4%, while in this report it is -2.4% and 19.9% respectively, values which are closer than the ones that appear when it is accounted as total. This situation indicates the generally similarity in the trend, but with different initial values that alter the final result.

In per decade analysis and starting from the first decade examined (2000-2010) there are significant differences even in the trend. Beginning with EC DG-TREN there is an increase 0.9% for EU 15 and 5.3% for NMS10 and a total of 1.6%, while in this report it is -11.7%, 12.5% and -7.8% respectively. The trend is slightly more similar in the next decade, where there is an overall increase of 3.1%, 1% for EU 15 and 13.2% for NMS10 in EC DG-TREN and 7.3%, 6.5% and 10.6% in this report respectively.

Other comparable data is the carbon intensity, meaning the weight of CO_2 emissions per energy content of source (tCO_2/toe). This rate is reasonably higher in the findings of this report throughout the period as the emissions are always much higher enhanced by the lower energy consumption than in EC DG-TREN. This is the reason behind the value in the latter report of 1.66 tCO_2/toe for EU 15 and 2.12 tCO_2/toe with a total (for EU 25) of

1.72 tCO_2/toe in 2000 compared with 2.68 tCO_2/toe, 3.23 tCO_2/toe and 2.76 tCO_2/toe respectively from this report. Similarly for the rest of the years 1.55 tCO_2/toe, 2.04 tCO_2/toe and 1.62 tCO_2/toe for the first report and 2.44 tCO_2/toe, 2.82 tCO_2/toe and 2.50 tCO_2/toe respectively for this report in 2010.

In the same way, for 2020 in EC DG-TREN report the value for EU 15 is 1.49 tCO_2/toe, for NMS10 1.93 tCO_2/toe and total (EU 25) 1.56 tCO_2/toe, whereas in this report 2.30 tCO_2/toe, 2.58 tCO_2/toe and 2.35 tCO_2/toe respectively and final for year 2030 the values are respectively 1.38 tCO_2/toe, 1.81 tCO_2/toe, 1.46 tCO_2/toe and 2.32 tCO_2/toe, 2.49 tCO_2/toe, 2.35 tCO_2/toe.

In the last decade for this report, a slight increase in the carbon intensity is identified, which can be explained by the bigger increase in the emissions than in the consumption. An explanation for this can be the transition from “Gas” to “Oil” or “Coal” or relevantly to more

Unfortunately these are the only values that are comparable from the EC DG-TREN report with the current one, as the rest of the indicators given are either for the whole Industry and Transport or either not calculated in this report.

III.4 Conclusions

As it is thoroughly explained in the previous chapter, energy consumption is growing steadily in Europe (EU 25) as well as CO_2 emissions in the Baseline scenario, unless policy makers decide for higher costs on emission as indicated mostly in High C cost and less in Medium C cost scenarios. Given the fact that environmental problems are attributed to the anthropogenic emissions, it is easily understood the sensitivity and the importance of the decision that the policy makers are to take.

It is also important to recognize the great effort that is taking place and it is indicated by the slow but steadily decreased carbon intensity of energy especially in EU 15 and more steep in NMS10, which is a sign either of changes in fuel mix towards less polluting ones or towards more efficient practices and generally improved efficiency. In any case it is an improvement that releases optimism for further improvements and development.

An important finding in this report is the role of the autonomous efficiency constant that is verified through the regression analyses. After calculating both with and without this constant it is found that the analysis has better fit when this concept is included. Therefore, changes in energy use are verified to be affected by technological improvements and not just by energy prices.

The general ambition for the future is except of decreasing energy use which is not very feasible, is to improve the share of sources that are better for the environment, such as “Biomass” and “Gas” instead of “Coal” and “Oil” in the energy mix so as to at least decrease the volume of the emissions. This is mostly achieved when it comes to “Gas” and less for “Biomass”, despite the shortage of supply that is projected to happen in this century. Highly significant is the role of “Electricity”, as it is the dominant source of energy supplier and its source mix is really important and crucial when it comes to emissions.

But here it can not be neglected that crucial role for the whole situation is the demand for energy and generally the services. Regardless of the feasible improvements that may happen and alterations in the source mix that may occur, it is mostly on the hands of individuals and their lifestyle to alter current trends even more effectively than carbon costs or their combination can alter the current trend of growing uncertainty for the prospect years into a more sustainable and better future.

Section IV

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Section V

Appendices

V.1 Appendix A. Significance of regression analyses for EU 15 from 1980-2004

After presenting the results from the period 1980-2004 in the report, the significance of the regression analyses are also presented in this sub-chapter of the appendices. Due to the large number of the regression analysis statistics that are calculated with the results, a sample of the validation statistics is given. The values of P, F and significance F are the ones from the price elasticity values that are presented both with and without efficiency improvement included in the calculations. The results are presented per branch separately and for all sources; “Coal”, “Oil”, “Gas”, “Electricity” and “Total”. Once again, the meaning of the concept “Total” is the aggregation of all sources mentioned above, enhanced by more sources; “Biomass” and “Heat”.

The first validation analysis is for “Manufacturing”, the aggregation of all the sectors available except “Mining”. As already said, this sector can be assumed to cover the whole sector examined in this report.

