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COMMISSION STAFF WORKING DOCUMENT

Energy Economic Develoments in Europe

Accompanying the document

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Energy prices and costs in Europe

{COM(2014) 21 final}
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European Commission
Directorate-General for Economic and Financial Affairs

Energy Economic Developments in Europe

ABBREVIATIONS AND SYMBOLS USED

COUNTRIES

AT	Austria
BE	Belgium
BG	Bulgaria
CY	Cyprus
CZ	Czech Republic
CIS	Commonwealth of Independent States
CN	China
DE	Germany
DK	Denmark
EE	Estonia
EL	Greece
ES	Spain
FI	Finland
FR	France
HU	Hungary
IE	Ireland
IT	Italy
JP	Japan
LT	Lithuania
LU	Luxembourg
LV	Latvia
MT	Malta
NL	Netherlands
NO	Norway
PL	Poland
PT	Portugal
RO	Romania
RU	Russia
SE	Sweden
SI	Slovenia
SK	Slovakia
TR	Turkey
UA	Ukraine
UK	United Kingdom
US	United States

UNITS

Btu	British Thermal Unit
GJ	Giga joule
GWh	Gigawatt hour
Ktoe	Kilo ton of oil equivalent
kva	Kilovolt-ampere
kWh	Kilowatt hour
MJ	Megajoules
Mtoe	Million tonnes of oil equivalent
MWh	Megawatt-hour
PPS	purchasing Power Standard
TCF	Trillion Cubic feet
TCO2	Tons of carbon dioxide emissions

TJ	Terajoule
TWh	Terawatt-hour

OTHERS

ARA	Antwerp/Rotterdam/Amsterdam
ARDL	Autoregressive distributed lag
BEA	Bureau of Economic Analysis
BBL	Oil barrel
CER	Certified emissions reductions
DSO	Distribution system operator
EC	Energy Cost
ECM	Error correction model
EEX	European Energy Exchange
EIA	Energy Information Administration
ENTSO	European network of transmission system operator
ERGEG	European Regulators' Group for Gas and Electricity
ERU	Emissions reductions units
ETS	Emissions trading scheme
EU	European Union
EUA	European Union allowances
EUR	Euro
FiT	Feed-in tariff
GDI	Gross Domestic Income
GDP	Gross Domestic product
GO	Gross Output
GVA	Gross Value Added
GHG	Greenhouse gas
HHI	Herfindahl-Hirschman index
HICP	Harmonized index of consumer prices
HS	Harmonized System
IEA	International Energy Agency
ISO	Independent system operator
ITO	Independent transmission operator
LM	Langrage multiplier
LRMC	Long run marginal cost
MS	Member State
NAP	National allocation plan
NBP	National balancing point
NGO	Non-Governmental organisation
NUEC	Nominal Unit Energy Cost
OECD	Organization for Economic Cooperation and Development
OU	Ownership unbundling
PV	Photovoltaic
RCA	Revealed comparative advantage
RES	Renewable energy sources
RTB	Relative trade balance
RUEC	Real Unit Energy Cost
TSO	Transmission system operator
TTF	Title transfer facility
TYNDP	Ten year network development plans
USD	US Dollar

VAT	Value added tax
WIOD	World Input-Output Database
WFD	Water Framework Directive

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EXECUTIVE SUMMARY

Since 2008, the EU has made a huge leap forward in promoting the transition to a low carbon economy

In recent years, the EU has set an ambitious agenda to foster the transition to low carbon economies. The Climate and Energy Package adopted in late 2008 sets an EU-wide 20% greenhouse gas emission reduction target for the 27 Member States by 2020, 20 % share of energy from renewable sources in EU gross energy consumption by 2020 and a 20% decrease in primary energy use by 2020. At the core of this strategy is an objective of achieving greenhouse gas emissions reduction while improving security of supply and promoting the emergence of new green sectors. The recent crisis has not put a brake on this level of ambition as these 20/20/20 targets are part of a broad coordinated exercise of economic and fiscal policies in the context of the European Semester.

Energy costs matter...

Recently, the cost of energy has emerged as an important dimension of international competitiveness of European industries, in particular in light of the "shale gas revolution" taking place in the US. Energy matters for the competitiveness of our economies as it affects the production costs of industries and services and the purchasing power of households. Energy costs are not only driven by the type of fuel mix used and consumed, but they have been influenced by our energy policy choices as well as by technological evolutions that can contribute to reducing our energy needs. This report provides analysis and evidence for the economic impact of energy developments in the EU and Member States over the past years. It could contribute to discussions about economic aspects of energy and climate policies and how they can best contribute to fostering the transition to low carbon economies.

...but the EU manufacturing has been successful in reducing its energy intensity

The comparison of energy costs in Europe and Member States and in the rest of the world helps assess our economies in terms of energy cost competitiveness. Chapter I.1 develops unit energy cost indicators that bring together the energy price and the energy intensity dimensions. One salient feature is that the dynamics of energy costs has been positive in the EU, but also in the rest of the world. Another salient characteristic is that, in a global context, the EU manufacturing sector exhibits a low level of energy costs relative to both output and value added. This positive outcome is mostly explained by the low energy intensity of the sector. The EU manufacturing sector has so far responded to energy price increases through sustained energy intensity improvements, thus maintaining its relatively favourable position. Although not visible over the longer period (1995-2009), the latest period analysed (2005-2009) shows that these improvements have been driven partly by restructuring towards sectors with lower energy costs as energy intensive industries have been more affected by energy cost increase pressure. In addition, Member States with high share of energy intensive industries are most exposed to unfavourable unit energy costs developments.

High energy prices should remain a concern, taking account of the increasing EU-US energy price gap.

Against this background, one cannot ignore the recent spectacular development of the production of shale gas and oil in the US which has started in 2009-2010 and is often seen as a major competitiveness threat in the near future. Chapter I.2 provides a focus on more recent developments in the US and EU. While the surge in US shale gas has led to marked changes in the US energy sector and a reduction in the US energy trade balance in GDP terms, the impact on the EU is limited at the moment as no major shift in the EU-US goods trade balance nor significant divergent trends in the overall production structure of manufacturing industry are observed and can be ascribed to the shale gas revolution. However, this should not imply complacency on the widening EU-US energy price gap as the full impacts may become visible only after some delay. Moreover, energy efficiency improvements may slow down in the EU and speed up in US due to diminishing low cost options, and increased policy effort. Consequently, high energy prices for EU industries should remain a policy concern, even more so in case the EU-US energy price gap will continue to increase.

It is therefore strategic for the EU to see whether and how energy prices have been affected by policy developments. This report analyses three important components of energy cost – electricity and natural gas retail prices, and carbon prices. EU electricity and gas markets have been fundamentally reshaped by the significant energy and climate policy initiatives over recent years, in the areas of market opening, renewables penetration, climate change mitigation, and security of supply. The report explores the impact of these policy reforms on end-user electricity and gas prices as after all, these are what industries and households are ultimately paying. The report also looks at carbon prices as it is expected to provide the price signal to change our consumption behaviour and reduce our carbon footprint.

Market opening in electricity and natural gas has brought significant downward price effects. Renewable support has contributed to increasing electricity prices...

Analysis shows that while fossil fuels still remain key drivers of electricity and natural gas price formation, market opening and competition appear to have significant downward price effects for both household and industrial consumers. In both markets, empirical estimates confirm that EU energy policies, such as unbundling of networks and market opening lower retail prices. In addition to these positive developments, natural gas and electricity prices are also affected by specific factors. In the natural gas market, security of supply plays an important role. High import dependency and low diversification of imports can significantly contribute to increasing end-user prices for industries and households. Hence Member States which rely on one foreign source are likely to be exposed to higher prices. In the electricity market, support to less mature renewables technologies has translated in higher electricity prices for both industry and households segments. Furthermore, in some Member States, the burden has not been evenly shared across consumer segments, i.e. industries and households.

... while renewable production, among other factors have negatively affected carbon prices.

By contrast, the carbon price is not found to have any statistical significant impact on electricity retail prices. The latest data on carbon price evolution show that its level is far lower than what was expected when the Energy and Climate Package was adopted in 2008. As it is, although the carbon price is seen as one of the key pieces for the transition to low carbon economies, it fails to provide a strong price signal for consumption behaviour and for investments in clean production technologies. The empirical estimate carried out in chapter II.2 analyses the main drivers of carbon prices and shows that economic factors have played a major role in driving carbon prices in phase 2. Without any doubt, the recent economic crisis has contributed to lowering the demand of allowances, contributing to a large part to the ETS market imbalance, hence the decrease in the carbon price. However, the European carbon market is not isolated from other shaping factors such as the fuel switching behaviour of the conventional power producers and the renewable penetration among other drivers. There is evidence that the deployment of renewable production has also contributed to a lesser extent to this ETS market imbalance, therefore lowering the carbon price. Such results show the importance of economic factors in driving carbon prices, but highlight the interplay between energy and climate policies and ultimately the trade-offs policy makers are confronted to when designing climate change and energy policies combining market instruments and support mechanisms.

Compared to the rest of the world, the EU has been successful in developing wind and solar energy

Finally, the Energy and Climate agenda provides a comprehensive regulatory and policy framework that favours the emergence of new green sectors. This means that energy markets in the context of well-designed policies, can offer many opportunities for growth and jobs ([1]). The report scrutinises the development of new technologies and energy sources - solar and wind - and their impact on trade flows as a way to assess one dimension of competitiveness. Chapter III.1 provides an overview of what happened in the EU and other parts of the world. In Europe, the support to renewable sectors stepped up from 2007 and has represented a strong opportunity to accelerate the expansion of less mature technologies such as wind and solar. Compared to the rest of the world, the EU has been one of the frontrunner in developing wind and solar energy although other countries have been catching up since.

The EU has developed strong positions in the wind equipment sector...

The expansion of renewables provided opportunities in terms of industrial equipment and trade flows. Chapter III.2 gives a closer look at trade developments in the EU and Member States in the wind and solar sector. Evidence shows that the EU displays strong comparative advantages in the wind industry, but has not managed to develop such position in the solar industry. When analysing the drivers of trade of wind and solar equipment, one interesting result is the role of knowledge in driving trade flows, with the EU export performance being strong in technologies where the EU has a strong portfolio of patents. This suggests that innovation and R&D policies should be seen as key policies in promoting the emergence of new green sectors.

... but the fuel costs avoided by renewable developments are still too low.

Another expected benefit of developing renewable is the impact on the energy trade bill and its contribution to reducing our energy dependence. The EU dependence on fossil fuels is higher than in the US, and the EU27 trade deficit in energy products amounted to 3.2% of GDP in 2012. Chapter III.3 shows that renewables help reduce import fuel costs and contribute to improving the energy trade balance, but only to a limited extent. Nonetheless, the avoided fuel costs are expected to rise in the coming years, due to increasing production of renewable energy in the EU and projected increase in EU fossil import prices.

([1]) COM(2012)663.

Part I

Energy Costs and Competitiveness

OVERVIEW

This part analyses energy cost competitiveness. The cost of energy has emerged as an important dimension of international competitiveness of European industries, in particular in light of the "shale gas revolution" taking place in the US. Energy matters for the competitiveness of our economies as it affects the production costs of industries and services and the purchasing power of households.

Chapter 1 introduces the concept of Unit Energy Costs (UEC). Similarly to Unit Labour Costs, the UEC indicator measures the energy cost per one unit of value added, in a given sector or in an aggregation thereof. This indicator enables to compare the relative importance of energy inputs – or in other words the sensitivity to energy price shocks - of a given sector over time. The UEC indicator brings together two key components of energy competitiveness: the value of energy inputs and energy intensity.

Chapter 2 analyses the impacts of the development of shale gas, always through the same integrated approach, i.e. observing the parallel evolution of energy intensity and energy prices in the EU and in the US. It discusses how the introduction of shale gas has affected the US and EU energy sectors, the development in the EU-US energy price-gap and in the trade balances for the EU and US in terms of energy trade, of current accounts and trade of goods.

1. UNIT ENERGY COSTS IN EUROPE AND THE WORLD

1.1. INTRODUCTION

Energy is a key input in many production processes. For this reason, its costs represent a competitiveness factor for manufacturing industry, with the intensity of use next to the energy price as the major drivers. However, another equally important factor is the intensity of its use. In order to provide a more comprehensive assessment of the role that energy plays in determining industrial competitiveness, these factors shall be looked at in combination, the same as it is done for other inputs such as capital and labour.

The objective of this chapter is to assess energy cost competitiveness using unit energy cost indicators. Section 1.2 describes the concept and methodology used to build these indicators. Section 1.3 provides an international comparison of unit energy costs in Europe and other parts of the world. Section 1.4 focuses on sectoral developments while section 1.5 assesses Member States unit energy costs development. Conclusions are presented in section 1.6.

1.2. ASSESSING UNIT ENERGY COSTS

1.2.1. Introductory remarks on the role of energy in the production process

Energy is a key aspect of competeveness. This follows from the energy's essential role in the production process of goods and services. Hence, an economic analysis of energy cost competiveness cannot limit itself to energy prices but needs to consider indicators which inform on how energy prices and energy use affect production decisions. Energy costs, energy productivity and energy intensity are such indicators which can be analysed.

The role of energy in production can be empirically analysed by using analytical frameworks firmly based on economic theory. Often, the production function is employed in such analysis, as it expresses in a mathematical form how the output of the production process is related to the production inputs. Two basic assessment methods rely on the production function concept, namely growth accounting and econometric studies on the production function. Decomposition based on the input-output method has a close relation to both methods.

As regards the first method, growth accounting is an empirical method which allows the identification of the sources of growth of output. Under the conventional assumptions of constant returns to scale and production input prices equal to their marginal productivity, it is possible to derive from a further unspecified production function that output growth is a weighted average of the growth of the production inputs with the cost shares of the various inputs as weights plus a remainder term called "multi-factor productivity" generally associated with technical progress. However, growth accounting as a method cannot be used to analyse the causes of changes in energy costs, intensity and productivity.

Growth accounting is more complicated at industry level than at macroeconomic level since intermediate deliveries between industries and also within a given industry serve both as input and output, rendering it more difficult to link the industry "multi-factor productivity" terms to economy-wide measures of productivity (Hulten 2009). For a growth accounting analysis at macro level, production output can be expressed in value added (2) since the costs of intermediate inputs cancel out against the gross income of delivering these inputs in the derivation of GDP (which thus equals GDI). At industry level, however, the intermediate deliveries do not cancel out, so one can argue in favour of gross production rather than value added as the appropriate output variable. For instance, O'Mahony and Timmer (2009) present as basis for industry-level growth accounting the so-called KLEMS production function which has gross production as output variable and capital (K), labour (L), energy (E), materials (M) and services (S) as production inputs. The contribution to overall growth by each production and intermediate factor is given by the product of its share in total cost and its growth rate. As observed by Hulten (2009), the weights for the primary

(2) This chapter uses gross value added at basic prices. The National Accounts define it as the output at basic prices (i.e. the sales revenues of the products without the taxes and subsidies) minus the costs of the products used up in the production process, valued at purchaser prices (i.e. without VAT)

production factors, capital and labour, are smaller than is the case for a "value added" production function, since industry gross output is bigger than industry value added. Hulten (2009) also notes that the gross output approach is sensitive to the degree of vertical integration of an industry, as a vertical merger of an industry with some of its suppliers could lead to the statistical elimination of intermediate flows. The same reasoning applies when an industry decides to outsource some energy-intensive parts of the production process either within the same industry or to other industries in the same country or to low-energy cost countries. While Hulten (2009) observes that the gross production approach is tainted by statistical problems regarding intermediate deliveries, he recalls that the choice between value added or gross output should take account of the specification of technical change. Hence, he cautions against the use of value added as industrial output variable since "it implies (improbably) that efficiency-enhancing improvements in technology exclude material and energy" (ibidem, p28).

The second method using the production function concerns direct econometric estimation of the production function (or, relatedly, the cost function) at industry level. This allows for estimating the output, substitution and price elasticity for the different input factors such as energy. The economics literature provides a wide array of studies varying considerably in aggregation level, in the coverage of sectors, countries and time period; and estimation method. Also the standard assumptions of constant returns to scale and competitive pricing (i.e. the absence of mark-ups) can be relaxed (Ecorys & CE, 2011, ch.4) Often the production function used has the shape of a translog function and mostly gross production is the output variable of choice, but value added is occasionally used as well, mostly for data availability and data quality reasons. For example, Krishnapillai and Thompson (2012) estimate for the US a production function for industrial value added, distinguishing capital, labour and electricity as production inputs; the estimated price elasticity suggest that electricity, capital and labour are substitutes.

The analytical framework underlying the input-output-table allows for a rigorous analysis of differences in industrial cost structures either over time or over countries / branches of industry. The point of departure is total gross production at industry level. One can directly relate the change in output to the corresponding changes in the cost shares of the various primary and intermediate inputs (up to the desired level of aggregation), such as for energy as a whole. However, this leaves out the indirect effects underlying the changes of the intermediate inputs. More formal decomposition methods allow for assessing the relative role of changes in input prices and input quantities in the overall change of sectoral costs. Fujikawa et al. (1995) compare the cost structure for industry sectors in Japan and US; they derive from the price version of the input-output model a decomposition of cost differences into a primary input price component, a primary input technology component and an intermediate input technology component, all three of which can be further divided into a direct and indirect component (i.e. following from deliveries from other sectors). The role of energy in relative productivity developments between countries has been studied with such decomposition methods, among others by Jorgenson and Kuroda (1992).

In addition to these elaborated analytical methods, one can also directly compare (unit) energy cost levels and developments over time and /or between countries outside of the input-output framework, hence without any restrictive assumption on the relation between output and the defined inputs. This allows much more freedom in choosing the output indicator, gross production, value added or even other indicators. These statistical decomposition exercises tend not to be reported in the economics literature, unless it involves an innovation in method. Among others, the US Department of Energy (2003) decomposes the index of energy use into the multiplicative relation of an activity index, an index on structure (changes in the composition of the economy or sector at hand) and an index of energy intensity or productivity. This index approach only accounts for changes relative to a base year and not for difference in levels (in the base year). One of the advantages is that one can choose for each of the (sub)-sectors / activities in the sector under study the best output variable possible.

Box I.1.1: **Real Unit Energy Cost (RUEC), Nominal Unit Energy cost (NUEC), Energy Prices and Energy Intensity**

RUEC is calculated as the ratio of energy costs in current prices (for the four category of energy inputs described in Appendix 1) over value added in current prices. NUEC in turn is defined as the ratio of energy costs in current prices over value added in constant prices (reference year 2005). Keeping both the numerator and the denominator in current prices in the RUEC cancels out the price dimension from the ratio, while keeping the numerator in current and the denominator in constant prices in the NUEC allows to capture the evolution of sectoral price developments. All data used for the analysis are expressed in USD to allow a global comparison.

The RUEC indicator can be decomposed in **two sub-indicators**: the *energy intensity* (the ratio of quantity of energy inputs used in calorific terms per unit of value added in constant prices) and the *average real energy price over different energy sources* (the monetary value paid by manufactures per unit of energy inputs deflated with the sectoral value added deflator). This price should be interpreted as an implicit unit value of 1 calorific unit of energy used relative to the sectoral deflator. As this price is an average unit price over all the different energy sources used by the sector, it is sensitive to the energy mix of the sector. The decomposition of RUEC can be illustrated as following:

$$RUEC = \frac{EC}{VA_{current}} = \frac{EC}{VA_{const} * P_{VA}} = \underbrace{\frac{EC}{Q_E * P_{VA}}}_{\text{real energy price}} * \underbrace{\frac{Q_E}{VA_{const}}}_{\text{energy intensity}}$$

where EC is the monetary value of energy costs in current prices, Q_e is the calorific value of energy inputs, $VA_{current}$ and VA_{const} are the value added in current and constant prices respectively and P_{VA} is the value added deflator.