Table 1a. Significance values of the regression of Manufacturing Industry including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Manufacturing							
	With efficiency improvement				Without efficiency improvement			
EU 15	R^2	P value	F	Significance F	R^2	P value	F	Significance F
Coal	0.99	0.00	528.7	0.00	0.98	0.09	299.9	0.00
Oil	0.87	0.27	21.7	0.00	0.85	0.51	30.5	0.00
Gas	0.38	0.1	2.1	0.17	0.24	0.38	1.76	0.22
Electricity	0.76	0.72	10.7	0.00	0.57	0.12	7.38	0.01
Total	0.9	0.12	29.2	0.00	0.83	0.74	27	0.00

Taking a closer look at the results, it is clear that the ones from “Gas” are not very consistent from all the statistics. It should also be mentioned the rather increased values of P value in some cases, indicating the low significance of the results. The rest of the statistics from the other sources seem to be rather good with slightly lower significance in the values from “Electricity”. Moreover, as it is expected due to the less explanatory variables and the generally importance of autonomous efficiency constant for the formula, the values of the regressions without efficiency improvement included in the calculations are slightly worse than with efficiency improvement in the calculations.

The significance analysis for “Mining” follows in the same form as above. In this set of statistics, the results can be said that they are pretty satisfying. R^2 values range around 0.85 with slightly lower in “Electricity”. On the other hand, rather high P value in “Electricity” and “Total” can indicate the “No Significant Relationship between the variables”, reducing the significance of the results.

Table 1b. Significance values of the regression of “Mining” including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Mining							
	With efficiency improvement				Without efficiency improvement			
EU 15	R^2	P value	F	Significance F	R^2	P value	F	Significance F
Coal	0.9	0.21	44	0.00	0.89	0.27	67.9	0.00
Oil	0.84	0.01	35.8	0.00	0.82	0.02	46.8	0.00
Gas	0.89	0.16	52.3	0.00	0.88	0.11	74.9	0.00
Electricity	0.69	0.45	11.3	0.00	0.69	0.43	18	0.00
Total	0.82	0.64	22.8	0.00	0.82	0.78	36.1	0.00

Table 1c. Significance values of the regression of “Food Industry” including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Food							
	With efficiency improvement				Without efficiency improvement			
EU 15	R^2	P value	F	Significance F	R^2	P value	F	Significance F
Coal	0.82	0.84	15	0.00	0.81	0.82	23.3	0.00
Oil	0.95	0.98	67.5	0.00	0.87	0.05	36.4	0.00
Gas	0.95	0.15	72.4	0.00	0.93	0.56	71.9	0.00
Electricity	0.97	0.03	122.6	0.00	0.95	0.08	109	0.00
Total	0.84	0.28	17.8	0.00	0.71	0.98	13.4	0.00

The peculiarity in this set for “Food Industry” is the rather high values of P-value in almost all sources except “Electricity”, where generally the statistics are not satisfying. The rest of the statistics can be assumed to be somehow satisfying by having high values of R^2, acceptable and some good values of F and always significance F on the wanted level.

Table 1d. Significance values of the regression of “Textile and Leather” including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Textile and leather							
	With efficiency improvement				Without efficiency improvement			
EU 15	R^2	P value	F	Significance F	R^2	P value	F	Significance F
Coal	0.88	0.02	23.8	0.00	0.61	0.58	8.5	0.00
Oil	0.69	0.57	7.47	0.01	0.62	0.11	8.85	0.00
Gas	0.95	0.19	70.3	0.00	0.87	0.54	35.6	0.00
Electricity	0.97	0.03	131	0.00	0.87	0.12	38.4	0.00
Total	0.86	0.00	21.3	0.00	0.85	0.00	31.8	0.00

For this branch, “Textile and Leather, what can be said is that once more the results are satisfying with only exception in “Oil” source in both cases and “Coal” when it comes to calculations without autonomous efficiency included. In these circumstances the results are not in an acceptable range, with R^2 around 0.65.

Table 1e. Significance values of the regression of “Paper,Printing” including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Paper, Printing							
	With efficiency improvement				Without efficiency improvement			
EU 15	R^2	P value	F	Significance F	R^2	P value	F	Significance F
Coal	0.95	0.12	62	0.00	0.91	0.08	58.8	0.00

Continue from table 1e

	Paper, Printing							
	With efficiency improvement				Without efficiency improvement			
EU 15	R^2	P value	F	Significance F	R^2	P value	F	Significance F
Oil	0.89	0.76	28.6	0.00	0.86	0.63	34.8	0.00
Gas	0.93	0.1	42	0.00	0.9	0.68	51.3	0.00
Electricity	0.96	0.22	72.5	0.00	0.93	0.32	76.3	0.00
Total	0.95	0.58	66.8	0.00	0.91	0.49	53.9	0.00

The results from the "Paper, Printing" branch can be seen in the table above (Table 1e). Despite the very good level of R^2, F and significance F, there are high values of P- value in "Oil" and "Total" in calculations with efficiency improvement and all sources except "Coal" without efficiency improvement. This is a situation that as mentioned above shows the "No Significant Relationship between the variables".

Table 1f. Significance values of the regression of "Chemicals" including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Chemicals							
	With efficiency improvement				Without efficiency improvement			
EU 15	R^2	P value	F	Significance F	R^2	P value	F	Significance F
Coal	0.89	0.06	28.4	0.00	0.86	0.25	33.3	0.00
Oil	0.78	0.15	11.9	0.00	0.74	0.41	15.6	0.00
Gas	0.87	0.41	22.6	0.00	0.78	0.16	20.1	0.00
Electricity	0.98	0.6	174.2	0.00	0.98	0.51	236.7	0.00
Total	0.96	0.09	83.9	0.00	0.95	0.31	112.4	0.00

In this set of statistics, once more it can be observed the high value of the P-value, when the rest of the statistics are not very satisfying in both cases this time, but very good results from "Total" when efficiency improvement is included in the calculations and is the only source with significant results in this case. Possible explanations and remarks are also said for the previous branches. Once again the significance of the results is not high.