Finally the relation that links RUEC with NUEC can be expressed as follows:

$$NUEC = \frac{EC}{VA_{const}} * s = \frac{EC}{VA_{current} * \frac{1}{P_{VA}}} * s = \underbrace{\frac{EC}{VA_{current}}}_{\text{RUEC}} * \underbrace{s * P_{VA}}_{\text{nominal effect}}$$

where EC is energy cost and s is the exchange rate.

This shows that the nominal effect is the combination of the nominal exchange rate and the domestic sectoral inflation. This nominal effect may add, compensate or offset the energy-related effects. This means for example that a country experiencing an increase in RUEC may succeed in partially or fully compensating this through currency depreciation or internal deflation. Conversely currency appreciation or domestic inflation may add additional pressure to its energy price developments.

Due to the potential problems with sectoral purchasing power parities (PPP), we use market exchange rates. This calls for caution when interpreting levels of NUEC, energy intensities and energy prices due to the

(Continued on the next page)

Box (continued)

problem of different purchasing power in non-tradable sectors. Therefore NUEC is only presented in changes, but the levels of energy prices and energy intensities are important source of information that we analyse. As the focus is on the manufacturing sector, the issue of PPPs is less problematic due to the lower share of non-tradable inputs. In addition, it is a concern only when comparing countries with significantly different per capita income levels, therefore comparing EU, US and Japan should not represent a major problem. Caution is necessary though when comparing levels of energy prices and intensities of countries with significantly different income levels.

Finally, the NUEC indicator is expressed in US dollars, and its change is compared among countries. An alternative way of presentation would be to compute real exchange rate indices by taking ratios of NUECs of different countries, or real effective exchange rate indices by using a weighted average of countries as the denominator of the ratio.

In this chapter, the approach proposed uses the input-output table as a starting point but it is not based on input-output-analysis. Compared to the range of methods presented above, the decomposition of energy costs proposed here is relatively straightforward. The comparison is between many countries whereas the literature, as reviewed above, tends to focus on a single or only a few countries. Because of the lack of clear guidance from the literature whether to use value added or gross production and for reasons of data availability and quality, the unit energy cost concept used here has followed the convention of using value added as benchmark (Box I.1.1). This seems fairly unproblematic since this decomposition is statistical and not embedded in a theoretical framework. Moreover, such a convention underlines the direct analogy with the study of unit labour costs and its split labour costs per worker and labour productivity. However, the analogy should be handled with care as energy is an intermediate input and not a primary production factor.

1.2.2. Unit Energy Costs: Concept and Methodology

This section introduces the concept of **Unit Energy Costs (UEC).** Similarly to Unit Labour Costs, the UEC indicator measures the energy cost per 1 unit of value added, in a given sector or in an aggregation thereof. This indicator enables to compare the relative importance of energy inputs – or in other words the sensitivity to energy price shocks - of a given sector over time ([3]). The analysis focuses on the manufacturing sector and 14 subsectors of manufacturing as these sectors are characterised by a relatively higher use of energy than others. Services are not analysed due to their low energy intensity([4]).

As Unit Labour Costs combine wages and labour productivity, the UEC indicator brings together two key components of competitiveness: the value of energy inputs and energy intensity, which is the reciprocal of energy productivity. In addition, in order to differentiate between pure energy-related effects and macroeconomic developments such as fluctuations in the exchange rate and inflation differentials, a distinction is made between Real Unit Energy Cost (RUEC) measuring the energy-related effect and Nominal Unit Energy Cost (NUEC) which incorporates both components (See Box I.1.1 for more details). The RUEC can then be decomposed into the real price of energy inputs – deflated with the value added deflator, hence helping to measure energy inflation above the inflation of the given sector – and energy intensity.

To summarize the different factors of NUEC:

NUEC = RUEC * nominal effect = real energy price * energy intensity * nominal effect

While the nominal effect is important from an international competitiveness perspective as businesses make their decisions on the basis of nominal values, the nominal effect of this decomposition is determined by factors that are not related to energy markets such as monetary policy, inflation expectations, financial market and labour market developments and exchange rate evolution. This analysis focuses on the energy-related effects,

([3]) See the description of the data used in Appendix 1.

([4]) Transport services are characterised by high energy intensity, but they are not included in the analysis.

therefore it concentrates on the RUEC while the NUEC is presented only to illustrate how nominal developments complemented the pure energy effect.

The RUEC and NUEC indicators should be interpreted in comparison among different countries. While the level of RUEC indicates the importance of energy inputs and sensitivity to energy price shocks, an increase that is greater than in other countries can signal an increased vulnerability of this sector to energy costs, but it could also reflect a restructuring of production towards more energy intensive production processes. Therefore, it is necessary to analyse the level and evolution of the price of energy inputs and energy intensity as well. Moreover, to address the issue of potential restructuring on changes in the RUEC, a shift share analysis is carried out, which is a common method to disentangle the effects of restructuring from the growth of an aggregate indicator (see below).

1.3. UNIT ENERGY COSTS: AN INTERNATIONAL COMPARISON

This section analyses the developments of energy costs and their drivers for the manufacturing sector in a global comparison.

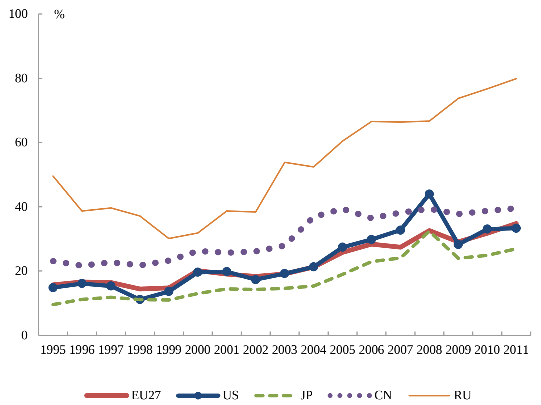
1.3.1. Real Unit Energy Costs

As mentioned above the level of Real Unit Energy Cost measures the amount of money spent on energy sources needed to obtain 1 unit of value added. Their evolution thus combines the energy component of the sector's inflation and the energy intensity of the sector.

Compared to its main economic partners, the EU manufacturing industry had in 2011 the third lowest RUEC in terms of value added after Japan while the US, after the hike of 2008, falls back to the just below the level of the EU in 2011 *(Graph* I.1.1). China, Russia and other major economies such as Brazil and Indonesia show substantially higher values than the EU ([5]).

The evolution and levels of energy costs over value added, and energy costs over gross output in manufacturing are broadly similar across developed countries such as the EU, US and Japan. This prominent feature is to a large extent explained by the industrial specialisation pattern towards high valued added sectors. By contrast, this is not the case for developing countries. A part of this difference can be explained by the fact that countries such as Russia, China or India and Brazil have more energy intensive production structures, specialized in sectors where energy inputs play a comparatively bigger role. Moreover, these production processes are often characterized by lower value added. This is confirmed when looking at the difference between the energy costs as a percentage of value added (RUEC) and as a share of gross output *(Graph* I.1.2). For the EU, Japan and the US, the RUEC are around three times higher than the share of energy costs in gross output. For countries such as China, India and Brazil the RUEC are four to five times higher, implying that the difference between gross output and value added for these countries is greater. The exception is Russia where the difference of RUEC and the share of energy costs in gross output is similar to that of the EU.

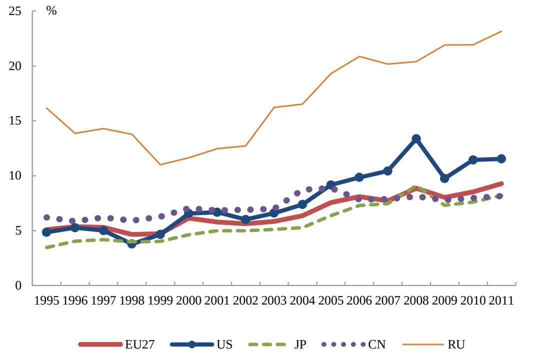
Graph I.1.1: **Real Unit Energy Costs as % of value added, manufacturing sector**



Source: Commission Services based on WIOD database.

([5]) Brazil and Indonesia (and the other world countries) are reported in Appendix 2.

Graph I.1.2: **Real Unit Energy Costs as % of gross output, manufacturing sector**



Source: Commission Services based on WIOD database.

It is interesting to note that, since 2006-2007, real energy costs as a share of gross output in the US increased much more than in the EU and this evolution has been confirmed in 2010-2011. As the levels of RUEC expressed in terms of value added are similar, this may imply that the US are able to extract higher value added from their production than the EU.

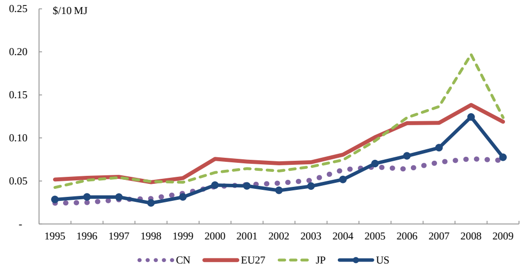
The EU's RUECs have steadily but slowly increased over time, a trend however that is also observed in the other major world economies. This signals the increasing importance of energy cost pressure on the manufacturing sector's value added on a global scale: for all the countries considered the energy costs have, as a matter of fact, increased proportionally more than the value added. If the refinery sector is excluded from the calculation of the RUEC (Appendix 3) the levels decrease substantially (more than halved) and the ranking of the countries changes with the US displaying the lowest level of RUEC, followed by the EU and Japan ([6]). This result indicates the importance of the refining sector in the US and it also highlights the fact that in the other industrial sectors, less dependent on oil, the RUEC level is higher in the EU than in the US. However even excluding the refinery sector, the EU RUEC remains among the lowest in the world.

1.3.2. The drivers of the Real Unit Energy Costs ([7])

The RUEC is decomposed into real energy prices and energy intensity.

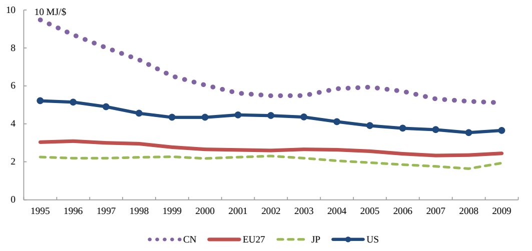
Japan and the EU are the two regions where the real energy prices are the highest in levels. However the evolution of real energy price has been similar for the four countries considered and it appears highly linked to the global oil price's fluctuation. With the oil price hike of 2008 however Japan and the US have registered a more severe increase in real energy prices than the EU and China signalling their greater sensitivity to oil prices.

Graph I.1.3: **Real Energy Price levels - Manufacturing**



Note: Energy prices deflated with value added deflator of the manufacturing sector (in 2005 USD)
Source: Commission Services based on WIOD, ESTAT and World Development Indicators databases.

Graph I.1.4: **Energy Intensity levels - Manufacturing**



Note: including feedstock
Source: Commission Services based on WIOD, ESTAT, OECD and World Development Indicators databases.

At the same time the EU and Japan have the lowest levels of energy intensity while the US

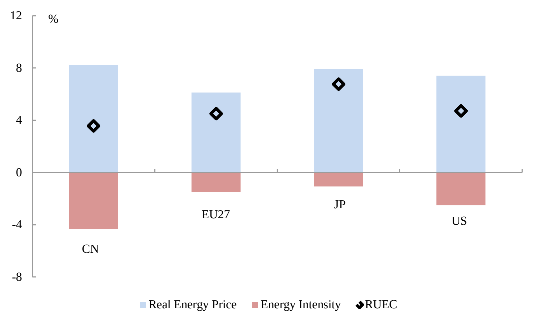
([6]) It is worth to note that excluding refineries from the manufacturing sector reduces the RUECs to levels of around 3-4% in gross output in the EU implying that energy costs play a smaller role in this segment of the economy.

([7]) Due to data limitation the assessment of Energy intensity and Real energy prices stops at 2009. Therefore to allow comparability the growth rates of RUEC have also been computed only up to 2009 (Graph I.1.5).

and China ([8]) show considerably higher levels. China and to a limited extent the US have been converging towards the European and Japanese levels. It is to note that graph I.1.4 shows energy intensity including feedstock. The level and trends of energy intensity would change if feedstock were excluded as shown in chapter 2 (graph I.2.10). Considering only final energy consumption, the catching up process of the US seems to have halted after 2009 while the EU performance keeps improving. The difference reveals another potential vulnerability for the EU industry, that is the cost pressure on EU industries stemming from the supply of energy sources to be used as raw material.

Graph I.1.5 summarizes the annualised growth rates of RUEC and of their two drivers.

Graph I.1.5: **Average annual change 1995-2009 - Manufacturing**



Note: Energy Intensity includes feedstock
Due to data limitation the assessment of Energy intensity and Real energy prices stops at 2009. Therefore to allow comparability the growth rates of RUEC have also been computed only up to 2009.
Source: Commission Services based on WIOD, ESTAT, OECD and World Development Indicators databases.

Japan is the country that faced the fastest increase in RUEC during the 15 years considered. A result that was brought about by a large increase in real energy prices compensated only partially by very little improvements in the terms of energy intensity. This indicates that the country suffered from strong energy cost pressure that was not compensated via a reduction of energy intensity.

China on the other hand shows the slowest increase in RUEC despite the fastest increase in real energy prices; substantial energy intensity improvements have counterbalanced the upward pressure of the real energy prices. China started from very high levels of energy intensity and had therefore greater margins to improve.

The EU and US have evolved in a very similar fashion and the increase in RUEC has been almost the same in the two regions. On average the real energy price increase has been slightly faster in the US than in the EU and was compensated by an equally slightly faster improvement in energy intensity performances (bearing in mind that the absolute levels of the two indicators are very different). The EU and the US have followed therefore very similar patterns where the differentials in real energy price levels have been matched by equally distant levels of energy intensity which translated in almost equal levels of RUEC.

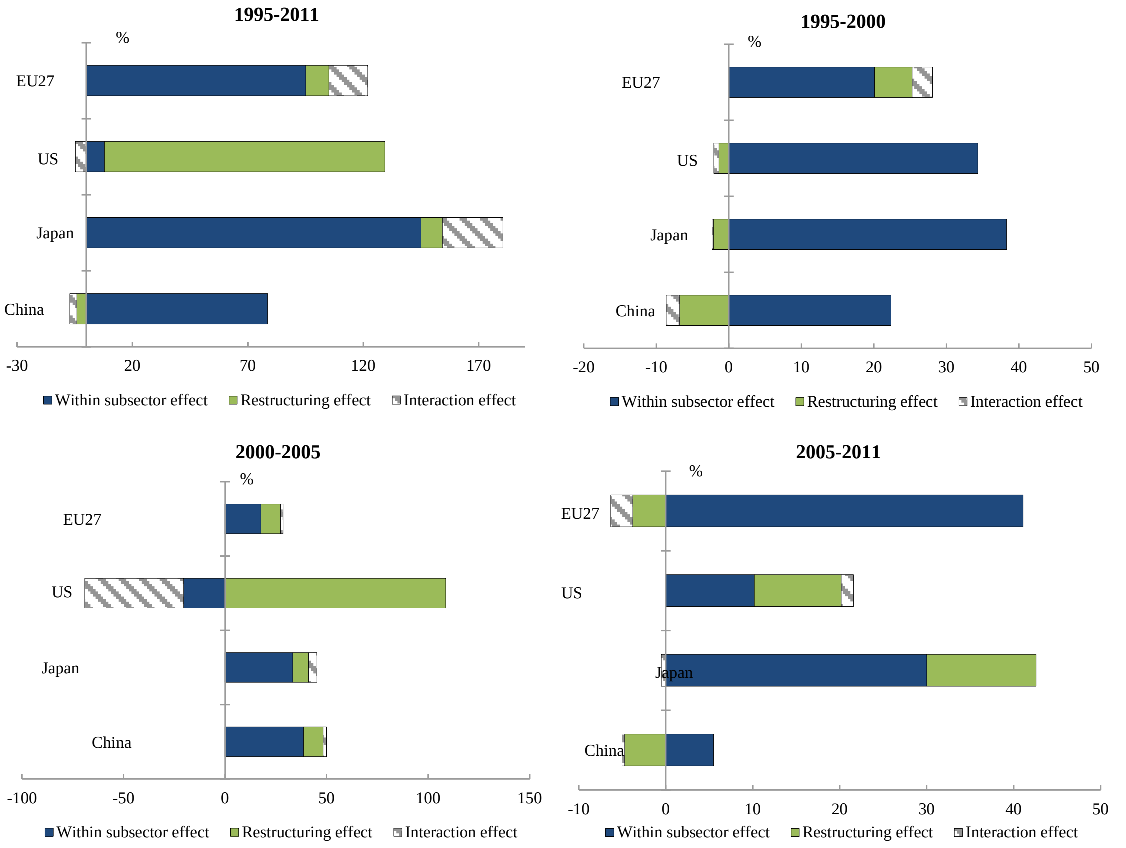
1.3.3. Disentangling the effect of industrial restructuring on the growth of RUEC

It is also interesting to analyse to what extent the developments in energy costs of the manufacturing sector were driven by (1) energy cost pressures apparent in all subsectors and/or (2) a restructuring taking place among subsectors. For instance when facing strong energy cost pressures, the industry may respond by reallocating resources from sectors with high energy costs to others with low energy costs. This would then result in a decline in the market share of high energy cost industries, while those with low energy costs would see a rise in their share.

In order to investigate the effects of these two factors, a shift share analysis is carried out. The RUEC in the total manufacturing industry can be interpreted as the weighted average of the RUECs of the subsectors making up the manufacturing sector with the weights being the shares of subsectors in total manufacturing value added. This way, changes in the RUEC of aggregate manufacturing can be broken down into two distinct effects: a change in the RUECs of subsectors (energy cost effect) and a change in the shares of subsectors in total manufacturing (restructuring effect) along with a dynamic

([8]) The high level of energy intensity in China can be partly explained by the PPP effect which however is not captured by the dataset used.

Graph I.1.6: **Shift share analysis of manufacturing sector RUEC growth**



Source: Commission Services based on WIOD.

interaction component of the two effects ([9]). In particular, the shift-share analysis decomposes the growth of RUEC into the following three components ([10]).

Within subsector effect: This shows what would be the growth of RUEC of the total manufacturing sector if the shares of the subsectors had stayed unchanged throughout the period of analysis. Therefore this effect shows the pure energy cost pressure filtering out the effect of restructuring.

Restructuring effect: This measures the contribution of changes in value added shares of the different subsectors to overall manufacturing RUEC growth keeping the RUECs of subsectors unchanged. This component therefore shows the static restructuring effect. For instance a negative restructuring effect could show that the share of industries with high energy costs has fallen, thereby reducing RUEC growth.

Interaction effect: This term captures the dynamic component of restructuring by measuring the co-movement between RUECs and value added shares. If it is positive, it signals that energy costs are rising in subsectors that are expanding, and/or they are falling in shrinking sectors, i.e. the two effects complement each other. If it is negative, then RUEC growth is positive in shrinking sectors, and/or negative in expanding sectors, i.e. the two effects are offsetting each other. A negative interaction effect could signal that businesses in a country are reallocating resources from high to low energy cost sectors in response to rising energy costs.

([9]) The decomposition of manufacturing is done with 14 subsectors on the basis of the NACE Rev.1 nomenclature. It is possible that there is some restructuring taking place at a lower aggregation level which may not be captured by this analysis.
([10]) See the technical details of the shift-share analysis in Appendix 1.