Table 1g. Significance values of the regression of "Non Metallic Minerals" including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Non Metallic Minerals							
	With efficiency improvement				Without efficiency improvement			
EU 15	R^2	P value	F	Significance F	R^2	P value	F	Significance F
Coal	0.97	0.53	115.3	0.00	0.85	0.35	30.3	0.00
Oil	0.32	0.26	1.54	0.26	0.25	0.45	1.84	0.2
Gas	0.85	0.58	18.9	0.00	0.65	0.8	10.4	0.00
Electricity	0.82	0.24	15.2	0.00	0.7	0.82	13	0.00
Total	0.63	0.6	5.6	0.02	0.45	0.01	4.56	0.04

In the table above (Table 1g), the statistics from "Non Metallic Minerals" are presented. In this case, there is a mixture of results in all statistics for all sources. So, it is very difficult to make a general comment for this branch, except that once more the P-values are high. The only safe outcome is the insignificance once more of the results that can be observed through the whole of the table.

Table 1h. Significance values of the regression of "Primary Metals" including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Primary Metals							
	With efficiency improvement				Without efficiency improvement			
EU 15	R^2	P value	F	Significance F	R^2	P value	F	Significance F
Coal	0.91	0.73	32.3	0.00	0.31	0.21	2.43	0.13
Oil	0.88	0.62	24.8	0.00	0.87	0.19	37.2	0.00
Gas	0.74	0.46	9.65	0.00	0.64	0.44	10	0.00
Electricity	0.86	0.46	21.5	0.00	0.81	0.2	24.1	0.00
Total	0.86	0.69	20.4	0.00	0.78	0.71	20.1	0.00

As it is observed from the above table (Table1h), the statistics from the "Primary Metals" branch, R^2 values are rather low, with just "Oil" and "Gas" exceeding 0.9 and especially "Coal" and "Electricity" with and without efficiency improvement included in the calculations. Furthermore, F and Significance F are also not in the acceptable and satisfying level and once more P values are rather increased in all cases.

Table 1i. Significance values of the regression of "Steel" including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Steel							
	With efficiency improvement				Without efficiency improvement			
EU 15	R2	P value	F	Significance F	R2	P value	F	Significance F
Coal	0.8	0.33	13.8	0.00	0.7	0.59	13.1	0.00
Oil	0.96	0.37	70.4	0.00	0.94	0.14	84.1	0.00
Gas	0.91	0.05	31.5	0.00	0.84	0.22	26.6	0.00
Electricity	0.38	0.73	1.81	0.21	0.37	0.52	2.93	0.1
Total	0.84	0.94	15.4	0.00	0.78	0.5	17.9	0.00

Low R^2 values in "Electricity" and pretty high values of P-value once more, are the characteristics of the statistics of the significance analysis of "Steel" industry for the time period 1980-2004.Nothing really special can be identified, distinguishing these results from the tables before.

Table 1j. Significance values of the regression of "Non ferrous Metals" including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Non ferrous Metals							
	With efficiency improvement				Without efficiency improvement			
EU 15	R2	P value	F	Significance F	R2	P value	F	Significance F
Coal	0.65	0.8	12.4	0.00	0.62	0.31	17	0.00
Oil	0.88	0.34	22.4	0.00	0.77	0.84	16.6	0.00
Gas	0.74	0.08	8.67	0.00	0.74	0.03	14	0.00
Electricity	0.53	0.25	3.44	0.06	0.53	0.08	5.73	0.02
Total	0.46	0.69	2.6	0.12	0.41	0.37	3.56	0.07

For this branch, "Non ferrous Metals", the general overview of the statistics indicate the low significance of the results, as there are low, relatively to the previous branches, values in R^2 and F, and as usual rather high values in P-value and in this case some values of Significance F spamming over zero in "Electricity" and "Total" for both methods of calculations.

Table 1k. Significance values of the regression of “Equipment Goods” including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Equipment Goods							
	With efficiency improvement				Without efficiency improvement			
EU 15	R2	P value	F	Significance F	R2	P value	F	Significance F
Coal	0.97	0.78	122.3	0.00	0.97	0.79	201.4	0.00
Oil	0.91	0.6	35.3	0.00	0.89	0.79	43.7	0.00
Gas	0.39	0.1	2.18	0.15	0.01	0.91	0.04	0.96
Electricity	0.61	0.92	5.18	0.02	0.43	0.15	4.23	0.04
Total	0.78	0.48	12.1	0.00	0.42	0.03	3.95	0.05

This set of results, for Equipment Goods” branch is characterized by very low values of R^2 in “Gas” source and generally low significance statistics. Exception can be said that are mainly “Coal” source and further the “Oil” source, but again followed by high values of P-value.

Table 1l. Significance values of the regression of “Equipment Goods” including R^2, P-value, F, Significance F for EU 15 for the period 1980-2004

	Other Industries							
	With efficiency improvement				Without efficiency improvement			
EU 15	R2	P value	F	Significance F	R2	P value	F	Significance F
Coal	0.37	0.43	2	0.18	0.06	0.81	0.33	0.73
Oil	0.76	0.57	10.4	0.00	0.73	0.29	14.9	0.00
Gas	0.24	0.17	1.07	0.4	0.17	0.29	1.13	0.36
Electricity	0.69	0.84	7.33	0.01	0.65	0.26	10.5	0.00
Total	0.62	0.76	5.46	0.02	0.59	0.53	8.05	0.01

The last set of results, the results from the branch named “Other Industries” are presented in the above table. As it can be easily observed, the statistics are not good indicating the complexity of this branch. Low R2 and F values, high P values rather high Significance F values reveal the heterogeneity existing in this branch and the difficulties in categorizing different industries in one branch.

V.2 Appendix B. Significance of regression analyses for EU 15 and NMS 10 from 1995-2004

Once again, the first validation analysis is for “Manufacturing”. The rest of the tables with the “Significance” analysis follow consequently.

Table 2a. Significance values of the regression of Manufacturing Industry including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Manufacturing with efficiency improvement					Manufacturing without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.98	0.76	0.27	0.67	0.86	0.94	0.76	0.17	0.63	0.8
	P value	0.00	0.72	0.75	0.96	0.17	0.15	0.51	0.29	0.65	0.52
	F	126	6.5	0.74	4.12	12.7	65.6	11.2	0.71	5.96	14.2
	Sig. F	0.00	0.02	0.56	0.07	0.00	0.00	0.01	0.52	0.03	0.00
NMS	R^2	0.91	0.92	0.98	0.96	0.95	0.85	0.91	0.95	0.92	0.93
	P value	0.5	0.09	0.03	0.08	0.18	0.75	0.02	0.26	0.69	0.39
	F	20.1	23.4	122	52.3	43.4	19.6	35.8	72.9	38.5	50.1
	Sig. F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poland	R^2	0.98	0.84	0.92	0.95	0.98	0.91	0.83	0.9	0.94	0.96
	P value	0.49	0.1	0.76	0.33	0.1	0.75	0.00	0.95	0.76	0.21
	F	134	10.9	23.3	43.1	96.9	36.6	17.5	32.3	52.8	99
	Sig. F	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Czech R.	R^2	0.8	0.85	0.91	0.74	0.79	0.71	0.77	0.86	0.74	0.77
	P value	0.35	0.36	0.67	0.47	0.99	0.07	0.34	0.38	0.38	0.97
	F	8.1	11.3	20.5	5.75	7.39	8.51	12.1	21.9	9.84	12
	Sig. F	0.01	0.01	0.00	0.03	0.02	0.01	0.00	0.00	0.01	0.00

Focusing firstly on the R^2 value, in general it can be said that the values are rather satisfying and close to 0.9 with some exceptions mainly in EU 15 and Czech Republic both with and without efficiency improvement included in the calculations. These low values in R^2 are followed by small values in F value and even in some cases smaller than one. This means that the independent variables explain less times the dependent variable than it is not explained. This is also represented by the increased rate in P value and not just in the cases of low R^2, where they span rather significantly in some cases from zero as they are opposite correlated with F value. Also it should be noted the high rate of Significance F in cases where R^2 and F values are low, showing a high probability of getting the ratio of F value from pure chance variation. Generally it should be noted the rather high values of P-value statistic in almost all the regions and sources, indicating that the null hypothesis can be rejected at a very high significance level.

Furthermore, a validation analysis of the regression analysis for “Mining Industries” is presented. The characteristic of this sector as far as the validation is concerned is the general impression of irregularity in the results, as the R^2 in many cases is considerably below 0.9, P value is also rather high as well as Significance F and combined with rather small number in F value.

Table 2b. Significance values of the regression of Mining including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Mining with efficiency improvement					Mining without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.25	0.82	0.32	0.82	0.58	0.25	0.79	0.19	0.71	0.57
	P value	0.35	0.54	0.25	0.5	0.37	0.17	0.18	0.45	0.66	0.07
	F	0.68	9.05	0.94	9.14	2.74	1.19	13.6	0.84	8.43	4.74
	Sig. F	0.59	0.01	0.48	0.01	0.13	0.36	0.00	0.47	0.01	0.05
NMS	R^2	0.93	0.17	0.75	0.58	0.83	0.86	0.14	0.7	0.57	0.76
	P value	0.26	0.55	0.05	0.09	0.42	0.27	0.59	0.01	0.07	0.82
	F	25.1	0.41	6.19	2.75	10	20.8	0.59	8.33	4.64	10.9
	Sig. F	0.00	0.75	0.03	0.13	0.01	0.00	0.58	0.01	0.05	0.01
Poland	R^2	0.91	0.33	0.82	0.82	0.88	0.82	0.26	0.82	0.75	0.81
	P value	0.64	0.4	0.8	0.22	0.74	0.82	0.67	0.71	0.61	0.74
	F	20.3	0.99	9.32	8.93	15.3	16.5	1.23	16.1	10.7	15.1
	Sig. F	0.00	0.46	0.01	0.01	0.00	0.00	0.35	0.00	0.01	0.00
Czech R.	R^2	0.8	0.29	0.87	0.84	0.11	0.48	0.23	0.33	0.8	0.11
	P value	0.32	0.88	0.67	0.18	0.49	0.75	0.34	0.1	0.36	0.4
	F	8.31	0.83	13.4	11	0.26	3.18	1.04	1.77	14.4	0.43
	Sig. F	0.01	0.52	0.00	0.01	0.85	0.1	0.4	0.24	0.00	0.67

Although it is not reasonable to always depend the robustness of the results to R^2, it is a sign of how much good the data fitted to the model. So, low R^2 means low goodness in fit for the results. Also, the lowest significance level at which a null hypothesis can be rejected, the P value, is pretty high, indicating that there is a high probability that the null hypothesis is correct and by so the result of the model is outside the result wanted. For F value and Significance F, some conclusions on irregular values are explained in the previous sub chapter.