Table I.1.1: **Average % annual change 1995-2009 - Manufacturing**

	Real Energy Price	Energy Intensity	RUEC	Nominal effect	NUEC
EU27	6.12	-1.50	4.51	1.19	5.71
US	7.42	-2.51	4.72	0.01	4.73
JP	7.92	-1.07	6.76	-2.51	4.25
CN	8.24	-4.3	3.57	3.46	7.03

Note: Energy Intensity includes feedstock.
Due to data limitation the assessment of Energy intensity and Real energy prices stops at 2009. Therefore to allow comparability the growth rates of RUEC have also been computed only up to 2009.
Source: Commission Services based on WIOD, ESTAT, OECD and World Development Indicators databases.

Looking at the shift share analysis of manufacturing sector RUEC growth in the period 1995-2011, the main result is that the bulk of RUEC growth in EU27, Japan and China were driven by the within effect; i.e. energy cost increases within sectors (Graph I.1.6**)**. There is no evidence of a significant restructuring effect in the EU during this long period. In contrast, RUEC growth in the US was dominated by the static restructuring effect, i.e. by an increase in the share of high energy cost industries, particularly of the coke and refined petrol industry. Overall these developments may signal an increased specialisation of US manufacturing in high energy cost production with respect to other countries ([11]).

The picture is changed if the shift share analysis is decomposed into three shorter periods. The period 1995-2000 was characterised by a marked increase in RUEC dominated by the within subsector effect in the EU, US and Japan. The period 2000-2005, however, brought significant differences with the US being the only country with a negative within subsector effect. At the same time the US showed a very large positive restructuring effect which was mitigated to some extent by a negative interaction term. Overall this indicates that the US started specialising in high energy cost production already in this period ([12]). Finally, the last period – 2005-2011 – includes the beginning of the development of shale gas in the US as well as the peak in oil prices of 2008 and the subsequent fall in 2009 and has brought a significant adjustment and restructuring on a global scale. While the RUEC of the EU rose only moderately, this was due to a limited restructuring – both static and dynamic – away from high energy cost sectors offsetting a pure energy cost effect which was substantially higher than in the other countries. In the US, RUEC increased visibly less than in the EU over this period. Once again a positive restructuring effect can be observed, and is brought about by the continuous growth of some energy intensive sectors, in particular coke and refined petrol. Japan saw a positive within subsector effect with a positive restructuring effect and its RUEC grew more than in the US and in the EU. Finally, China experienced positive but modest within subsector effect and a similarly modest negative restructuring effect.

The shift share analysis of the manufacturing sector excluding the coke, refined petrol and nuclear fuel sector helps to single out the relevance of this sector in the evolution of the RUEC and of the industrial composition of the countries (Appendix 3). The restructuring effect observed with the full data set essentially disappears once the refinery sector is excluded. This is most evident in the US where in the period 1995-2011 the shift share analysis reported above in Graph I.1.6 displays a very big positive restructuring effect while excluding the refinery sector this effect is no longer present. This points to the increased relevance of this sector in the US economy over the past years which is also confirmed when looking at the growing contribution of the sector to the total industrial

([11]) In order to check the sensitivity of these results to the start and end date of the analysis, we carried out the calculations for the period 1998-2006 as well, which gave similar conclusions.
([12]) This evolution could be explained by a domestic restructuring or investment of foreign companies in the US. The analysis here does not differentiate between these factors.

GVA of the US. Another important observation can be made looking at the period 2005-2011 which includes the shale gas production surge. By excluding the refinery sector highly dependent on oil products, the RUEC growth in the US is actually negative. This is probably due to the substantial reduction in electricity and gas prices which shale gas has made possible. In the EU the difference between the shift share analysis with or without the refinery sector is also significant. For a start the growth of RUEC is greatly diminished, over both the longer period 1995-2011 and the shorter period 2005-2011. This implies that oil price dynamics play a major role in determining the energy costs of the manufacturing sector. The less dependent a sector is from oil products the less it appears to be exposed to real unit energy costs increase. The second observation is that once the refinery sector is excluded from the analysis the small negative restructuring effect observed over the period 2005-2011 disappears, implying that it was mostly related to this sector ([13]).

1.3.4. Nominal Unit Energy Costs

Table I.1.1 presents the decomposition of the different elements of NUEC and can be read from left to right in an (approximately) additive manner. The nominal effect represents the difference between RUEC and NUEC and it measures the combination of sectoral inflation and exchange rate fluctuations.

The table shows that nominal developments have added some pressure to the energy costs of the EU over the period 1995-2009 as compared to the US and Japan as shown by the higher average growth rate of nominal effect for the EU than for the US and Japan. With US dollar being the common currency of comparison, the nominal effect of the US is close to 0 ([14]). On the other hand Japan has gone through a period of internal deflation which resulted in a negative nominal effect partially offsetting the evolution of the RUEC. China experienced the lowest annual change in RUEC complemented by a sizeable increase of the nominal effect and therefore has experienced the fastest increase in NUEC. This means that other sectoral price and exchange rate dynamics have added upward pressure to the pure energy-related effects captured by the RUEC in China.

1.4. UNIT ENERGY COSTS: A SECTORAL COMPARISON

A more disaggregated analysis involving 14 manufacturing subsectors shows that most of these subsectors in the EU have a generally low unit energy costs per value added in an international comparison ([15]).

Certain sectors in the EU show however a significant vulnerability because of their high RUEC levels and/or RUEC growth rates in a global comparison, indicating elevated sensitivity to energy-cost pressures (Table I.1.3 **and Table** I.1.2**)**. Overall the sectoral analysis confirms that the low unit energy costs level for the total manufacturing industry of the EU hides a substantial heterogeneity among subsectors. This highlights the need for more disaggregated sectoral analysis as it is possible that some subsectors of manufacturing show high vulnerability to energy inputs despite the fact that energy costs are very low for total manufacturing. A more detailed split could reveal even more vulnerabilities within sectors. In this sense the top-down approach applied here – from a high to a medium level aggregation – should be interpreted as complementary information to more disaggregated sector-specific analyses.

In the **food, beverages and tobacco** sector the RUEC of the EU were the second highest in 2009. They showed a similar pattern to that of the US, but both of them were performing significantly worse than China and Japan. Energy intensity improvements in the EU have been rather limited but Japan and the US deteriorated their performances. The real energy price increased

([13]) It is important to keep in mind that there may be restructuring taking place at a lower level of aggregation than the available data which cannot be captured by this analysis.

([14]) For the US the nominal effect measures only the sectoral value added inflation, since all figures are expressed in USD. Between 1995 and 2009 the US had a sectoral deflator evolution somewhat U-shaped which after a period of inflation came back down to its initial levels. This explains the annual growth figure being close to 0 in the table.

([15]) As for the total RUEC, data limitation does not enable a full decomposition after 2009. For this reason data for 2011 are presented separately.

faster in the EU than in either Japan or US although in absolute levels the EU is still below Japan. Compared to 2011 the RUEC of the EU have increased while in the US they have decreased, this was however matched in both countries by a small decline in the share of the sector in total manufacturing value added.

The **textile** industry of the EU has performed substantially worse than that of the US and Japan in terms of RUEC and their level is also higher than in China, both in 2009 and in 2011. The energy costs of the Chinese textile industry showed a marked upward trend and reached similar levels to that of the EU at the end of the sample. The increasing trend of China and the stable trend of the US could be a sign of outsourcing although data availability does not allow the assessment of the evolution of energy intensity and real energy prices in the two countries. The good performances in terms of energy intensity in both the EU and Japan have been met by opposite trends in terms of real energy prices which translated into similar annual increases of RUEC.

The developments in the **leather and footwear** sector are in many ways similar to those of the textile industry. The EU, Japan and China have reached similar levels in the second half of the sample period in terms of RUEC. The US reached a considerably lower level by 2009, and again the opposite trends between the US and China raises the possibility of potential outsourcing. As with most other sectors, Russia exhibited by far the highest levels of RUEC throughout the entire period. Both the textile and leather sectors have experienced a sharp decline in the share of manufacturing value added in Japan, Russia and US, while the decline in the EU and China was much less evident during this period. Data from 2011 confirms the trend of the previous period.

In the **wood and wood product** industry the EU has shown the second lowest RUEC following Japan. The pattern of marked improvement in 2009 for the US is not visible in this sector, in fact, RUEC was trending upwards in US over the entire period of analysis, much so than in any other of the five countries. China was slightly above the EU while Russia was fluctuating at a considerably higher level. Unlike for other sectors, the energy intensity performances of the EU and Japan have deteriorated but have been matched by a moderate decrease in real energy prices similarly to Japan. In the US the increase in real energy prices has been much faster than the decrease in energy intensity. In 2011 however the RUEC in the EU, Japan and China continues to increase while the opposite happens in the US.

Table I.1.2: **Sectoral breakdown: decomposition of RUEC and annual growth rates 1995-2009**

	Energy Intensity (10MJ/$)		Real Energy price ($/10MJ)		RUEC (%)		*Share of sector in Manufacturing VA*		RUEC level	Share of sector in manufacturing VA
	level 2009	annual growth rate	level 2009	annual growth rate	level 2009	annual growth rate	*level 1995*	*level 2009*	2011	
Other Non-Metallic Mineral										
EU27	2.04	-0.7%	0.13	3.1%	25.6	2.4%	*4.8%*	*4.4%*	27.2	*4.0%*
US	3.27	1.8%	0.05	1.3%	16.1	3.2%	*2.8%*	*2.3%*	15.2	*2.0%*
JP	2.20	2.0%	0.20	2.9%	43.1	4.9%	*3.7%*	*2.4%*	53.8	
RU					50.6	2.6%	*10.9%*	*5.3%*	49.8	*5.1%*
CN					53.6	3.7%	*10.8%*	*6.8%*	56.8	
Basic Metals and Fabricated Metal										
EU27	1.42	-2.8%	0.12	4.3%	17.3	1.3%	*13.4%*	*13.9%*	18.2	*15.2%*
US	1.55	-1.5%	0.07	3.5%	11.6	2.0%	*12.2%*	*10.0%*	12.9	*9.4%*
JP	2.02	2.5%	0.15	3.5%	30.1	6.1%	*15.7%*	*16.1%*	39.2	
RU					57.2	1.9%	*18.7%*	*15.5%*	55.3	*17.7%*
CN					49.6	3.0%	*14.2%*	*16.0%*	50.1	
Machinery										
EU27	0.17	-2.1%	0.28	2.9%	4.7	0.7%	*10.8%*	*11.9%*	4.7	*12.8%*
US	0.39	0.4%	0.07	-1.1%	2.8	-0.7%	*8.1%*	*7.3%*	2.2	*8.2%*
JP	0.14	-2.3%	0.30	4.6%	4.2	2.1%	*9.5%*	*8.6%*	4.4	
RU					37.4	2.1%	*7.6%*	*7.7%*	36.8	*7.3%*
CN					15.0	3.8%	*9.6%*	*9.6%*	15.4	
Electrical and Optical Equipment										
EU27	0.12	-5.2%	0.37	6.9%	4.6	1.3%	*11.3%*	*10.9%*	4.6	*10.8%*
US	0.08	-19.8%	0.19	16.5%	1.5	-6.6%	*13.7%*	*17.1%*	0.8	*19.2%*
JP	0.13	-9.5%	0.56	14.9%	7.0	4.0%	*15.9%*	*13.4%*	7.1	
RU					20.6	2.0%	*6.5%*	*5.3%*	21.1	*5.5%*
CN					8.1	3.2%	*9.3%*	*14.3%*	8.4	
Transport Equipment										
EU27	0.20	-1.5%	0.32	2.7%	6.4	1.2%	*9.6%*	*10.2%*	6.3	*11.0%*
US	0.33	-1.1%	0.11	3.6%	3.5	2.5%	*12.1%*	*10.1%*	3.9	*7.1%*
JP	0.09	-5.2%	0.69	8.3%	6.5	2.7%	*9.8%*	*11.9%*	6.9	
RU					18.1	1.9%	*9.2%*	*5.7%*	20.6	*5.9%*
CN					7.9	1.0%	*5.2%*	*6.7%*	8.2	
Manufacturing, Nec; Recycling										
EU27	0.32	1.6%	0.26	1.1%	8.0	2.7%	*3.9%*	*4.2%*	8.4	*3.8%*
US	0.13	-6.9%	0.21	6.7%	2.7	-0.7%	*3.8%*	*3.7%*	1.5	*4.0%*
JP	0.61	1.2%	0.21	4.7%	12.9	5.9%	*1.8%*	*0.9%*	14.3	
RU					26.8	3.6%	*2.2%*	*2.1%*	31.5	*1.8%*
CN					4.8	-1.8%	*1.6%*	*2.0%*	5.0	
Total Manufacturing										
EU27	2.45	-1.5%	0.12	6.1%	29.1	4.5%			34.8	
US	3.65	-2.5%	0.08	7.4%	28.3	4.7%			33.3	
JP	1.94	-1.1%	0.12	7.9%	23.9	6.8%			26.9	
RU					73.7	2.9%			79.9	
CN	5.11	-6.6%	0.07	8.2%	37.7	3.6%			39.6	

Note: Energy Intensity includes feedstock.
Due to data limitation the assessment of Energy intensity and Real energy prices stops at 2009. Therefore to allow comparability the growth rates of RUEC have also been computed only up to 2009.
Source: Commission Services based on WIOD, ESTAT, OECD and World Development Indicators databases.

In the **pulp, paper and printing** sector the EU has been performing in line with the US with Japan also reaching similar RUEC levels at the end of our sample. China and particularly Russia showed higher levels of RUEC. The almost stable performances in terms of energy intensity in the EU means that the increase in real energy prices has been therefore almost symmetrically translated into higher energy costs for EU industries although the trends in the US and Japan are broadly comparable. As for the other sectors, data for 2011 show an increase in RUEC for EU, Japan and China while the opposite is true in the US and to a lesser extent Russia.

The production of **coke, refined petrol and nuclear fuel** is the sector that shows the worst performance in the EU with RUEC several times above the levels of US, Japan, China and Russia. RUEC in this sector showed a steep upward trend

Table I.1.3: **Sectoral breakdown: decomposition of RUEC and annual growth rates 1995-2009**

	Energy Intensity (10MJ/$)		Real Energy price ($/10MJ)		RUEC (%)		*Share of sector in Manufacturing VA*		RUEC level	Share of sector in manufacturing VA
	level 2009	annual growth rate	level 2009	annual growth rate	level 2009	annual growth rate	*level 1995*	*level 2009*	2011	
Food, Beverages and Tobacco										
EU27	0.56	-0.8%	0.22	3.2%	12.1	2.3%	*12.1%*	*13.0%*	12.8	*12.0%*
US	0.77	1.2%	0.14	1.9%	10.5	3.1%	*10.9%*	*12.9%*	8.0	*12.0%*
JP	0.21	0.2%	0.28	2.8%	5.9	3.0%	*13.4%*	*16.6%*	6.4	
RU					16.2	0.4%	*17.9%*	*18.0%*	19.4	*13.6%*
CN					5.6	1.0%	*12.9%*	*11.6%*	6.3	
Textiles and Textile Products										
EU27	0.40	-2.5%	0.29	5.1%	11.5	2.5%	*5.1%*	*3.4%*	11.9	*3.0%*
US					6.0	0.9%	*4.1%*	*1.6%*	5.9	*1.4%*
JP	0.27	-1.5%	0.30	4.1%	8.3	2.5%	*3.7%*	*1.7%*	8.8	
RU					15.8	-2.8%	*3.2%*	*1.6%*	18.1	*1.5%*
CN					9.9	5.2%	*11.1%*	*8.2%*	10.8	
Leather and Footwear										
EU27					5.3	0.2%	*1.0%*	*0.8%*	5.6	*0.8%*
US					1.3	-8.2%	*0.2%*	*0.1%*	1.6	*0.1%*
JP	0.21	-1.2%	0.28	3.7%	5.9	2.4%	*0.3%*	*0.1%*	6.3	
RU					16.5	-1.1%	*0.4%*	*0.3%*	17.7	*0.3%*
CN					5.2	6.1%	*2.2%*	*1.7%*	5.9	
Wood and Products of Wood and Cork										
EU27	1.12	2.8%	0.10	0.0%	11.6	2.8%	*2.3%*	*2.1%*	12.4	*2.0%*
US	2.10	-2.1%	0.07	7.9%	14.8	5.6%	*2.1%*	*1.3%*	9.4	*1.3%*
JP	0.78	3.3%	0.10	-0.8%	7.7	2.4%	*2.6%*	*1.4%*	8.3	
RU					29.5	1.7%	*3.3%*	*2.0%*	27.0	*2.1%*
CN					13.1	1.4%	*2.3%*	*2.4%*	13.7	
Pulp, Paper , Printing and Publishing										
EU27	0.98	0.6%	0.11	1.6%	11.0	2.2%	*9.2%*	*8.2%*	11.4	*7.6%*
US	1.52	-0.7%	0.06	3.1%	9.0	2.3%	*11.6%*	*10.3%*	8.5	*9.5%*
JP	0.74	-0.1%	0.14	1.6%	10.1	1.6%	*6.3%*	*6.4%*	10.9	
RU					30.3	2.6%	*4.7%*	*4.1%*	29.8	*4.1%*
CN					14.0	0.6%	*4.2%*	*3.5%*	14.7	
Coke, Refined Petroleum and Nuclear Fuel										
EU27					1033.4	7.2%	*1.6%*	*1.6%*	1051.9	*2.0%*
US	31.01	-5.4%	0.09	5.9%	275.2	0.2%	*3.0%*	*7.3%*	264.1	*9.9%*
JP	18.29	1.3%	0.07	7.1%	129.4	8.6%	*4.5%*	*7.3%*	138.7	
RU					199.4	-4.7%	*5.1%*	*22.7%*	201.5	*24.8%*
CN					398.1	3.7%	*3.1%*	*2.8%*	412.5	
Chemicals and Chemical Products										
EU27	2.96	-3.0%	0.11	6.9%	33.2	3.7%	*10.3%*	*10.9%*	36.2	*10.7%*
US	4.38	-0.7%	0.05	2.6%	22.1	1.9%	*11.1%*	*12.6%*	23.1	*12.2%*
JP	3.53	-0.6%	0.13	6.8%	44.1	6.2%	*8.4%*	*9.2%*	47.3	
RU					74.0	-0.5%	*8.5%*	*7.3%*	77.9	*8.1%*
CN					84.9	6.5%	*9.5%*	*10.2%*	92.6	
Rubber and Plastics										
EU27	0.47	0.5%	0.29	3.0%	13.4	3.5%	*4.5%*	*4.5%*	14.1	*4.4%*
US	0.26	-5.7%	0.38	7.1%	10.0	1.0%	*4.2%*	*3.4%*	6.8	*3.7%*
JP	0.16	-5.5%	0.81	9.2%	13.3	3.2%	*4.3%*	*3.9%*	13.7	
RU					36.6	1.7%	*2.0%*	*2.2%*	42.1	*2.2%*
CN					17.0	3.0%	*4.2%*	*4.0%*	17.9	

Note: Energy Intensity includes feedstock.
Due to data limitation the assessment of Energy intensity and Real energy prices stops at 2009. Therefore to allow comparability the growth rates of RUEC have also been computed only up to 2009.
Source: Commission Services based on WIOD, ESTAT, OECD and World Development Indicators.

in the period 1995-2009 in the EU unlike in any other country analysed here which indicates an increasing vulnerability. Looking at energy costs as a share of output – not reported here – would show a somewhat better relative performance of the EU suggesting that this sector is suffering not only from high energy costs but also from low and drastically worsening value added in a global comparison. The oil-price shock of 2008 had a significant upward effect on the RUEC of all the five countries, the EU however further increased its RUEC in 2009 while in the other four countries a reduction took place, bringing the levels back to pre-2008. However, the share of the sector in manufacturing valued added for the EU was and remained very small. At the same time the sharp increase of the share in Russia and the US need to be recorded as it signals the growing importance of coke and refinery activities in these two countries. Data for 2011 show that while in the EU the RUEC have further increased, an inverse trend is observed in the US where the sector reached almost 10% of total manufacturing value added.