The robustness of the results of the Regression Analysis of "Food Industry" is presented in the following table (Table 2c). The general impression for the statistical data presented is quite mixed for R^2, as for EU 15 the only problematic results are for "Coal", although P values are also pretty high, for NMS the same phenomenon can be observed for "Gas" but with again increased prices for P value but in both regions the rest of the results are encouraging. Unfortunately, it can not be said the same for Poland and Czech Republic, where the majority of the R^2's are low, high P values, moderated F and Significance F values.

Table 2c. Significance values of the regression of Food Industry including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Food with efficiency improvement					Food without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.31	0.91	0.92	0.99	0.83	0.31	0.91	0.87	0.96	0.73
	P value	0.69	0.42	0.62	0.01	0.72	0.51	0.21	0.73	0.48	0.4
	F	0.91	21.7	21.9	214	10	1.6	36.4	24.5	86.8	9.5
	Sig. F	0.48	0.00	0.00	0.00	0.01	0.27	0.00	0.00	0.00	0.01
NMS	R^2	0.92	0.81	0.22	0.8	0.9	0.81	0.7	0.1	0.65	0.78
	P value	0.22	0.89	0.48	0.17	0.11	0.99	0.19	0.86	0.13	0.87
	F	23.1	8.49	0.56	7.85	17.9	15.3	8.26	0.42	6.39	12.2
	Sig. F	0.00	0.01	0.66	0.02	0.00	0.00	0.01	0.67	0.03	0.00

Continue from Table 2c

		Food with efficiency improvement					Food without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
Poland	R^2	0.93	0.19	0.11	0.72	0.85	0.86	0.06	0.06	0.67	0.78
	P value	0.39	0.52	0.84	0.85	0.49	0.92	0.54	0.69	0.31	0.76
	F	25.8	0.46	0.24	5.12	11.5	21.1	0.23	0.25	7	12.6
	Sig. F	0.00	0.72	0.87	0.04	0.01	0.00	0.8	0.79	0.02	0.00
Czech R.	R^2	0.83	0.46	0.49	0.25	0.69	0.57	0.33	0.47	0.14	0.42
	P value	0.26	0.09	0.25	0.27	0.73	0.16	0.11	0.09	0.34	0.83
	F	10.1	1.72	1.91	0.68	4.39	4.73	1.73	3.15	0.56	2.56
	Sig. F	0.01	0.26	0.23	0.59	0.06	0.05	0.24	0.1	0.59	0.15

In the next table (Table 2d), table of the validation analysis of "Textile and leather" sector, the values of the statistics tend to be, at least most of them, at the moderate and once again not significant in general level. For EU 15, with exception at "Oil" where R^2 is low and the rest of the values following the same irregular trend and "Oil" and "Coal" when efficiency improvement is not included, the values are a bit better but again not satisfying in all stats. Almost the same situation exists for the NMS, but with an addition of electricity, although its values are not that abnormal. Almost moderate values exist for Poland and Czech Republic, without the appearance of extreme values, except the P value in some cases.

Table 2d. Significance values of the regression of Textile and Leather including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Textile and leather with efficiency improvement					Textile and leather without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.88	0.36	0.92	0.95	0.95	0.55	0.31	0.83	0.93	0.85
	P value	0.03	0.93	0.68	0.15	0.18	0.67	0.13	0.12	0.4	0.21
	F	15.5	1.11	22.1	37.6	38.3	4.25	1.5	16.7	46.4	19.6
	Sig. F	0.00	0.42	0.00	0.00	0.00	0.06	0.28	0.00	0.00	0.00
NMS	R^2	0.98	0.3	0.9	0.69	0.9	0.95	0.21	0.83	0.58	0.89
	P value	0.5	0.23	0.35	0.11	0.74	0.82	0.21	0.00	0.24	0.84
	F	93.7	0.88	18.1	4.42	18.1	72	0.94	16.8	4.8	28.4
	Sig. F	0.00	0.5	0.00	0.06	0.00	0.00	0.43	0.00	0.05	0.00
Poland	R^2	0.95	0.31	0.56	0.61	0.92	0.81	0.29	0.5	0.49	0.84
	P value	0.51	0.84	0.9	0.36	0.18	0.44	0.15	0.34	0.76	0.93
	F	38.3	0.9	2.53	3.12	24.4	15.4	1.41	3.48	3.33	18.3
	Sig. F	0.00	0.5	0.15	0.11	0.00	0.00	0.3	0.09	0.1	0.00
Czech R.	R^2	0.91	0.69	0.32	0.15	0.9	0.89	0.6	0.04	0.14	0.77
	P value	0.21	0.87	0.99	0.61	0.2	0.06	0.52	0.6	0.33	0.13
	F	21.4	4.38	0.92	0.36	18.7	29.9	5.38	0.15	0.57	11.5
	Sig. F	0.00	0.06	0.48	0.78	0.00	0.00	0.04	0.86	0.59	0.01

Moreover, in the table below (Table 2e), table of the validations analysis of "Paper and Printing Industry", there is an obvious setback with the statistics of "Gas" for EU 15 and NMS, although the significance is very different. For EU 15, R^2 can be supposed to be at acceptable levels, whereas at NMS there is clearly a problem with its value almost zero and with the rest of the statistics following the same irregularity both with and without efficiency improvement in the formula. On the other hand, Poland and Czech

Republic have moderate values, with Poland slightly better ones, but again with high values of P value.

Table 2e. Significance values of the regression of Paper and Printing including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Paper and printing with efficiency improvement					Paper and printing without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.95	0.86	0.61	0.97	0.94	0.87	0.83	0.52	0.78	0.93
	P value	0.01	0.59	0.46	0.35	0.04	0.06	0.94	0.62	0.97	0.00
	F	41.7	12.2	3.15	73.3	31.7	23.4	16.8	3.87	12.8	49
	Sig. F	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.07	0.00	0.00
NMS	R^2	0.91	0.94	0.00	0.85	0.68	0.65	0.92	0.00	0.72	0.56
	P value	0.33	0.00	0.9	0.01	0.31	0.4	0.00	0.95	0.04	0.61
	F	21.4	31.9	0.01	11.4	4.35	6.41	39.6	0.00	9	4.42
	Sig. F	0.00	0.00	0.9	0.01	0.06	0.03	0.00	0.99	0.01	0.06
Poland	R^2	0.9	0.62	0.78	0.87	0.93	0.18	0.61	0.56	0.68	0.82
	P value	0.2	0.53	0.69	0.02	0.01	0.4	0.07	0.26	0.55	0.37
	F	16.2	3.3	7.1	13.7	28.9	0.77	5.46	4.5	7.56	15.9
	Sig. F	0.00	0.1	0.02	0.00	0.00	0.5	0.04	0.05	0.02	0.00
Czech R.	R^2	0.77	0.55	0.8	0.63	0.54	0.61	0.32	0.41	0.52	0.19
	P value	0.87	0.92	0.52	0.7	0.99	0.82	0.54	0.66	0.03	0.79
	F	6.87	2.41	8.13	3.43	2.38	5.55	1.68	2.48	3.82	0.85
	Sig. F	0.02	0.16	0.01	0.09	0.17	0.03	0.25	0.15	0.07	0.47

For the next industry, "Chemicals", there is also a similar trend between EU 15 and NMS, distinguishing the peculiarities in the statistics mostly in "Oil" and less in "Coal", but again with rather increased values for P statistic. After observing all the regions and countries it can generally be said once again the results are rather insignificant.

Table 2f. Significance values of the regression of Chemicals including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Chemicals with efficiency improvement					Chemicals without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.75	0.48	0.89	0.97	0.89	0.67	0.47	0.86	0.96	0.89
	P value	0.15	0.61	0.69	0.79	0.57	0.39	0.53	0.08	0.22	0.62
	F	5.97	1.83	14.4	60.9	17	7.15	3.16	21.1	99.2	28.94
	Sig. F	0.03	0.24	0.00	0.00	0.00	0.02	0.1	0.00	0.00	0.00
NMS	R^2	0.66	0.55	0.96	0.94	0.97	0.25	0.46	0.83	0.86	0.73
	P value	0.73	0.23	0.18	0.37	0.05	0.17	0.53	0.85	0.72	0.16
	F	3.89	2.49	55.8	30.2	57.4	1.2	2.95	17	21.8	9.6
	Sig. F	0.07	0.16	0.00	0.00	0.00	0.36	0.12	0.00	0.00	0.01
Poland	R^2	0.94	0.85	0.64	0.94	0.95	0.47	0.81	0.54	0.87	0.69
	P value	0.35	0.14	0.74	0.05	0.09	0.04	0.31	0.04	0.56	0.19
	F	32	11.2	3.63	29.2	40.5	3.12	14.6	4.1	24	7.75
	Sig. F	0.00	0.01	0.08	0.00	0.00	0.11	0.00	0.07	0.00	0.02
Czech R.	R^2	0.59	0.27	0.48	0.84	0.62	0.47	0.17	0.3	0.83	0.52
	P value	0.94	0.9	0.67	0.23	0.04	0.42	0.52	0.23	0.21	0.03
	F	2.93	0.76	1.83	10.5	3.25	3.11	0.74	1.5	16.7	3.75
	Sig. F	0.12	0.55	0.24	0.01	0.1	0.11	0.51	0.29	0.00	0.08

A general comment after taking a closer look at the statistics of the next table (Table 2g), table of significance of the regression analysis of "Non metallic Mineral Industry", is the overall rather good significance of them. Despite the fact of some exceptions and as in many cases the high values of the P value, the rest of them are convincing that the results are close to the real ones when it comes to price elasticity. Special notice should be paid to NMS, where the values can be supposed to be ideal, with very high R^2, close to zero P values, high F values and Significance F not spanning significantly over zero, indicating the almost high level of approximation of the results.