In the **chemicals and chemical products** sector the EU has shown the lowest RUEC together with the US in the period of analysis ([16]). The low levels of energy costs of the EU and US significantly outperformed the other countries and also present the lowest growth rates. In 2011 RUEC increased in both regions. Russia and China showed the highest levels of RUEC throughout most of the period of analysis. A marked improvement is visible in Russian RUEC in the years of the Russian financial crisis (1998-99). This pattern is visible for many other sectors as well, but the improvement was only temporary and RUEC returned to pre-crisis levels in the following years. For the EU the fast increase in real energy prices which outpaced that of the US and to a lesser extent that of Japan, was counterbalanced by significant improvements in energy intensity which both in levels and progress way outperform the two competitors.

In the **rubber and plastics sector**, during the period 1995-2009, the EU has performed relatively well together with the US and Japan, while China and especially Russia exhibited much higher levels of RUEC. However the EU registers in 2009 higher RUEC than Japan and US and has the highest growth rate since 1995 mostly driven by the deterioration of its energy intensity. Looking at the components of RUEC it is to note that the EU had in 2009 the highest levels of energy intensity (compared to Japan and US) and unlike the other two countries did not record any improvement. The EU compensated partially with a lower real energy price than both Japan and US and with lower growth rates. In 2011 the RUEC in the EU and Japan continued to increase while in the US they significantly reduced, at the same time the contribution of the sector to the manufacturing value added remained broadly unchanged.

In the **non-metallic mineral sector and the metals sector** the EU showed a much lower level of RUEC than Japan, China and Russia. The EU, however, was performing worse than the US and the gap in favour of the US has increased also in 2011. RUEC growth rates in the EU have been anyway the lowest among the five countries, mostly driven by energy intensity good performances. Energy intensity in the EU was in 2009 the lowest and it has experienced the most significant improvements while for Japan it actually deteriorated. At the same time, while the level of real energy prices is comparable in 2009 the EU experienced faster growth rates than both Japan and the US.

In the sector of **machinery** the RUEC of EU, Japan and US have had comparable very low levels in the entire period. The US is the country with the lowest level of RUEC and the only one for which the growth rate is negative. This positive evolution has been mostly driven by a decrease in real energy prices while energy intensity slightly deteriorated. US RUEC further decreased in 2011 while in the EU they remained stable. This happened in a context of increase in share of the sector in total manufacturing value added, in both regions. China has shown a moderately increasing trend and reached a level that is substantially higher than that of the other three economies. Russia in turn exhibited the highest RUEC in this sector but lower growth rates than China and also Japan. Energy intensity in the EU decreased rapidly but on the other side real energy prices increased at almost the same pace. In the US conversely energy intensity did not improve but real energy prices decreased by an average of only 1% per year.

In the **electrical and optical equipment** sector the EU, US, Japan and China started from similar levels of RUEC but have shown a remarkable divergence in the period of analysis. This concerns primarily the US and China, where the opposing trend again suggest the possibility of outsourcing of energy-intensive processes from the US to China. The EU exhibited a relatively constant RUEC which put it at the second lowest level after the US in 2009. Japan showed a mild increase over the period, while Russia fluctuated again at a substantially higher level. The dramatic collapse in energy intensity matched by an almost equally fast increase in real energy price in the US tends to confirm the assumption that the country may have experienced a substantial relocation of energy intensive activities. However the simultaneous increase in the share of the sector in the manufacturing value added signals that the US industry focused on innovation and higher valued added activities. Japan also presents similar features. This trend is confirmed also by looking at 2011, where the share of the sector in the

([16]) This sector includes basic chemicals as well as cosmetics and pharmaceuticals.

manufacturing value added further increased while RUEC decreased. The EU also recorded remarkable improvements in energy intensity although compensated by a significant increase in real energy prices.

In the sectors of **recycling and transport equipment** the EU has shown a significantly higher RUEC than the US and also of Japan, a gap that has further widened in 2011. In transport equipment the performance of the EU was more or less in line with that of Japan. China was fluctuating at a higher level and Russia at an even higher level in the transport equipment sector. However the collapse of energy intensity registered in Japan in the transport equipment sector could be the consequence of a drastic industrial restructuring and outsourcing of the most energy intensive activities in favour of lower energy intensive production with comparatively greater value added. EU RUEC in 2011 decreased slightly while an increase was registered in the other countries. On the other hand in recycling the EU has worsened its energy intensity performances while recording only a moderate increase in real energy price. The US shows the opposite picture, rapidly falling energy intensity matched by an increase in real energy prices which resulted in small decrease of RUEC over the 15 years considered.

In sum, the sectors that are most exposed to energy price shocks in terms of high RUEC levels in the EU are coke and refined petrol, chemicals, non-metallic mineral, metals, rubber and plastics. Coke and refined petrol stands out with much higher RUEC levels than in other countries and a growth rate that is also among the highest ones. This indicates significant vulnerability of this sector, though its share in total manufacturing value added of the EU has been low and stable. In contrast, US, Japan and Russia have seen a significant increase in this share. In the other four sectors with high energy cost vulnerability (chemicals, non-metallic mineral, metals, rubber and plastics) the EU shows RUEC levels that are generally comparable with those of Japan. The EU levels are, however, noticeably higher than the US in chemicals, non-metallic mineral, and metals. Nonetheless in all four sectors the figures of the EU remain substantially lower than those of China and Russia. In terms of the growth rates of RUECs, the four sectors in the EU perform generally in line with other countries with some variability observable.

Data for 2011 show that for all sectors the RUEC have generally increased in all countries, except in the US where the picture is more mixed and most sectors actually recorded a decrease. Although EU RUEC are above the US for all sectors in 2011, they are similar for total manufacturing due to the different composition of the manufacturing value added in the two regions. It is nonetheless interesting to note that two of the four sectors in the EU where the contribution to the manufacturing value added has increased are among the most energy intensive sectors such as: coke and refined petroleum products; basic metals and fabricated metals.

1.5. EU MEMBER STATES ASSESSMENT

The evolution of RUEC for EU Member States ([17]) between 2000 ([18]) and 2009 is in general characterised by an upward trend. With the exception of a handful of countries most Member States saw their RUEC increase on average by 47%. The biggest increases in percentage terms were recorded in Ireland (89%) followed by Malta (70%), Sweden, France and Belgium (around 60%). The upward trend is broadly confirmed with the data for 2011([19]) with the exception of Ireland and Germany where RUEC have been reduced. Looking at the evolution between 2000 and 2011 the Member States with the greatest percentage increase were France (144%) Belgium (124%) and Finland (111%). On the other hand Cyprus, Slovakia, Romania and the Czech Republic recorded a decrease in RUEC.

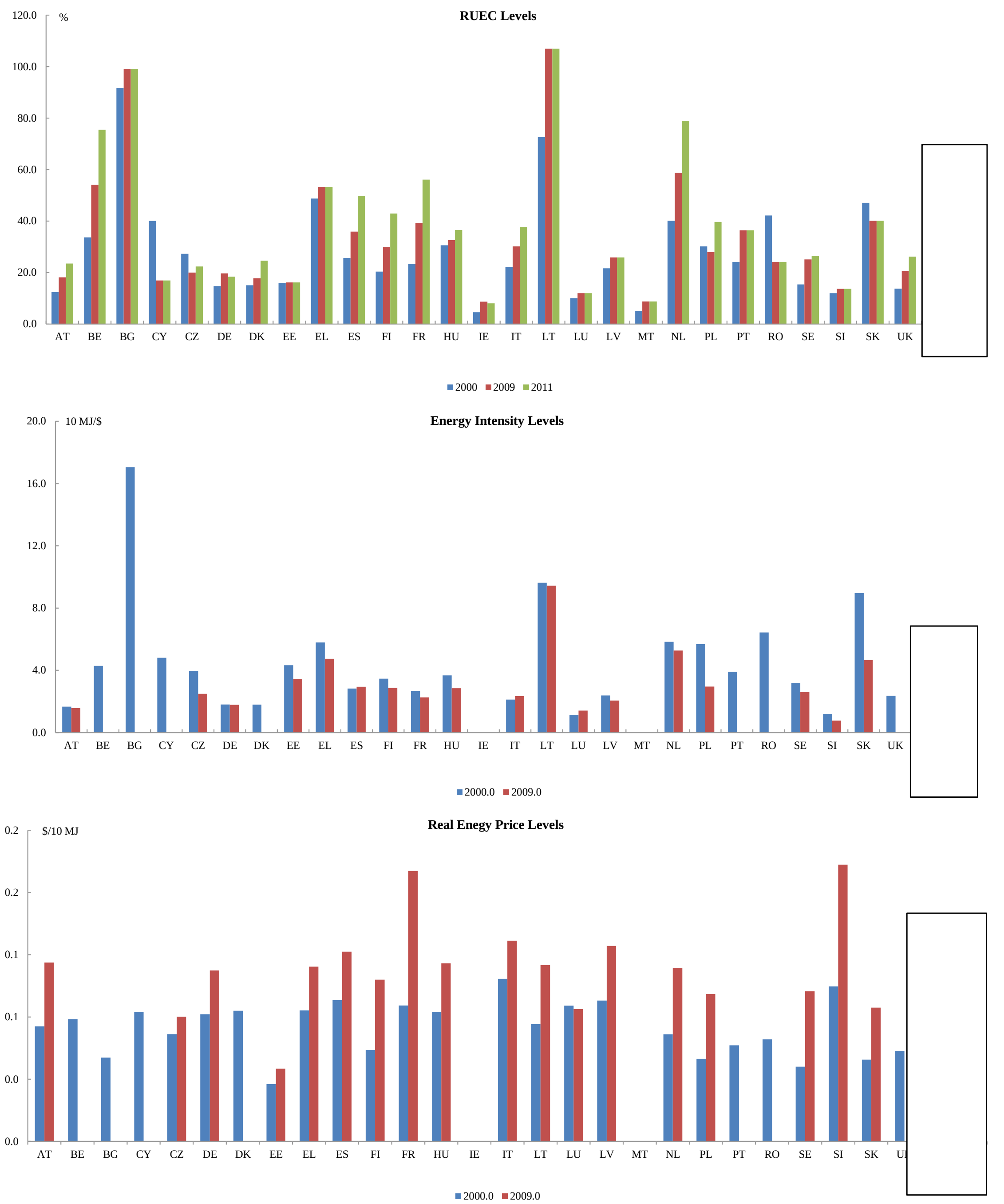
The heterogeneity in levels is rather wide. For some Member States the RUECs are sensibly lower than the EU average while others on the

([17]) There are two preliminary observations, first these data are aggregated to include all the manufacturing sectors hence the indicator can be affected by outliers; second, the occurrence in 2008 of a significant price increase for crude oil may have had more severe impacts on those countries with production activities more dependent on oil such as the refinery industry.
([18]) Due to data limitation, the analysis at Member States level starts with 2000 and not 1995.
([19]) As for the other sections, data limitations for real energy prices and energy intensity are not available after 2009.

contrary display levels that are significantly higher, not only than the average but also than the levels of their main international competitors (Graph I.1.7). In absolute terms Ireland and Malta, together with Luxembourg, Slovenia and Austria, display the lowest levels of RUEC in 2000, 2009 and 2011. The highest levels were reached by Bulgaria which however recorded a percentage increase well below the EU average (7.9%, between 2000 and 2011) and Lithuania, followed by the Netherland, Greece, Belgium and France.

The evolution of energy costs at Member States level is analysed in combination with the trends of energy intensity and real energy prices presented in Graph I.1.7.

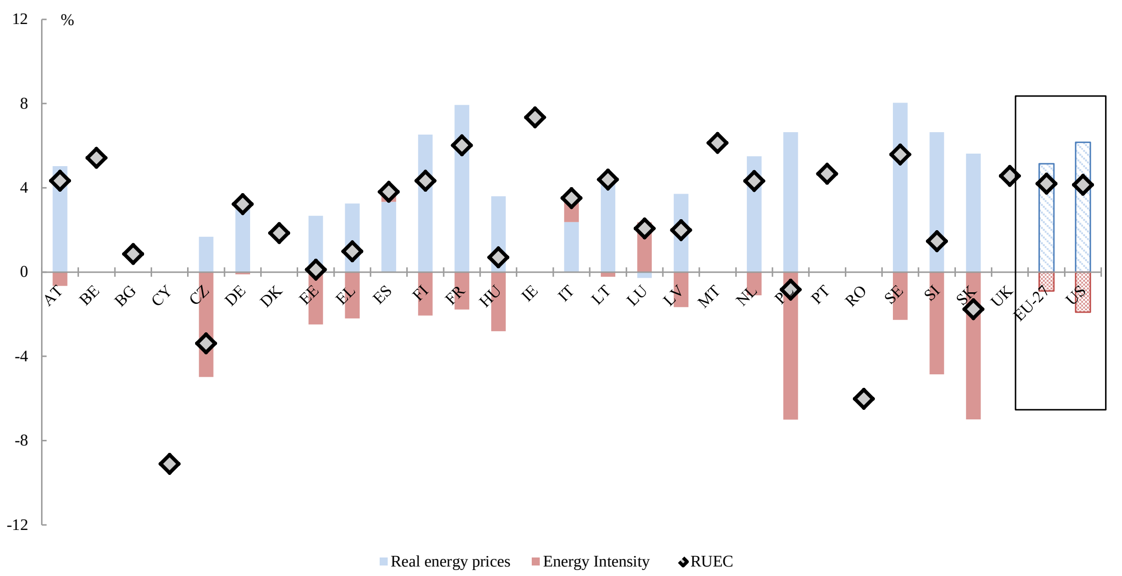
Graph I.1.7: **Decomposition of Real Unit Energy Costs - Manufacturing**



Note: Energy Intensity includes feedstock.
Due to data limitation the assessment of Energy intensity and Real energy prices stops at 2009. Therefore to allow comparability the growth rates of RUEC have also been computed only up to 2009.
Source: Commission Services based on WIOD, ESTAT and OECD.

The Member States with the highest levels of energy intensity in 2009 were Lithuania, the Netherlands and Slovakia. However, it is to note

Graph I.1.8: **Annual Growth Rates 2000-2009 - Manufacturing**



Note: Energy Intensity includes feedstock.
Due to data limitation the assessment of Energy intensity and Real energy prices stops at 2009. Therefore to allow comparability the growth rates of RUEC have also been computed only up to 2009.
Source: Commission Services based on WIOD, ESTAT and OECD.

that Bulgaria had until 2006 the highest level of energy intensity, but lack of data for 2009 does not enable a full comparison ([20]). The lowest levels of energy intensity are found in Slovenia, Luxembourg and to a lesser degree Latvia, Austria, Germany and Italy. At the same time real energy prices were the highest in France, Slovenia and Italy, while Estonia, the Czech Republic and Slovakia enjoy the lowest real energy prices, sometimes even below the US levels.

By looking at the growth rates, some new Member States (Czech Republic, Poland, Slovakia and Slovenia) stand out in terms of energy intensity improvements and, for the Czech Republic also for the low rates of real energy prices growth. These factors contributed to determine a negative growth of RUEC for these countries; except for Slovenia where the upward pressure of real energy prices determined a minor increase in RUEC. In some Member States (Italy, Spain and Luxembourg), despite worsening performances in terms of energy intensity, a moderate increase (a decrease in the case of Luxembourg) in real energy prices resulted in RUEC growth rates below the EU average and also the US. By contrast, some Member States such as France, Sweden and Finland report fast growing real energy prices, well above the EU average, which were not offset by sufficient improvements in energy intensity, hence a growth rate in RUEC well above the average of the EU and the US.

As said, an increase in Real Unit Energy Costs means that the amount of money spent on energy sources to obtain one unit of value added has increased and this negatively weights on the margins of the sector. The growth rates of NUEC presented in Table I.1.4 show to what extent other macroeconomic dynamics, such as sectoral price inflation and exchange rate fluctuations, have either exacerbated or alleviated the growth of RUEC.

Spain had the fastest growing NUEC in the EU followed closely by a group of other Member States which present all similar features, i.e. an high increase of the nominal effect well above the EU average (with the notable exception of France where the NUEC growth is more linked to

([20]) Note that energy intensity in this framework includes feedstock, which is a particularly important factor for the coke and refinery sector and to a lesser extent the chemicals sector. Moreover, energy intensity levels may be influenced by the PPP effect which is not captured by the present dataset.

the energy costs components). Conversely the lowest increases in NUEC have been in Poland, the Czech Republic and Slovakia. However only in the case of Poland this result can be ascribed mostly to the very low growth of the nominal effect. In Czech Republic and Slovakia the improvement in their performances must therefore be found in the energy components, notably in remarkable reductions of energy intensity.

Table I.1.4: **Average % annual change 2000-2009 - Manufacturing**

	Real Energy Price	Energy intensity	RUEC	Nominal Effect	NUEC
AT	5.0%	-0.7%	4.3%	4.9%	9.2%
BE			5.4%		
BG			0.9%		
CY			-9.1%		
CZ	1.7%	-5.0%	-3.4%	6.9%	3.5%
DE	3.3%	-0.1%	3.2%	5.2%	8.5%
DK			1.9%		
EE	2.7%	-2.5%	0.1%	7.5%	7.6%
EL	3.3%	-2.2%	1.0%	8.5%	9.5%
ES	3.3%	0.5%	3.8%	7.9%	11.7%
FI	6.5%	-2.1%	4.3%	1.2%	5.5%
FR	7.9%	-1.8%	6.0%	4.2%	10.2%
HU	3.6%	-2.8%	0.7%	7.8%	8.5%
IE			7.3%		
IT	2.4%	1.1%	3.5%	7.2%	10.7%
LT	4.6%	-0.2%	4.4%	6.4%	10.8%
LU	-0.3%	2.4%	2.1%	8.7%	10.8%
LV	3.7%	-1.7%	2.0%	8.7%	10.6%
MT			6.1%		
NL	5.5%	-1.1%	4.3%	5.9%	10.2%
PL	6.6%	-7.0%	-0.8%	3.3%	2.5%
PT			4.7%		
RO			-6.0%		
SE	8.0%	-2.3%	5.6%	0.6%	6.2%
SI	6.6%	-4.9%	1.5%	5.0%	6.5%
SK	5.6%	-7.0%	-1.8%	5.6%	3.9%
UK			4.6%		
EU27	5.1%	-0.9%	4.2%	4.9%	9.1%

Note: Energy Intensity includes feedstock.
Due to data limitation the assessment of Energy intensity and Real energy prices stops at 2009. Therefore to allow comparability the growth rates of RUEC have also been computed only up to 2009.
Source: Commission Services based on WIOD and ESTAT databases.

1.6. CONCLUSIONS

The results shown above indicate that the EU manufacturing sector has enjoyed some of the lowest Real Unit Energy Costs together with Japan and similarly to the US. This means that to obtain 1 USD of valued added they have spent a lower amount of money on energy sources than Russia or China. In addition, the evolution of RUEC plotted in Graph I.1.1 shows that the EU have suffered relatively less than other countries the oil price shock of 2008 which has on the other hand affected severely both Japan and the US. This impact is also clearly shown in Graph I.1.3 where real energy prices are presented. This may be the outcome of the energy mix composition of the US industry compared to that of the EU, since the US industry is more reliant on oil products than EU manufacturers ([21]).

The trend of the EU RUEC could also be determined by an industrial structure based on higher value added production. The relatively higher real energy prices may have induced EU manufacturers – together with Japan and US – to specialize in higher value added product categories with lower energy intensity while conversely the industry in countries such as China, Russia, India, Brazil lead by competitive energy prices may have opted for more energy intensive production activities with a comparatively lower value added.

The RUEC levels for the entire manufacturing sector in 2011 signal a continuation of the upward trend for all the countries. It is to note however that the EU overtakes the US, by a very thin margin, and China further converges towards the US, Japan and the EU.

The improvements of the EU industry in terms of energy intensity have helped to offset the increase in real energy prices. Despite the already low starting point the EU manufacturers have steadily improved their energy intensity

([21]) See in Appendix 3, Graph I.A3.7 and Graph I.A3.8.

performances converging towards the Japanese levels. The US and China have been catching up but the difference in absolute levels remain substantial.

The sectors that are most exposed to energy price shocks in terms of high RUEC levels in the EU are coke and refined petrol, chemicals, non-metallic mineral, metals, rubber and plastics. Coke and refined petrol stands out with much higher RUEC levels than in other countries and a growth rate that is also among the highest ones. This indicates significant vulnerability of this sector, though its share in total manufacturing value added of the EU has been low and stable. In contrast, US, Japan and Russia have seen a significant increase in this share. In the other four sectors with high energy cost vulnerability (chemicals, non-metallic mineral, metals, rubber and plastics) the EU shows RUEC levels that are generally comparable with those of Japan. The EU levels are, however, noticeably higher than the US in chemicals, non-metallic mineral, and metals. Nonetheless in all four sectors the figures of the EU remain substantially lower than those of China and Russia. The growth rates of RUECs of the EU in the four sectors are generally in line with other countries with some variability observable.

In 2011 data confirm that for all sectors, EU RUEC are higher than in the US. While this points to additional cost pressure on EU firms it is however to be noted that some typically energy-intensive sectors (coke and refined petroleum and basic metal products) have incremented their shares in the manufacturing value added of the EU.

The situation of Member States, is heterogeneous. On the one hand countries such as Bulgaria, Lithuania and the Netherlands have the highest levels of RUEC therefore their production structure is more sensitive to energy cost pressure and any increase in energy prices not matched by improvements of energy intensity may severely affect the margins of their manufacturing sectors. On the other hand countries like Italy and Luxembourg have experienced a worsening of their energy intensity performance which was however met by moderately increasing real energy prices. The growth of their RUEC has been therefore modest and their absolute levels remain low. More vulnerable in this sense appears France where the very fast growth in real energy prices was not sufficiently counterweighted by significant improvements in energy intensity. The growth rate of RUEC in France is well above the average although its level is still relatively low. Finally for some countries, especially Spain, the nominal effect led to a fast increase in NUEC. These dynamics are outside the scope of the present study but have nonetheless added cost-pressure on the Spanish manufacturing sector exacerbating the energy cost component.

2. THE RECENT DEVELOPMENT OF US SHALE GAS AND ITS IMPACT ON EU COMPETITIVENESS

2.1. INTRODUCTION

The previous chapter on Unit Energy Costs presented an empirical analysis based on the WIOD Database which provides data only until the year 2009 for some of the indicators (namely energy intensity and real energy prices) and for 2011 for the Real Unit Energy Costs.

The period after 2009 has however been marked by important events, some energy-related and some not. The development of US shale gas belongs to first category. It has changed substantially the energy system of the US and by consequence it has widely impacted on the global energy markets. The extent of these changes and their implication for the EU are the subject of this chapter. The economic and financial crisis that spread after 2008 is instead part of the second category of events, not energy-related. The economic recession that has affected the EU economic economy has however made more urgent the need to look at energy prices for consumers and industry, in a context of lacklustre domestic demand and loss of competitiveness.

The surge of the US shale gas ([22]) and the corresponding fall in energy prices for US manufacturers has reignited the debate on the EU's industrial competitiveness and has led to calls for policy changes aimed at reducing the energy costs for EU firms, either through reducing the stringency of energy and carbon policies or through stepping up EU gas production including shale gas ([23]).

This chapter will endeavour to assess impacts of the development of shale gas through a step-by-step comparison between the EU and US, using data from Eurostat, OECD and the US Energy Information Administration. Section 2.2 discusses how the introduction of shale gas has affected the US energy sector. The impacts are assessed through an EU-US comparison on the energy mix and on the energy import dependence. Section 2.3 addresses the development in the EU-US energy price-gap. The disparity in energy intensity and some reflections on the impacts on the production structure in the EU and US are presented in Section 2.4. Finally the developments in the trade balances for the EU and US will be discussed in section 2.5. The chapter is concluded by some preliminary remarks and open questions for future discussions.

2.2. THE IMPACTS OF THE SURGE IN US SHALE GAS ON THE US ENERGY SECTOR AND EU AND US ENERGY MIX

Many observers have noted the strong surge in US gas production and consumption because of what has been coined the "shale gas revolution." As depicted in Graph I.2.1, shale gas was already produced in the US in modest amounts at the turn of the century, but it became significant after the middle of the last decade.

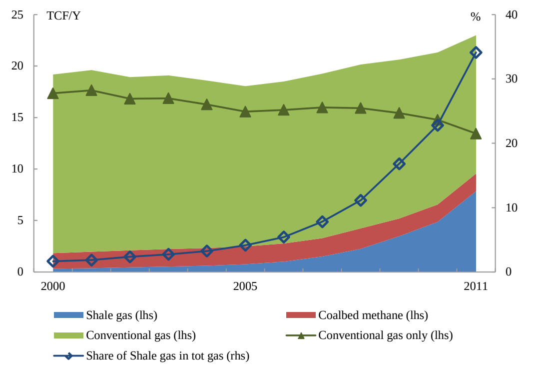
The exponential growth in production volume started to profoundly affect the make-up of the US natural gas supply from 2007/2008 onwards. By 2011, the US has become the biggest gas producer in the world, ahead of Russia, while shale gas constitutes now over one third of the natural production in the US (while only about 5% in 2005).

The current impact of shale gas on the overall make-up of the US energy sector has been significant but it should not be overstated, both as regards the net impact on the domestic gas sector and as regard the changes in the energy mix. Shale gas has revived the domestic natural gas sector whose production had stagnated earlier in the decade, and since a few years shale gas is also replacing domestic supply of conventional natural gas.

([22]) Shale gas refers to natural gas that is trapped within shale formations. Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas. Over the past decade, the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that were previously uneconomical to produce.

([23]) PISM (2011) and Artus P (2013).

Graph I.2.1: **Natural gas production in the US and share of shale gas on total gas production**

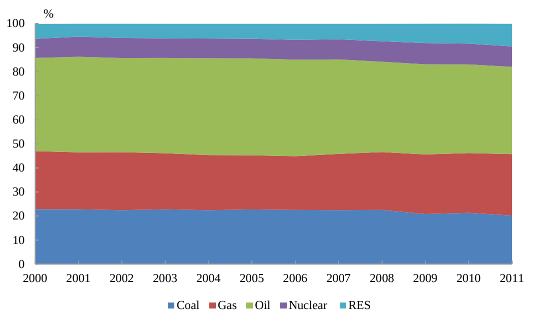


Source: Commission Services based on Energy Information Administration, US.

Over the period 2000 – 2011 natural gas production has increased by almost 20% and since the historic low in production in 2005 it has increased by almost 27%.

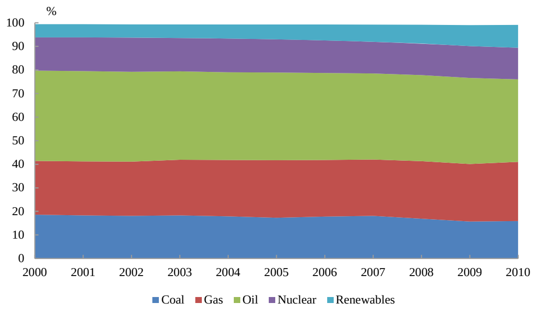
However, the share of natural gas in the US energy mix has only increased by 2 percentage points between 2000 and 2011, while it increased from 18% to 25% in the electricity mix (Appendix 4, Graph I.A4.3).

Graph I.2.2: **Energy mix US**



Note: Expressed as share per source in Primary Energy Consumption
Source: Energy Information Administration.

Graph I.2.3: **Energy mix, EU**



Note: Expressed as share of source in Gross Inland Consumption
Source: Eurostat.

The resurgence of gas as primary energy source in the US should be seen against the background of changes in the US consumption and production of the other primary energy sources. Graph I.2.2 on the US energy mix in the period 2000 – 2011 shows a similar increase in importance of renewable energy sources: its consumption share has risen from 6% in 2008 up to a share of 9% in 2011. On the other hand, a relative decline of oil and coal as primary energy sources is observed with their shares falling over the decade from 39% to 36% for oil and from 23% to 20% for coal.

These changes in shares reflect changes in domestic production levels: renewable energy generation has increased by 49% in the past ten years and natural gas, as already mentioned above, by 20%. Coal production has fluctuated but in 2011 it had decreased by 2% compared to 2000. In 2011 natural gas has for the first time overtaken coal as first source of energy produced in the US. Oil production after a period of slow and steady decline, culminated in 2008 has picked up again but in 2011 it was still 3% less than in 2000 (Appendix 4, Graph I.A4.1).

Together with renewables, US shale gas has undoubtedly contributed to significantly reducing the energy dependence of the United States and hence to decreasing their exposure to global commodity prices fluctuation and geopolitical risks.

As depicted in Graph I.2.4, the US energy import dependency has reached 18% in 2011, the lowest point since 2000.

Box I.2.1: **Potentials and Uncertainties for Shale Gas Exploration in the EU and in the US**

Various sources ([1]) ([2]) reported that the proved natural gas reserves of the world were in 2011around 190/200 trillion of cubic meters (tcm). However the estimation of potential natural gas reserves is an uncertain exercise.

The US had about 9 tcm of proved gas reserves in 2011 2.7 tcm of which concerns shale gas. According to the US-based, independent "Potential Gas Committee" (PGC) assessment in 2012, the total reservoir of potentially recoverable natural gas in the United States amounted to around 67 tcm, ([3]) 48% of which should be shale gas (30,5 tcm). One year earlier, the US Energy Information Administration (EIA) estimated total recoverable gas reserves in the US and the shale gas potential as about 72 tcm and 24.4 tcm respectively ([4]). A little less than half of this recoverable amount (11 tcm) should be found in what appears to be the largest US shale gas field, the Marcellus basin.

However, a recent study by the US Geological Survey has radically lowered these potential reservoir estimates: on the basis of more recent drilling and production data, they estimate the Marcellus basin potential to be only 2.3 tcm ([5]), which is about 80% less than previously reported by EIA. The EIA's Annual Energy Outlook 2012 reflects these newer insights as they have cut their reported estimate ([6]) of the "total unproved technically recoverable reserves" of US shale gas from 2011 to 2012 by almost half (around 13,6 tcm).

Finally, in the most recent update of its assessment in June 2013, the EIA has further revised the potential unproved shale gas reserves in the world: in the US, slightly upward to 16.1 tcm; in the EU slightly downward to 13.3 tcm from 15.8 in 2011 ([7]) (Graph 1).

Some noted energy experts have expressed more pessimistic views as they not only expect recoverable reserves to be significantly smaller than predicted but also shale gas wells to be depleted at a much faster rate (33% a year) than conventional gas wells (20% a year), ([8]) indicating yet another source of uncertainty underlying the reservoir estimates ([9]).

In this context of uncertainty, the estimates for shale gas potentials in the EU appear equally diverging although also fewer in number. According to some sources, recoverable shale gas in the EU could range between 2.3 tcm and 17 tcm ([10]) against the background of which the EIA estimates for the EU, presented in Graph 1, appear rather optimistic. The EIA estimate for shale gas of 13.3 tcm for the whole EU should be seen against the background of total proved natural gas reserves in 2011 of about 4 tcm in the EU.

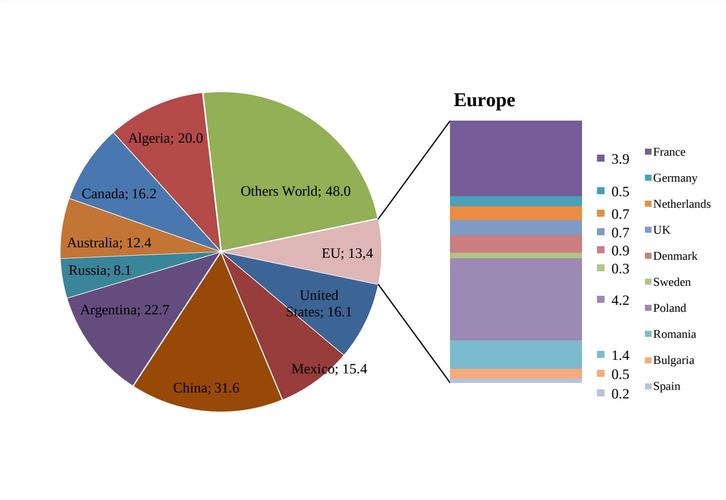
Graph 1's confrontation of the EU and US shale gas reservoir estimates leads to the following general observations. First, despite the wide range of estimates, Europe's shale gas reserves appear to be significantly smaller than the US ones. In addition, they are also more dispersed: while between one third and half of the potential US reserves are located in one huge basin (namely Marcellus) and some other US basin appear quite large as well (Haynesville, 10% of total, around 2 tcm), the EU estimated reserves are scattered across several countries, with France and Poland having the largest reserves. The dispersion over many smaller fields suggests lower economies of scale in their exploitation, compared to the US.

([1]) Energy Information Administration, Proved Reserves of Natural Gas, http://www.eia.gov/dnav/ng/ng_enr_sum_a_EPG0_R11_BCF_a.htm
([2]) BP Statistical Review of World Energy June 2012
([3]) http://potentialgas.org/press-release (MAGNITUDE OF U.S. NATURAL GAS RESOURCE BASE, Press Release, 2012)
([4]) EIA (2011).
([5]) http://www.usgs.gov/newsroom/article.asp?ID=3419
([6]) EIA (2012), Table 14 on p57.
([7]) EIA (2013)
([8]) A prominent example is Arthur Bernam, http://petroleumtruthreport.blogspot.be/, blog entry of the 16th February 2013.
([9]) European Commission (2012c), p 24.
([10]) European Commission (2012c), p 29.

(Continued on the next page)

Box (continued)

Graph 1: **Unproved technically recoverable shale gas resource**



[redacted]

Total EU	18.1	13.3
France	5.1	3.9
Netherlands	0.5	0.7
UK	0.6	0.7
Sweden	1.2	0.3
Bulgaria	/	0.5
Romania	/	1.4
Of which		
Total World	187.5	203.9

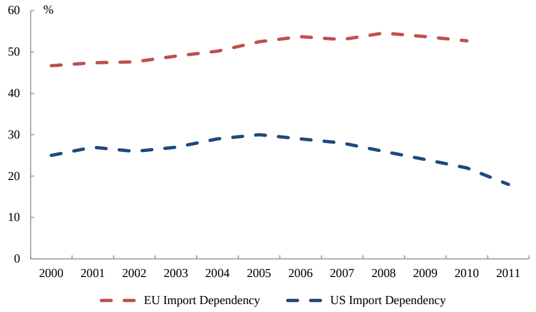
Source: Energy Information Administration

The second and more controversial observation relates to the actual extraction costs of shale gas. As mentioned in section 2.3, the prices for gas in the US have substantially fallen since the onset of the surge. Some expert assessments consider the current gas price level and production levels as incompatible, expecting prices to rise and production to fall in the medium term. This is because the current wholesale price appears too low for many shale gas fields (on-going and envisaged) to be profitably extracted (11) (12). However, these predictions have so far not materialised: shale gas supply and gas consumption have soared while prices have remained at low levels, notwithstanding a mild upward correction since early 2012 (13).

The learning curve of shale gas extraction may be one major cause of the sustained low prices: technological progress may help to keep on enlarging the part of the reserves that can be commercially exploited and reducing the production costs (14). The US EIA also provides another explanation: currently US shale gas is often jointly recovered with oil and liquid gas (NGL) reserves, the prices of which are closely related to the crude oil price (15). Since the oil price per MBtu is markedly higher than the various gas prices (Graph I.2.5), producers have been able to compensate for the lower margins made on shale gas sales. It is questionable whether the EU shale gas producers would be able to enjoy such a joint-production bonus, because oil drilling is rather marginal in Europe and therefore shale gas extraction is not likely to be associated with it.

Whether the low price levels will persist or not is subject of debate in the US and it is the reason of the request from some industrial sectors not to allow the export of shale gas in order to prevent domestic gas price increases. Due to the recent start-up of shale gas exploration, the information on EU shale gas reservoirs is rather scant and quite uncertain but seems to suggest that prospective shale gas producers in the EU cannot attain similar production volumes and production costs as their US counterparts. In addition, potentially significant imports of US shale gas into Europe at relatively low prices may discourage commercial exploitation of the more marginal EU shale gas fields.

Graph I.2.4: **Energy Import Dependency**



Source: Commission Services based on Energy Information Administration and Eurostat.

However, the fall in energy import dependency started around 2005 and hence somewhat *before* shale gas production levels became significant. This can be explained by the expansion of renewables and by the start of the increase in overall gas production.

In sharp contrast to the US, the EU's import dependency has increased from 46% to 52% between 2000 and 2010 ([24]). This reflects the combination of a decline in domestic energy production and an increase in energy consumption, even when taking account for the abrupt contraction of economic activities in 2008.

The production decline over the decade concerns all primary energy sources except renewables. EU gas and oil production have fallen by a quarter and 40% respectively. However coal, because of its sheer volume (still larger than for all other energy sources combined), has been the major driver of the overall decline with a production fall over 10%. In contrast, renewables increased their output in caloric terms by 72%.

Since the EU energy mix has similar make-up and trends as the one of the US (with a higher share of nuclear power as the major difference), the rise in consumption has been met by increasing imports. Natural gas provides an apt illustration: the increase of consumption share by 2 percentage points over the decade has prompted an import increase of more than 45%, whereas the US has satisfied the increased demand mainly from domestic sources (gas imports in monetary terms decreased by 56%, compared to their peak in 2005).

([24]) European Commission (2013b)

There is another recent phenomenon triggered by the development of shale gas and observed mainly between 2011 and 2012: the US have decreased their consumption of coal, exporting their excessive production and reducing their imports. This has driven coal prices down. As gas has became relatively more expensive and coal relatively cheaper in Europe a substitution is taking place: gas consumption declined by 7% while coal consumption increased by about 20% between the first half of 2011 and the first half of 2012. Notably imports of coal from the US increased substantially especially in some Member States: looking at the first half of 2012, Germany, Italy and the Netherlands respectively imported 37%, 83% and 86% more hard coal from the US than in the first half of 2011 ([25]). This shift raises evident climate change concerns as currently carbon prices are too low to offset the comparative advantage of coal over natural gas.

2.3. ELECTRICITY AND GAS PRICES: A US-EU COMPARISON

In the developed world, gas is increasingly seen as an attractive substitute for oil as it is a relatively clean source of energy and also because it has become relatively cheap (Graph I.2.5). For the purposes of this analysis, however, it is not enough to look at the gas spot market price, for a number of reasons.