Table 2g. Significance values of the regression of Non Metallic Mineral including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Non metallic minerals with efficiency improvement					Non metallic minerals without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.95	0.83	0.7	0.87	0.63	0.92	0.79	0.6	0.63	0.58
	P value	0.26	0.1	0.92	0.01	0.99	0.28	0.00	0.1	0.13	0.11
	F	40.1	10.2	4.7	13	3.36	40.9	13.3	5.32	6.03	4.84
	Sig. F	0.00	0.01	0.05	0.00	0.1	0.00	0.00	0.04	0.03	0.05
NMS	R^2	0.99	0.86	0.96	0.98	0.97	0.98	0.77	0.89	0.9	0.95
	P value	0.04	0.05	0.02	0.00	0.23	0.2	0.3	0.33	0.2	0.43
	F	250	12.5	49.5	107	57.7	189	11.5	29.9	33.4	72
	Sig. F	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Poland	R^2	0.99	0.61	0.73	0.96	0.97	0.98	0.51	0.55	0.9	0.96
	P value	0.09	0.06	0.12	0.07	0.1	0.14	0.05	0.57	0.62	0.14
	F	251	3.18	5.38	51.3	67.5	207	3.66	4.25	30.2	76.2
	Sig. F	0.00	0.11	0.04	0.00	0.00	0.00	0.08	0.06	0.00	0.00
Czech R.	R^2	0.8	0.96	0.92	0.6	0.92	0.67	0.92	0.92	0.53	0.91
	P value	0.72	0.71	0.11	0.39	0.79	0.4	0.4	0.08	0.96	0.71
	F	8	47.3	24.8	2.95	23.3	7.08	39.2	43.2	3.98	35.5
	Sig. F	0.02	0.00	0.00	0.12	0.00	0.02	0.00	0.00	0.07	0.00

When coming to the significance of elasticity estimates of "Primary Metals Industry", the values of the statistics are not satisfying as a general overview. Observing first the values for EU 15, there can be found a peculiarity because there are simultaneously high values in R^2 and in P value and having the rest of the statistics in normal levels. For NMS and the two countries examined in this report the trend is almost similar, with the majority of R^2 around 0.5 with variations and surprisingly better values for P value than expected and compared to the ones of EU 15. At the same time, F and Significance F values are in many situations pretty small and rather immense respectively.

Table 2h. Significance values of the regression of Primary Metals including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Primary metals with efficiency improvement					Primary metals without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.87	0.91	0.75	0.84	0.9	0.8	0.89	0.63	0.74	0.75
	P value	0.98	0.98	0.65	0.27	0.04	0.4	0.72	0.49	0.63	0.49
	F	13.2	20.2	6.15	10.2	18.5	13.7	27.8	5.89	9.78	10.3
	Sig. F	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.03	0.01	0.01
NMS	R^2	0.47	0.73	0.5	0.51	0.11	0.46	0.72	0.07	0.39	0.06

Continue from Table 2h

		Primary metals with efficiency improvement					Primary metals without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
NMS	P value	0.15	0.28	0.08	0.05	0.48	0.08	0.16	0.85	0.07	0.57
	F	1.78	5.44	1.99	2.1	0.24	2.96	9.1	0.26	2.27	0.22
	Sig. F	0.25	0.04	0.22	0.2	0.86	0.12	0.01	0.78	0.17	0.81
Poland	R^2	0.65	0.55	0.47	0.69	0.73	0.48	0.35	0.47	0.68	0.71
	P value	0.26	0.6	0.37	0.15	0.09	0.13	0.12	0.07	0.02	0.01
	F	3.8	2.42	1.8	4.55	5.51	3.3	1.92	3.05	7.61	8.7
	Sig. F	0.07	0.16	0.25	0.05	0.04	0.1	0.22	0.11	0.02	0.01
Czech R.	R^2	0.62	0.15	0.43	0.49	0.49	0.28	0.12	0.1	0.4	0.16
	P value	0.51	0.45	0.48	0.68	0.76	0.15	0.54	0.75	0.09	0.41
	F	3.33	0.37	1.51	1.95	1.9	1.4	0.46	0.39	2.3	0.66
	Sig. F	0.1	0.78	0.3	0.22	0.23	0.31	0.64	0.69	0.17	0.54

For “Steel Industry” branch, as already mentioned in the elasticity results, there is data just for EU 15. So, accordingly just the significance of these results is explained in this sub section. As it can be seen, just the statistics for “Oil” and “Gas” can be said as satisfying, high R^2 value, rather increased P value and rather high F value and Significance F very close to zero, concerning the prices when efficiency improvement is included. Identical is the trend when efficiency improvement is not included, with a bit worse levels of R^2, whereas P and F values are slightly better as well as Significance F. So, generally once more the results tend to be rather insignificant.

Table 2i. Significance values of the regression of Steel including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Steel with efficiency improvement					Steel without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.36	0.95	0.9	0.17	0.72	0.33	0.95	0.89	0.14	0.71
	P value	0.6	0.34	0.09	0.32	0.69	0.2	0.29	0.04	0.32	0.24
	F	1.11	37.7	17.9	0.4	5.2	1.71	65	27.5	0.57	8.71
	Sig. F	0.41	0.00	0.00	0.76	0.04	0.25	0.00	0.00	0.59	0.01
NMS	R^2	-	-	-	-	-	-	-	-	-	-
	P value	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Sig. F	-	-	-	-	-	-	-	-	-	-
Poland	R^2	-	-	-	-	-	-	-	-	-	-
	P value	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Sig. F	-	-	-	-	-	-	-	-	-	-
Czech R.	R^2	-	-	-	-	-	-	-	-	-	-
	P value	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Sig. F	-	-	-	-	-	-	-	-	-	-

Having the same gap in the data, just the significance of the price elasticity of EU 15 is presented for “Non Ferrous Metals Industry”. As it can be seen from the table just the values of “Coal” and “Gas” are not significant, with high R^2, but once more not reasonable P value, decent F and almost zero Significance F. For the rest of the sources, the values are moderate with exception in Significance F, where in all cases it is almost zero. Similar trend also exists when efficiency improvement is not calculated, but in most cases with worse values for all of the statistics.