First, unlike oil, there exists no global wholesale market and no global reference price for natural gas. In the European Union the majority of natural gas is supplied through bilateral long-term contracts which are negotiated between two parties, importer and exporter, and traditionally indexed to the price of oil. Currently, half of natural gas supply in the EU is still indexed to oil while across the EU a wide variation in import prices of piped gas and LNG has been observed ([26]). This is remarkable as at the same time a growing share of gas is traded on spot-markets ([27]) where short-term contracts are concluded on the basis of the market price determined by actual demand and supply. Spot

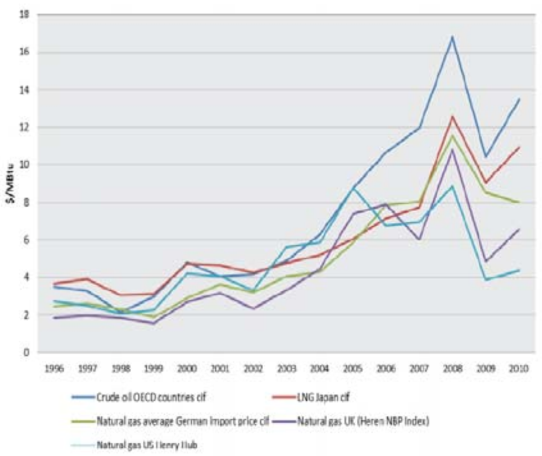
([25]) European Commission (2012b) (ii).
([26]) European Commission (2012b) (iii).
([27]) European Commission (2012c) and (2012d which reports on p182 that one quarter of continental European gas is spot traded).

market prices in the EU have been constantly lower than long-term contracts' prices, at least since 2005 ([28]).

In addition, gas can be used directly for heating or other purposes but can also be used as a primary energy source for electricity generation: in both regions, the share of gas in the electricity mix is currently around 25% and it has increased with a similar pace over the past ten years. Consequently, the wider impact of shale gas on energy prices can be illustrated by looking at the electricity prices.

In both the US and in the EU, spot-market gas prices have progressed in a similar fashion over the past decade and have followed the movements in the oil price, as depicted in Graph I.2.5. In 2005, however, these gas prices have started to clearly fall below the level of the oil price. Between 2008 and 2009 they fell significantly in both regions, likely as a consequence of declining demand due to the economic downturn.

Graph I.2.5: **Wholesale natural gas prices in Germany, Japan, UK and US compared with crude oil price**



Source: European Commission (2012).

The fall in energy consumption has led to an excess supply of gas on the gas markets around the world and both US and the UK spot markets temporarily converged, trading at around 4/5 USD/MBtu in mid-2009, while the German hub prices fell less evidently, trading still above 8 USD/MBtu in 2009. From 2007 onwards, the US gas spot price has fallen under the price level of the other gas spot markets, which most likely reflects the effect of the surge in domestic shale gas supply. This becomes quite clear after 2009, when energy consumption picked up again following the recovery of the economy.

Statistics from more recent years show that while the US spot prices remained low (around 4 USD/Btu in 2011), the EU spot prices (both in the UK and German hub) kept increasing([29]). Wholesale gas prices have continued to rise in the EU while economic activity contracted and consequently natural gas consumption in the EU has been declining: the first half of 2012 represented the EU's lowest first half year consumption of the last ten years. It was 7% and 14% less than the first half of 2011 and 2010 respectively ([30]).

The continued rise in EU wholesale gas prices despite the slump in gas demand and the lower gas spot prices vividly depicts the kind of vulnerability the EU is exposed to due to its high import dependency: as the Asian markets offer higher returns ([31]) and more robust demand, gas producing countries have increased their trade with Asia lowering supply to Europe. As a consequence wholesale gas prices in Europe have increased while in the US, which now can rely more heavily on domestic production, prices have remained low. US prices were shielded from potential upwards pressure from export demand because of export restrictions (generally expected to be gradually lifted). Furthermore, the impacts on

([28]) European Commission (2012b) (i).

([29]) On average in Q2 2013 wholesale consumers on the UK's NBP – traditionally the lowest priced hub in the EU, which however in March 2013 experienced a price spike - paid more than double the price paid by consumers on Henry Hub in the US. The gap between Henry Hub in the US and German border prices was even larger, with German border prices almost three times higher than Henry Hub prices over the first four months of 2013. European Commission (2013a).

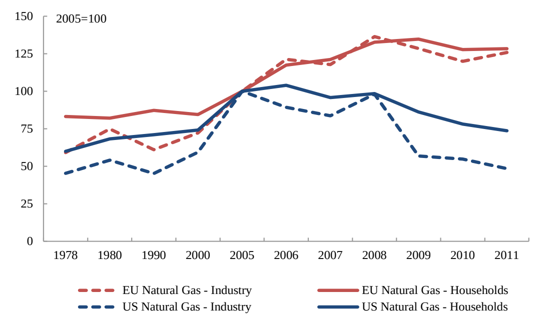
([30]) European Commission (2012) (ii).

([31]) European Commission (2012b) (ii). Average LNG price in Europe in 2012 was between $9 or $10/MMBtu, in Japan it was $17/MMBtun, in Korea $16.6/MMBtu. The price differences suggest that, in vivid contrast to oil, the world is divided in various regional gas markets. Some commentators have hinted at the possibility that the price differences may be reduced in the next decade due to an increase in gas consumption; the abandonment of the practice to base long-term gas contracts on the international oil price; and the world-wide surge in gas exploration and exploitation, including but not exclusively shale gas.

the EU have been further aggravated in this context due to the oil-price indexation of many long-term gas import contracts.

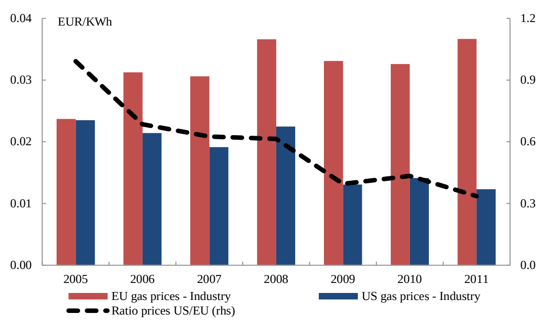
The evolution of end-user's prices ([32]) for gas (Graph I.2.6 and I.2.7) follows a pattern similar to that of the wholesale market.

Graph I.2.6: **Indices of real gas prices for end-users**



Note: "Real" price indices are the current price indices divided by the country specific producer price index for industrial prices, and by the consumer price index for the household sector.
Source: OECD - Electricity Information (2012).

Graph I.2.7: **End-user gas prices for industry**



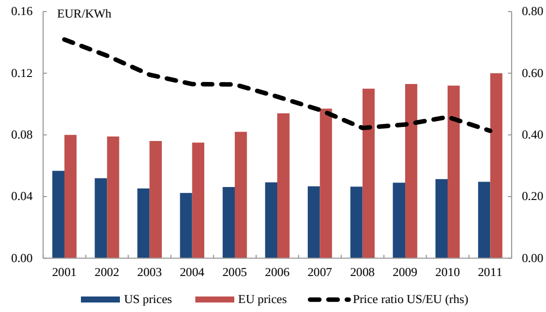
Note: For the US prices it was not possible to identify a specific consumption band. The EU prices are for the consumption band I3 (I3.1 and I3.2 until 2006) that is between 10,000 and 100,000 GJ.
Prices are nominal and the exchange rate used is from OECD. Taxes are included.
Source: Energy Information administration and Eurostat data.

A significant gap between the EU and the US starts appearing in 2006, prior to the development of shale gas but coinciding with the divergence observed between the oil price and the natural gas prices on the wholesale markets in the various regions in the world.

While the EU gas end user prices seem to stick closer to the oil prices and increased from 0.022 EUR/KWh in 2005 to 0.035 EUR/KWh, the US gas prices declined from about the same starting point of the EU in 2005 to 0.010 EUR/KWh in 2011.

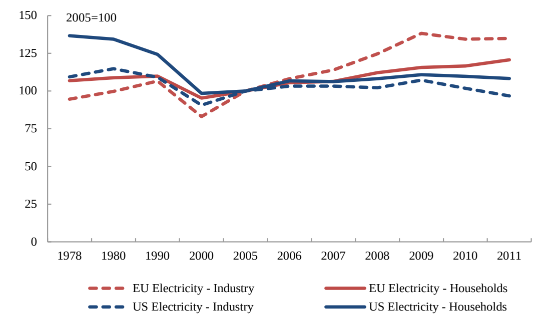
On the other hand, the impacts of the fall in the gas price on electricity end user prices is much less evident yet it can still be observed. As shown in Graph I.2.8, electricity prices in the US have historically been much lower than in the EU.

Graph I.2.8: **End-user electricity prices for industry**



Note: For the EU prices refer to average of consumption bands Ie If Ig until 2007, after 2007 consumption band ID. Prices are nominal and the exchange rate used is from the OECD. For the US no consumption band was available. 2011 provisional data. Taxes are included.
Source: Eurostat and Energy Information Administration.

Graph I.2.9: **Indices of real electricity prices for end-users (2005=100)**



Note: "Real" price indices are the current price indices divide by the country specific producer price index for industrial prices, and by the consumer price index for the household sector.
Source: OECD - Electricity Information (2012).

([32]) Comparing end-user prices is complicated as there are differences in statistical conventions between the two regions as well as different taxation regimes. Nonetheless both the OECD data and the Eurostat data provide a similar picture (Appendix 4, Graph I.A4.6).

The gap has been persistent at least since 2001 (Graph I.2.8). Also in this case, the price difference predates the development of shale gas.

The price differential has however been widening in the past few years as the European prices increased over the period (although not in a linear manner) while the US prices remained more or less constant.

The development of US shale gas is likely to be at the root of this widening gap mainly because its increased energy independence and export restrictions in the US has to some extent sheltered them from fluctuations on the global energy markets; in addition it has reduced the supply costs of gas for electricity generation. At the same time the EU energy dependence has increased and this has led to a higher exposure of the EU to energy prices volatility.

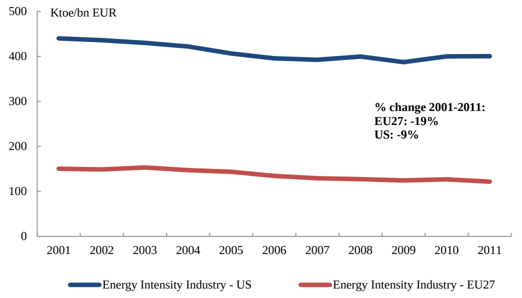
Finally it is to note that shale gas prices in the US do not fully reflect external costs as the current regulatory regime exempts shale gas projects from a number of pieces of federal environmental legislation, including the provisions of the US Safe Drinking Water Act.

2.4. ENERGY INTENSITY (33): A US-EU COMPARISON

Over the past years, the European industrial sector has been able to successfully decouple its performance in terms of value added from its energy consumption. The remarkable wide energy price gap between EU and US should be considered next to the equally remarkable energy intensity gap between the two regions.

The EU industry's energy intensity has been substantially lower than its US counterpart. In addition it has improved by almost 19% between 2001 and 2011 while in the US the improvement over the same period was only 9%.

Graph I.2.10: **Energy intensity of industry**



Note: Final energy consumption industry divided by gross value added in 2005 reference year, ktoe in billion of euros.
Source: Eurostat, Energy Information Administration, Bureau of Economic Analysis USA.

It appears that the increase in the European energy prices is likely to have provided manufacturing industry with the incentive to improve their energy intensity in order to limit the cost of their production inputs. Conversely, the relatively cheaper energy supply in the US did not provide similar incentives.

The development of shale gas has exacerbated this difference as it has further lowered electricity and gas prices. This seems to have halted the gradual improvement in the energy intensity of the US industry: after 2006 energy intensity performances remained constant and actually started to slowly deteriorate in the last two years considered.

There appear no significant divergences in the production structure between the two regions which can explain the marked difference in energy intensity performance between EU and US industry. First, the general picture of the EU-US energy intensity divergence also emerges when looking at various branches within manufacturing industry (Graph I.2.12).

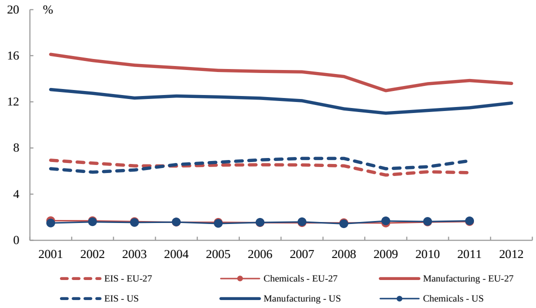
Second, in terms of contribution to GDP, the European manufacturing sector is still larger than its US counterpart, although the difference seems to have become smaller during the decade.

A similar convergence can be observed in the energy intensive industry sector, whose GDP share has become smaller in the EU than in the US but

(33) It is to note that for the calculation of energy intensity in this section data taken from Eurostat and Energy information administration of the US have been used. Unlike in section 1, energy consumption does not take into consideration feedstock (ie. energy sources used as raw material). In addition the definition of Industry is broader than the 14 Manufacturing sectors included in the analysis of section 1 and it includes also agriculture, construction and electricity and gas supply. Differences in levels and evolution with respect to what observed in section 1 can therefore be explained by these statistical differences.

the difference in size seems to slightly widen only in 2011.

Graph I.2.11: **Share of some Energy Intensive Sectors (EIS) and share of Manufacturing in GDP - 2001-2012**



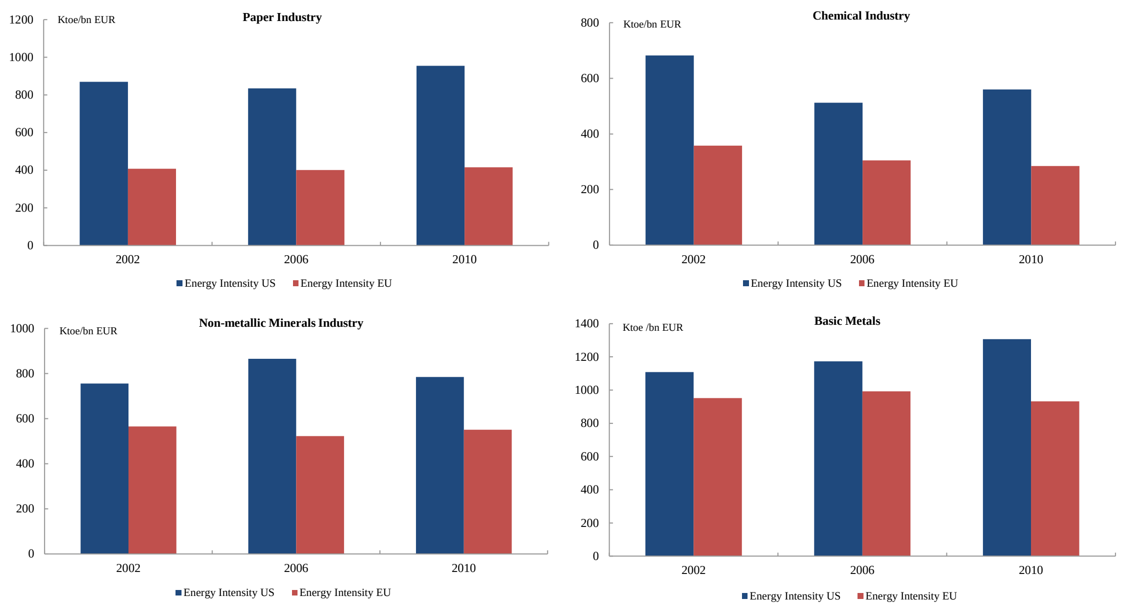
Note: For the EU-27 energy intensive sectors include Fabricated metal products, Basic metal, Other non-metallic mineral products, Chemicals and chemical products, Coke and refined petroleum products, Paper and paper products, Mining and quarrying.
For the USA, energy intensive sectors include Mining, Non-metallic mineral products, Paper products, Petroleum and coal products, Chemical products, Primary metals, Fabricated metal products.
Source: Own calculations on Eurostat and US Bureau of Economic Analysis.

The better performance of the EU's manufacturing industry in terms of energy intensity has therefore happened in the context of comparable overall production structures. Nonetheless, a certain process of restructuring away from energy intensive sectors is observed in the EU from 2005 (see the shift-shares analysis carried out in chapter 1). Graph I.2.11 corroborates this insight as it shows that it is around 2005 that the share of energy intensive sectors in the US exceeds that of the EU. However as shown in chapter 1 and Appendix 3 this is largely driven by the increased importance of the refinery sector in the US economy.

This suggests that while European business as a whole has been able to compensate for the higher energy prices through improvements in energy intensity and possibly also through other non-energy-related efficiency gains - facilitating the substitution of energy with other production factors ([34]) - the energy intensive sectors have been relatively more strongly affected. Yet the restructuring started already before the development of shale gas and might therefore accelerate as the energy price gap widens. .

([34]) The extent and nature of this adaptation would require more in-depth empirical research.

Graph I.2.12: **Energy intensity of industry, selected sectors**



Note: Final energy consumption in Ktoe per billion EUR, reference year 2005.
Paper Industry for the EU includes Paper and paper products and Printing and reproduction of recorded media. For the US: Paper; Printing and Related support
Chemical Industry for the EU includes Chemicals and chemical products and Basic pharmaceutical products and pharmaceutical preparations. For the US: Chemicals, Pharmaceuticals and Medicines.
Non-metallic minerals for the EU includes Other non-metallic mineral products. For the US: Non-metallic Mineral Products.
Basic Metals for the EU includes Basic metals. For the US: Primary Metals.
Source: Eurostat, Energy Information Administration and US Bureau of Economic Analysis.

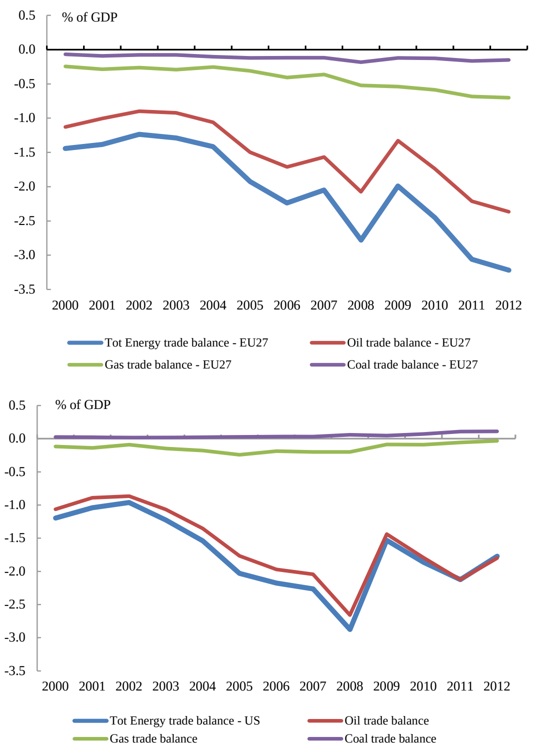
2.5. TRADE

2.5.1. Energy trade

The most evident effect on trade of the US shale gas development has been the sizeable reduction of the US energy trade deficit over the past few years. While for the first eight years of the decade the energy trade deficits of EU and US deteriorated in very similar fashion, after 2008 they developed quite differently.

The US energy trade deficit improved much more in 2009 than the EU counterpart, while in later years it has deteriorated much less pronouncedly, also in part because of its higher share of oil in its energy imports that experienced larger volatility than the other energy carriers. This has resulted in a wider gap in GDP terms between the US and EU energy trade deficit.

Graph I.2.13: **Energy trade balances as % of GDP, total and per energy source - 2001-2011, EU-27 and US**



Source: Commission Services on Eurostat and US Bureau of Economic Analysis.

The drive to self-sufficiency in domestic gas consumption and the related increase in coal exports which took place after 2008 help to explain this trend. In contrast, the EU became more dependent on gas and coal. Graph I.2.13 illustrates these divergent developments.

While the US gas trade has tended to move closer to balance, the EU's gas trade deficit has actually increased. This trend has its origins well before 2008 but the gap in GDP terms has widened considerably after 2008. The difference is likely to become bigger when the US starts to export shale gas; this tendency could be countered if the EU could rely more on domestically produced gas ([35]).

The significantly larger trade surplus for coal in GDP terms from 2008 onwards reflects the US excess coal supply. As a consequence, the relative price of coal vis-à-vis that of other primary energy sources has fallen, triggering a process of partial substitution in the European energy mix.

Finally, with the current near balance in both coal and gas trade, the US energy trade balance appears now basically driven by the developments in the oil trade balance. The US oil trade deficit has also been significantly reduced compared to its 2008 levels, indicating, next to a fall in oil prices from a peak level, a shift in US energy use away from oil towards gas (and renewables). In contrast, the EU energy trade balance is driven by the trends in all three main tradable primary energy sources (oil, gas and coal) and for each of them the deficit has worsened over the past ten years considered, although more for oil and gas than for coal. The increase in import dependency may expose the EU as a whole more to supply disruptions and geopolitical risks, and to the related danger of increased price volatility.

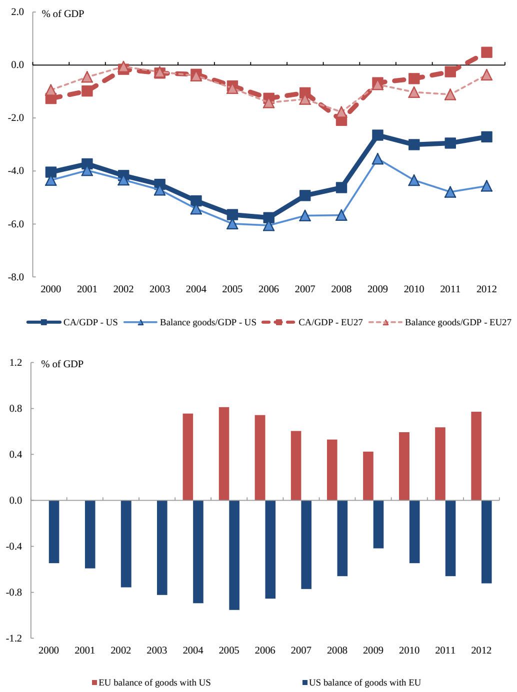
2.5.2. Trade of goods

The developments in the energy trade deficit should be seen in the context of the trends in the overall current account balance.

As it is well-known, the US has had a persistent large current account deficit, for a part fuelled by the global finance trends before the onset of the current financial and economic recession. However, it is of note that already in the years just before the outbreak of the financial crisis, the current account deficit had already started to fall.

([35]) This is possible when, for instance, Cyprus' large offshore gas reservoirs turn out to be commercially viable for exploitation. Moreover, a number of EU countries report large potential reservoirs of shale gas.

Graph I.2.14: **Current account balance, external balance for goods and bilateral balance for goods, 2001-201 - US and EU-27**



Source: Commission Services based on Eurostat and US Bureau of Economic Analysis.

The sharp reduction in this deficit between 2008 and 2009 appears to have a close connection with a sharp reduction in domestic demand due to the onset of the economic crisis, as the goods trade balance moves in tandem ([36]). However after 2008, the goods trade deficit widens again, while the current account deficit more or less stabilises on a level close to 3%.

At the same time the US energy trade deficit has been reduced by about 1%-point of GDP, this suggests that the increasing self-reliance in energy has helped the US to get the current account more in balance. From this perspective, the US energy sector has helped to address one of the more prominent global imbalances.

Interestingly, the EU-US goods balance has shown a persistent surplus for the EU without any clear sign of deterioration. Since the direct trade in goods constitutes one of the key indicators for assessing (changes in) competitiveness, one can tentatively conclude that the widening EU-US energy price gap has so far not visibly affected the EU industry's market performance vis-a-vis their US counterpart, at least on the EU and US markets. This can for some part be explained by a better overall energy intensity performance in the EU; the relatively large share of services in US exports which are less energy-intensive than goods; the success of EU industry to realise cost improvements through a heavier reliance on global supply chains ([37]); the "income effect" of cheaper energy on US consumers' demand and for parts of the EU industry the cost benefit of cheaper US intermediary goods.

2.6. CONCLUSIONS

The findings of this chapter point to the importance to carefully check the on-going trends and to put them into perspective. The surge in US shale gas since 2007/2008 has led to marked changes in US energy sector and energy trade balance, as gas has replaced coal as dominant energy source in domestic production and the US energy trade deficit in GDP terms has been reduced since the dip of 2008. This improved performance of domestic US energy production and subsequent price differential has occurred in absence of any opening up of export of US shale gas to the rest of the world. Any such opening might limit future price differentials with the EU.

However, the investigated energy and trade data do not reveal any major shift in the EU-US goods

([36]) The analysis focuses on overall trade balance changes and it does not explicitly adress the impacts which run through changes in the exchange rate. It is of note however that over the period of study the Euro has almost steadily appreciated vis-à-vis the US dollar.

([37]) These first three points are corroborated by the elaborate empirical analysis of WIOD data 1995-2009 in section 3.2 of the Commission's 2012 European Competitiveness Report which shows that, next to improving its energy efficiency, the EU export sector has maintained its competitiveness by exploiting the opportunities from globalisation to source their intermediate inputs more cheaply. Table 3.2 of that publication shows that the total energy inputs embodied in one unit of goods exports has more or less stayed constant for the EU15 (and has fallen dramatically for the EU 12) where it has on balance increased for the US. Moreover, the share of embodied foreign energy inputs per unit of goods export has increased much more significantly in the EU than in the US. For services exports, a similar picture emerges, but with a smaller share of energy embodied per unit services exports than is the case for goods exports and with a level for the US exceeding that for the EU15.

trade balance nor significant divergent trends in the overall production structure of manufacturing industry which can be directly ascribed to the shale gas revolution.

In contrast to the US, the EU economy and industry have ever more heavily relied on energy imports, including gas imports, but the data strongly suggest that the EU industry has so far also responded to the persistently higher energy prices through the realisation of significant improvements in the use of energy as reflected in a secular decline in its energy intensity. By contrast, the US industry's energy intensity seems to have risen with the surge in consumption of the cheap shale gas. This divergence in EU-US energy intensity trends has partially helped EU industry to offset the energy price differential with the US and hence might have acted as a buffer to the US shale gas surge. The EU has been somewhat restructuring away from energy intensive sectors while maintaining an overall share of manufacturing in value added above that of the US. Moreover, although not demonstrated by the data presented in this chapter, one may surmise that cheaper US intermediate goods and the (future) availability of cheap (US) shale gas on the EU gas markets ([38]) can act as further buffers to the shale gas shock ([39]). The price gap with the EU may also be reduced should the shale gas producers be mandated to fully internalize external costs, on the environment and human health, as it is not currently the case.

However, this should not imply complacency on the widening EU-US energy price gap. Firstly because the impacts may become visible only after some delay and they may have in fact been obscured by the divergence in timing of the economic crisis between EU and US. Finally and importantly, energy efficiency improvements may slow down in the EU and speed up in US due to diminishing low cost options; but that would seem to require increased policy effort. Similarly the magnitude of opportunities to increase the foreign part of the EU industry’s supply chain remains unclear.

Consequently, high energy prices for EU industries should remain a policy concern, even more so in case the EU-US energy price gap will continue to increase. For this reason, EU energy and carbon policies have to be cost efficient while maintaining their ambition. Hence, on-going efforts to improve the efficiency of energy markets in the EU should be vigorously pursued, namely to diversify the energy mix, including a shift to multiple gas suppliers, increase the effective competition on the global and EU energy markets, and by integrating the various national energy markets in the EU into regional or EU energy markets.

Finally, since steady energy intensity improvements have proven to be one of the best asset of the EU industry to maintain their competitiveness, the EU should maintain and perhaps intensify its policy to bolster the EU industry's energy efficiency efforts.

([38]) This implies as well that so far the effects of the US shale gas on the EU have run through US goods production and the export of other energy sources such as coal, since US shale gas has not (yet) been exported to other parts of the world in signficant amounts.

([39]) Another counter-argument further explored in box 1.2.1 is that US gas prices may be unsustainably low and will inevitably increase to match production costs or decline in supply.

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APPENDIX 1
Data and Methodology

Unit Energy Costs: description of the data

The sectoral data on quantities of energy used, energy costs and value added in constant prices are collected from the World Input Output Database (WIOD) ([40]). The advantage of using this source is that it provides a large, consistent dataset of globally comparable sector-level data for a relatively long period of time 1995-2011, while its drawbacks are that it does not include the developments of the most recent years and data for some countries and sectors for 2009-2011 are estimated. In addition data limitations do not enable to compute energy intensity and real energy prices for the years 2010 and 2011. Data from WIOD allows the calculation of Real Unit Energy Costs for 27 EU Member States plus 13 other countries. These indicators are computed for the manufacturing sector and its 14 subsectors on the basis of the Nace Rev.1. nomenclature. The 14 subsectors of manufacturing are the following: food, beverages and tobacco; textile and textile products; leather and footwear; wood and products of wood and cork; pulp, paper, printing and publishing; coke, refined petroleum and nuclear fuel; chemicals and chemical products; rubber and plastics; other non-metallic mineral; basic metals and fabricated metal; machinery; electrical and optical equipment; transport equipment; manufacturing NEC, recycling. This is the most detailed sectoral breakdown available in the database. It is worth noting that in certain cases these sectoral aggregates could hide substantial variability in terms of lower subsectors.

Data is taken from national Use Tables of WIOD in purchasers' prices, because these prices reflect the total cost of inputs payable by the sector, as opposed to basic prices, which exclude taxes and margins (both of which can be substantial for energy products). Data from WIOD was complemented with constant price value added are taken from Eurostat for EU countries, from the OECD for the US and Japan and from the World Development Indicators for China. This enables the calculation of Nominal Unit Energy Costs, energy intensities and real (deflated) energy prices for these countries and sectors.

The analysis focuses only on direct energy costs. These are defined as the costs incurred by companies to directly purchase energy inputs including feedstock. The energy inputs considered here are the sum of 4 products categories: i) coal and lignite; ii) peat crude petroleum and natural gas, services incidental to oil and gas extraction excluding surveying; iii) coke, refined petroleum products and nuclear fuels; iv) electrical energy, gas, steam and hot water. The indirect energy costs are not analysed in the present note. These are defined as the share of energy embedded into the other production inputs used by the various sectors (for instance the energy inputs contained in the chemicals used by textile industry). Although admittedly the indirect energy costs could be significant for certain sectors, data availability and methodological issues represent important trade-offs that limit the usefulness of incorporating indirect costs into the analysis.

The methodology of shift share analysis

The shift share analysis presented in the paper is based on the following decomposition of the growth of RUEC between period *0* and period *T*:

$$\frac{\Delta RUEC_T}{RUEC_0} = \underbrace{\frac{\sum_i \Delta RUEC_{i,T} * m_{i,0}}{RUEC_0}}_{\text{within subsector effect}} + \underbrace{\frac{\sum_i \Delta m_{i,T} * RUEC_{i,0}}{RUEC_0}}_{\text{restructuring effect}} + \underbrace{\frac{\sum_i \Delta m_{i,T} * \Delta RUEC_{i,T}}{RUEC_0}}_{\text{interaction effect}}$$

([40]) The WIOD project was funded by the European Commission as part of the 7th Framework Programme for Research.

Where $\Delta RUEC_T = RUEC_T - RUEC_0$, *i* denotes a given subsector of total manufacturing, *mi,T* denotes the share of sector *i* in the value added of total manufacturing in period *T*, and $\Delta m_{i,T} = m_{i,T} - m_{i,0}$.

APPENDIX 2

Real unit energy cost in the world

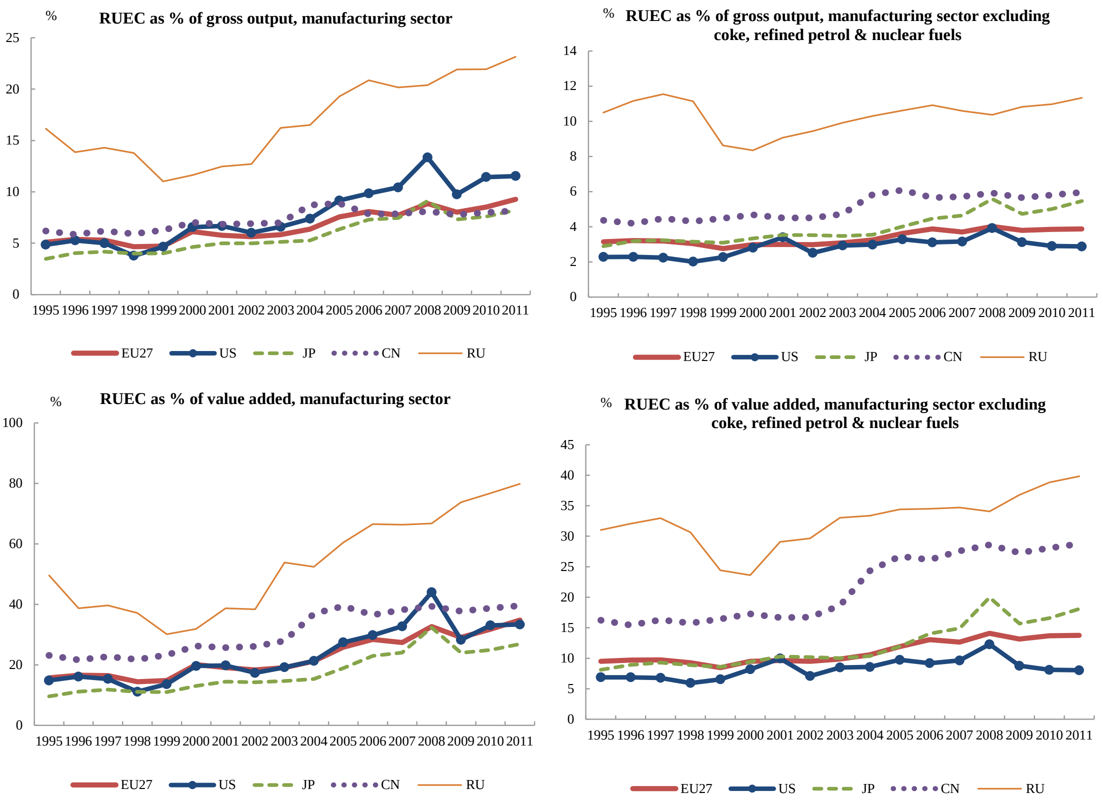
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
EU27																	
RUEC as % of Value Added	15.7	16.6	16.4	14.4	14.8	20.1	19.1	18.3	19.1	21.2	25.8	28.4	27.4	32.6	29.1	31.8	34.8
RUEC as % of Gross Output	5.1	5.4	5.3	4.7	4.7	6.1	5.8	5.6	5.8	6.4	7.6	8.1	7.7	8.9	8.0	8.5	9.3
Australia																	
RUEC as % of Value Added	18.6	19.2	17.4	16.5	20.7	23.9	22.2	21.2	19.1	24.2	25.1	25.3	26.1	24.9	27.2	27.7	27.9
RUEC as % of Gross Output	6.0	6.2	5.9	5.4	6.6	7.3	6.6	6.5	6.1	7.2	7.4	7.4	7.7	7.3	8.0	8.1	8.2
Brazil																	
RUEC as % of Value Added	30.7	33.7	34.2	35.7	39.9	44.2	46.5	48.0	49.2	49.4	54.4	57.5	53.7	56.9	42.7	43.3	44.7
RUEC as % of Gross Output	9.4	9.8	10.1	10.4	11.4	12.1	12.6	12.9	12.8	13.0	13.8	14.6	13.5	13.6	11.7	11.9	12.3
Canada																	
RUEC as % of Value Added	10.4	10.9	10.4	9.4	8.7	10.9	11.8	11.2	13.0	12.6	15.3	15.4	15.1	15.0	14.7	13.2	13.1
RUEC as % of Gross Output	3.4	3.5	3.3	3.1	2.9	3.4	3.7	3.5	4.0	3.9	4.6	4.5	4.4	4.4	4.3	3.9	3.8
India																	
RUEC as % of Value Added	55.0	52.1	56.3	54.6	60.8	72.6	75.6	80.3	79.8	77.4	75.3	76.4	76.4	76.6	75.0	75.5	76.1
RUEC as % of Gross Output	12.2	11.9	12.2	11.9	13.5	15.9	16.3	17.0	16.7	16.2	16.1	16.1	16.1	16.0	15.5	15.6	15.7
Indonesia																	
RUEC as % of Value Added	7.6	10.1	8.3	18.8	20.2	25.7	23.1	22.5	22.8	23.4	26.6	27.0	27.1	25.0	23.4	22.6	22.3
RUEC as % of Gross Output	2.7	3.6	3.0	6.7	7.2	9.2	8.3	8.2	8.4	8.7	10.1	10.2	10.2	9.4	8.7	8.4	8.2
Korea (South)																	
RUEC as % of Value Added	23.7	27.9	34.0	38.5	35.7	40.1	40.6	34.6	35.7	38.3	43.9	49.3	49.5	69.5	58.3	60.6	63.4
RUEC as % of Gross Output	6.1	7.0	8.5	9.4	8.7	9.8	9.8	8.5	8.6	9.1	10.0	10.9	10.8	13.6	11.6	12.2	12.8
Mexico																	
RUEC as % of Value Added	30.1	24.5	25.1	24.3	23.7	23.6	25.1	25.1	24.6	27.2	29.3	31.2	31.5	38.5	33.1	31.3	32.9
RUEC as % of Gross Output	9.1	7.7	8.1	7.9	7.8	7.6	8.3	8.3	8.0	8.8	9.1	9.8	9.9	11.8	10.2	9.7	10.3
Turkey																	
RUEC as % of Value Added	20.7	19.3	18.4	17.1	28.6	36.3	36.4	26.5	26.2	26.1	26.9	28.4	28.0	23.5	24.2	23.8	23.6
RUEC as % of Gross Output	8.2	8.0	7.2	6.5	9.3	10.6	9.9	6.9	6.8	6.8	7.0	7.4	7.3	6.1	6.3	6.2	6.1
Taiwan																	
RUEC as % of Value Added	22.5	21.4	21.6	20.6	21.5	26.2	28.3	29.4	34.6	42.2	50.9	59.7	61.3	85.0	61.8	62.0	65.0
RUEC as % of Gross Output	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9