Table 2j. Significance values of the regression of Non Ferrous Metals including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Non ferrous metals with efficiency improvement					Non ferrous metals without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.88	0.73	0.9	0.64	0.46	0.7	0.56	0.73	0.44	0.41
	P value	0.3	0.65	0.25	0.12	0.89	0.46	0.49	0.04	0.24	0.31
	F	14.3	5.32	18.1	3.6	1.69	8.13	4.53	9.3	2.74	2.42
	Sig. F	0.00	0.04	0.00	0.08	0.27	0.01	0.05	0.01	0.13	0.16
NMS	R^2	-	-	-	-	-	-	-	-	-	-
	P value	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Sig. F	-	-	-	-	-	-	-	-	-	-
Poland	R^2	-	-	-	-	-	-	-	-	-	-
	P value	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Sig. F	-	-	-	-	-	-	-	-	-	-
Czech R.	R^2	-	-	-	-	-	-	-	-	-	-
	P value	-	-	-	-	-	-	-	-	-	-
	F	-	-	-	-	-	-	-	-	-	-
	Sig. F	-	-	-	-	-	-	-	-	-	-

For "Equipment Goods Industry" branch, the values for the NMS and Poland should be noted, but again with exception in some high values of P value the rest of the statistics are good but once again not significant. For EU 15 and Czech Republic even the rest of the statistics are not good. Although there are some good exceptions as well, the majority of the statistics are not at the wanted level. Low values of R^2 and F value can be observed in both cases, combined with high values of P and Significance F.

Table 2k. Significance values of the regression of Equipment Goods including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Equipment goods with efficiency improvement					Equipment goods without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.92	0.81	0.11	0.33	0.57	0.91	0.81	0.11	0.07	0.5
	P value	0.98	0.44	0.69	0.41	0.89	0.47	0.27	0.49	0.66	0.11
	F	21.9	8.4	0.25	0.99	2.71	34.1	14.5	0.43	0.28	3.46
	Sig. F	0.00	0.01	0.86	0.46	0.14	0.00	0.00	0.7	0.76	0.09
NMS	R^2	0.98	0.98	0.97	0.99	0.98	0.98	0.82	0.96	0.95	0.98
	P value	0.89	0.46	0.2	0.00	0.14	0.13	0.1	0.54	0.32	0.19
	F	118	102	71.8	215	119	182	15.7	86.1	73.3	180
	Sig. F	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poland	R^2	0.99	0.9	0.98	0.98	0.98	0.98	0.83	0.9	0.96	0.98
	P value	0.54	0.58	0.1	0.12	0.45	0.42	0.04	0.6	0.56	0.62
	F	202	18.3	100	108	113	208	17.6	32.8	85.2	151
	Sig. F	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Czech R.	R^2	0.32	0.83	0.97	0.79	0.67	0.27	0.38	0.95	0.75	0.65
	P value	0.75	0.58	0.06	0.19	0.8	0.19	0.4	0.29	0.27	0.95
	F	0.96	10.2	74.3	7.76	4.09	1.3	2.11	65.2	10.7	6.59
	Sig. F	0.47	0.01	0.00	0.02	0.07	0.33	0.19	0.00	0.01	0.02

The "Other Industries" sector, by covering a lot of branches that could not fit in the previous ones is more reasonable to give even less significant estimates of elasticity. Similar trends can be observed to both regions and both countries, with values ranging for all statistics significantly.

Table 2l. Significance values of the regression of Other Industries including R^2, P-value, F, Significance F for all regions and countries for the period 1995-2004

		Other industries with efficiency improvement					Other industries without efficiency improvement				
Region	Stat	Coal	Oil	Gas	Elec.	Total	Coal	Oil	Gas	Elec.	Total
EU 15	R^2	0.47	0.76	0.39	0.77	0.87	0.02	0.75	0.24	0.63	0.64
	P value	0.13	0.58	0.67	0.36	0.06	0.9	0.72	0.23	0.73	0.92
	F	1.77	6.45	1.27	6.7	13.6	0.08	10.6	1.1	6.1	6.31
	Sig. F	0.25	0.03	0.36	0.02	0.00	0.92	0.00	0.38	0.03	0.03
NMS	R^2	0.72	0.72	0.4	0.74	0.36	0.56	0.57	0.39	0.35	0.17
	P value	0.91	0.81	0.76	0.76	0.49	0.18	0.19	0.1	0.4	0.27
	F	5.12	5.23	1.31	5.72	1.1	4.56	4.71	2.25	1.9	0.73
	Sig. F	0.04	0.04	0.35	0.03	0.42	0.05	0.05	0.18	0.22	0.51
Poland	R^2	0.83	0.95	0.35	0.54	0.74	0.69	0.85	0.35	0.51	0.73
	P value	0.43	0.21	0.38	0.2	0.41	0.31	0.2	0.24	0.05	0.04
	F	9.72	35.9	1.1	2.33	5.7	7.65	19.8	1.87	3.68	9.44
	Sig. F	0.01	0.00	0.42	0.17	0.03	0.02	0.00	0.22	0.08	0.01
Czech R.	R^2	-	0.45	0.72	0.9	0.79	-	0.45	0.57	0.88	0.62
	P value	-	0.68	0.33	0.48	0.65	-	0.44	0.99	0.11	0.5
	F	-	1.67	5.26	17.5	7.46	-	2.82	4.71	25	5.66
	Sig. F	-	0.27	0.04	0.00	0.02	-	0.13	0.05	0.00	0.03