Source: Commission Services based on WIOD database

APPENDIX 3

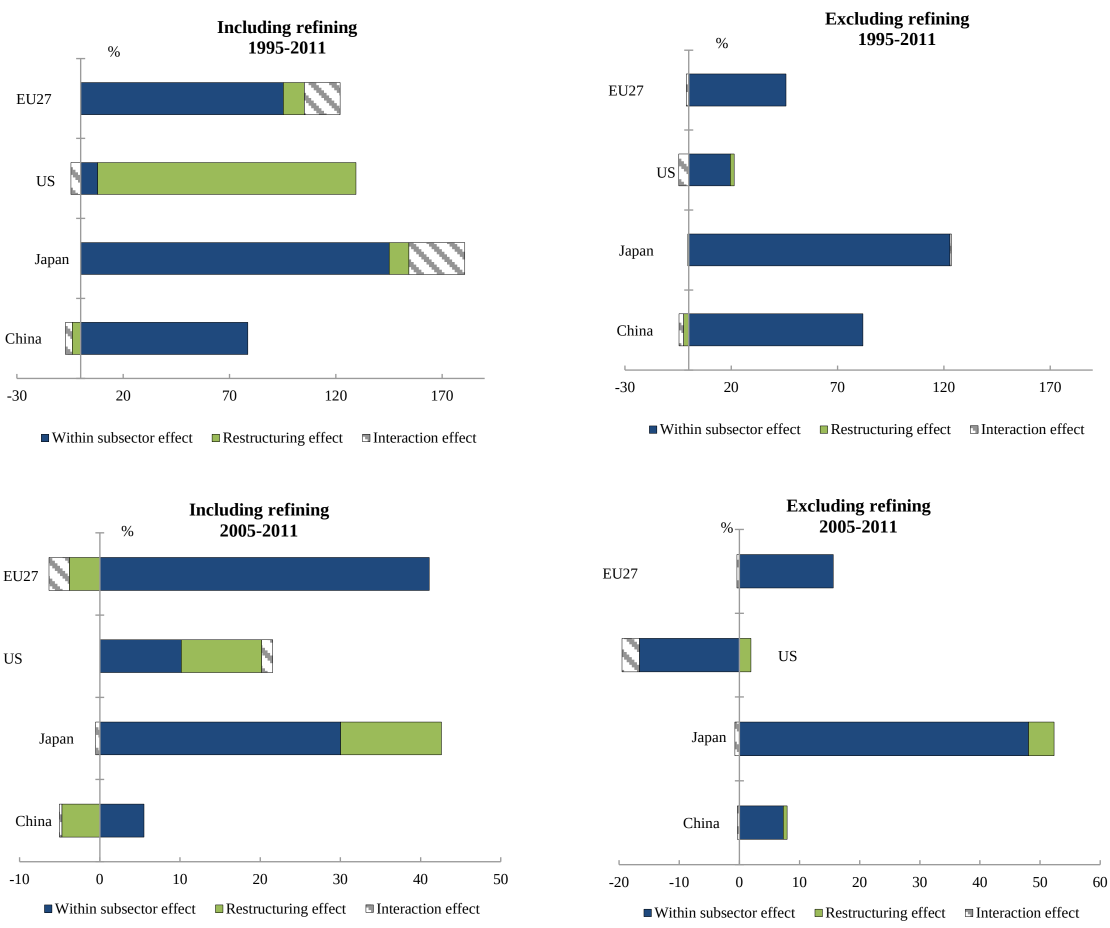
Real Unit Energy Costs & Shift-share excluding refining sector

Graph I.A3.1: **Real Unit Costs manufacturing sector including vs. excluding coke, refined petrol & nuclear fuels**



Source: Commission Services based on WIOD, ESTAT, OECD & World Development Indicators.

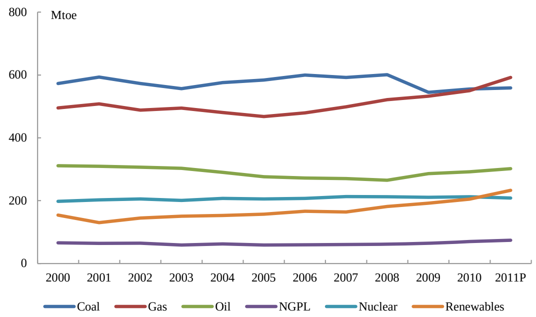
Graph I.A3.2: **Shift-share analysis for the manufacturing sector including vs. excluding coke, refined petrol & nuclear fuels**



Source: Commission Services based on WIOD, ESTAT, OECD & World Development Indicators.

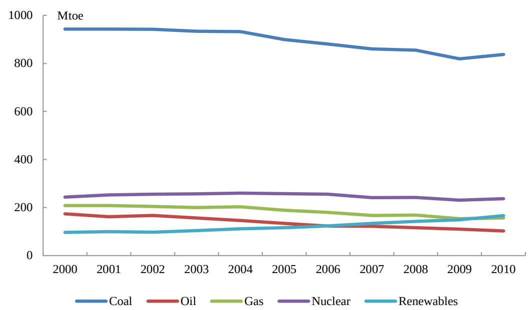
APPENDIX 4
Additional energy data on EU and US

Graph I.A4.1: **US Energy domestic production by source, 2000-2011**



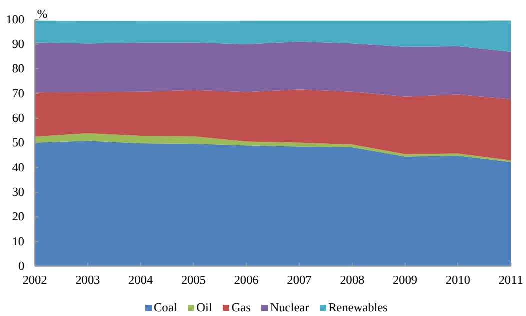
Source: US Energy Information Administration, conversion from BnBtu to Mtoe (1 BnBtu= 2,51996E-05 Mtoe)

Graph I.A4.2: **EU-27 Energy domestic production by source, 2000-2011**



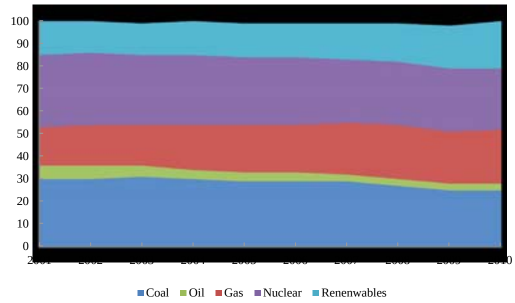
Source: DG ENERGY factsheet

Graph I.A4.3: **Electricity mix US, 2002-2011**



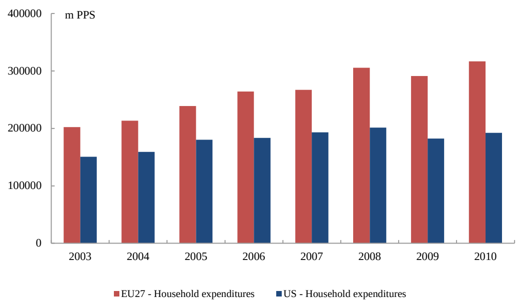
Note: Due to statistics collection differences, the US measures its electricity mix in terms of net electricity generation while the EU uses the gross electricity generation.
2011 provisional data
Source: Commission Services based on Eurostat data and Energy Information Administration of the US.

Graph I.A4.4: **Electricity mix EU-27, 2001-2010**



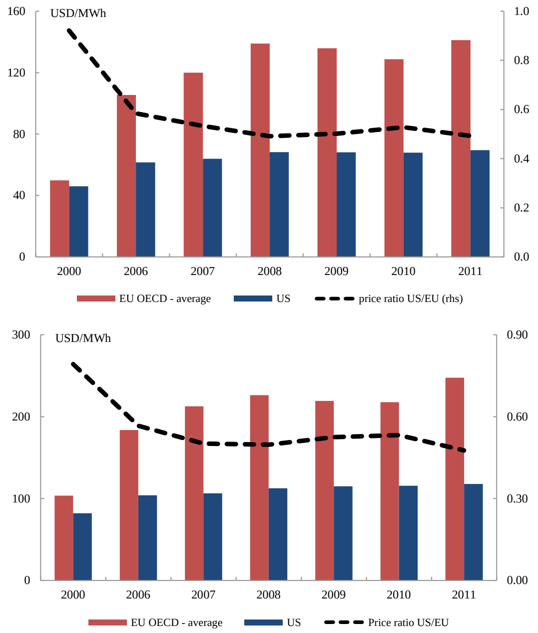
Due to statistics collection differences, the US measures its electricity mix in terms of net electricity generation while the EU uses the gross electricity generation.
Source: Commission Services based on Eurostat data and Energy Information Administration of the US.

Graph I.A4.5: **Household expenditures for energy products, 2003-2010 - EU-27 and US**



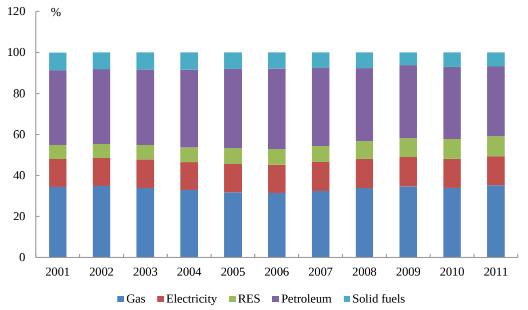
Note: Convention factor - OECD Dataset: 4. PPPs and exchange rates.
Source: Commission Services based on Eurostat and US Energy Information Administration.

Graph I.A4.6: **Electricity prices for industrial consumers and households for the European countries in the OECD and for the US**



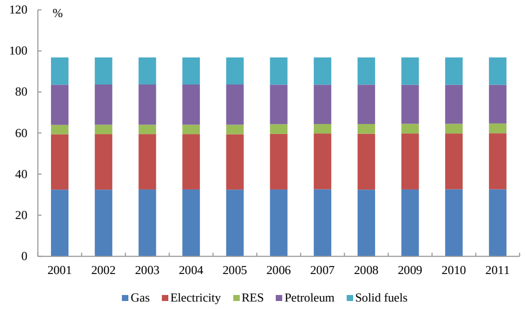
Source: Commission Services based on OECD Electricity Information (2012).

Graph I.A4.7: **Energy consumption of industry breakdown by sources - US**



Source: Commission Services based on US Energy Information Administration

Graph I.A4.8: **Energy consumption of industry breakdown by sources, EU**



Note: In order for the data to be comparable with the US, Industry includes also agriculture and fishing.
Source: Commission Services based on Eurostat database.

Part II

Energy and carbon prices: assessing the impact of energy and climate policies

OVERVIEW

Part I has shown that, despite the good performance of EU industries in terms of energy intensity, high energy prices should remain a policy concern, even more so in case the EU-US energy price gap will continue to increase. This is why it is important to investigate how energy prices have been affected by policy developments. This part analyses three important components of energy costs – electricity and natural gas retail prices, and carbon prices.

Electricity and natural gas are a substantial part of energy costs; hence they have a significant impact on the welfare of European citizens and on the competitiveness of industries. Over recent years, EU electricity and gas markets have been fundamentally reshaped by the significant energy and climate policy initiatives in the areas of market opening, renewables penetration, climate change mitigation, and security of supply. Chapter 1 explores the impact of these reforms on end-user electricity and gas prices for households and industries, while controlling for other factors such as fossil fuels.

The carbon price represents a cost component of electricity prices and is expected to play a crucial role in the transition to low carbon economies. However, it fails to provide a strong price signal for consumption behaviour and for investments in clean production technologies. The empirical estimate carried out in chapter 2 analyses the main drivers of carbon prices, assessing the role of economic and energy factors.

1. THE IMPACT OF ENERGY POLICIES ON ELECTRICITY AND NATURAL GAS PRICES: AN EMPIRICAL ASSESSMENT

1.1. INTRODUCTION

The last two decades have seen a number of significant changes in EU energy policy, designed to tackle the fundamental challenge of sustaining economic competitiveness amidst rising global competition for scarce natural resources and the risks associated with climate change ([41]). Several major EU policy initiatives in the areas of market opening and integration, renewables policy and climate change mitigation have contributed to reshaping energy markets.

Since 1996, the EU has engaged in a process of market opening in network industries, including in the energy markets. In 2009, the process made a huge leap forward with the adoption of the Third Energy Package, which aims to create a single electricity and gas market. In parallel, the Climate and Energy package adopted in 2009 has introduced a policy framework to reach the three "20" targets: achieving a 20% reduction in EU-wide greenhouse gas emissions, a 20 % share of energy from renewable sources in overall EU energy consumption and a 20% decrease in primary energy use by 2020 compared to a pre-defined baseline.

While these measures may be aimed primarily at fulfilling the competitiveness, security of supply, and sustainability objectives of EU energy policy, what ultimately matters for consumers is the retail price they will have to pay for their gas and electricity. These consumers are not only limited to households; they are also industries including SMEs. Thus any increase in retail prices has an impact both on welfare of households and on the competitiveness of the European economy ([42]). In particular, between 2004 and 2011, retail electricity and gas prices have increased considerably by 65% and 42% respectively compared to 18% for inflation ([43]) over the same period.

The objective of this chapter is to assess the impact of market opening reforms, and energy and climate policies, on retail gas and electricity prices in the EU 27 over the period 2004 – 2011. Section 2 presents price evolution over the two past decades. Section 3 describes the key policy drivers of energy prices in the EU. Then data and methodology are discussed, and results from the empirical analysis are presented. Lastly, the main conclusions and policy implications based on these results are outlined.

1.2. ENERGY PRICE DEVELOPMENTS IN THE EU

1.2.1. Electricity Market

Retail prices in the electricity sector have risen much more than wholesale prices over the period 2004-2011 (Graph II.1.1)**.** In the electricity market, both industrial and household end-user prices ([44]) have followed an increasing trend since 2004, rising by more than 50% on average across Member States, compared to a 23% increase in average wholesale prices over the same period. The latter has shown greater fluctuation compared to retail prices, which have been rising continuously. Between 2008 and 2009, the average wholesale price fell by over a third, reflecting the negative demand shock following the economic and financial crisis and the increasing penetration of renewable technologies.

The largest percentage increase among the components of end-user electricity prices was observed in taxes and levies (Graph II.1.2). This fact may partly explain the observation that retail prices in both consumer segments have risen more than wholesale prices. Over the period 2008-2011, average electricity taxes and levies in the EU have risen by 43% and 67% in households and industrial customers respectively ([45]), whereas the equivalent changes in average energy and supply costs were

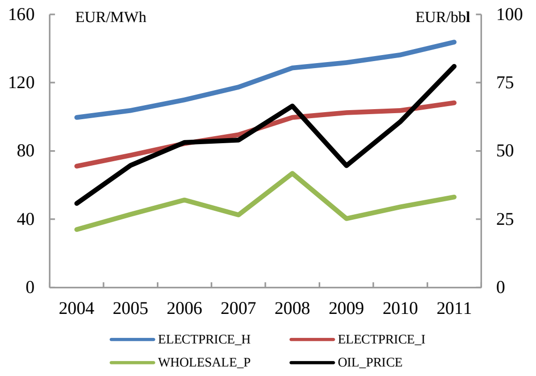
([41]) Delgado et al. (2007); European Commission (2007).
([42]) Although industries in certain Member States are exempted from charges that increase the retail prices or have long-term fixed contracts.
([43]) HICP, Eurostat.

([44]) The electricity prices of the consumption bands DC for Households (2500 kWh < Consumption < 5000 kWh) and IC for Industry (500 MWh < Consumption < 2000 MWh) were selected and are considered as a representative household and industrial customer, respectively.
([45]) These upward dynamics were, however, largely driven by a few countries: Latvia and Estonia in the household segment and Finland and Estonia in the industrial segment.

3% and -2% and in network cost 17% and 21% ([46]).

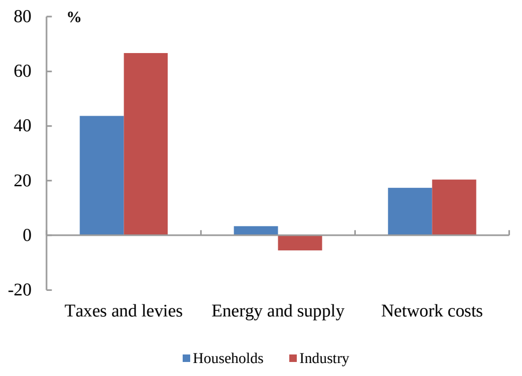
Retail electricity prices have also roughly followed the trend of international oil prices over the first half of the sample period, but the co-movement has diminished since 2008. This pattern observed post-2008 may be due to the presence of price regulation which may have become more responsive to oil price movements from 2008 onwards, in order to smooth electricity price developments in the face of increased crude oil price volatility ([47]). This is in contrast to wholesale electricity prices where, as expected, the co-movement with international oil prices is much closer and more evident over the period.

Graph II.1.1: **EU-27 Average domestic and industrial retail electricity price, wholesale price and crude oil price evolution 2004-2011**



(1) The Consumption bands used were DC for Households (2500 kWh < Consumption < 5000 kWh) and IC for Industry (500 MWh < Consumption < 2000 MWh), wholesale prices are average spot prices from different European power exchanges and pools.
Source: Eurostat.

Graph II.1.2: **EU average change per electricity tariff component between 2008 and 2011**



(1) The Consumption bands used were DC for Households (2500 kWh < Consumption < 5000 kWh) and IC for Industry (500 MWh < Consumption < 2000 MWh), wholesale prices are average spot prices from different European exchanges and pools.
Source: Eurostat.

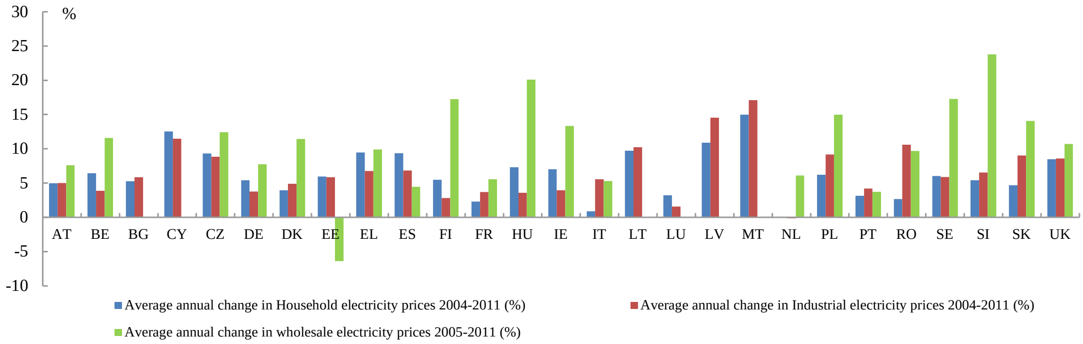
These aggregate figures mask large differences in the experiences of individual Member States. **The evolution of wholesale and end-user prices over the sample period have been highly heterogeneous across Member States.** In Poland, the country experiencing the largest wholesale price increase in percentage terms in 2011 compared to 2005, the wholesale market weathered a price hike of around 82%. In the Netherlands, the United Kingdom and Spain however, wholesale prices fell over the same period, with Spain experiencing a decrease of approximately 7%. On an annual basis, the average rate of change in wholesale prices has ranged from 24% in Slovenia to -6% in Estonia (Graph II.1.3). These differences in wholesale price dynamics may be explained by the vast heterogeneity in the maturity of wholesale markets across the EU, the fuel production mix that affects the degree of sensitivity of domestic electricity markets to external energy shocks, as well as the degree of interconnection with neighbouring countries.

Retail price evolution has been equally varied. Malta, Cyprus and Latvia had the largest increases in end-user prices in both household and the industrial sector with prices more than doubling on average, while the Netherlands was the only Member State to experience a fall in prices in both markets over the same period. These rankings were mirrored to some extent in the relative

([46]) Eurostat data on end user price components are only available for the years 2007-2011. Data from 2007 was not considered due to a large number of missing data points. In the Household category, data from 22 countries were used to calculate the average changes in the price components. In the Industrial category, due to a greater degree of missing data, only 20 countries were included in the calculated average changes. Arithmetic average is used; it follows the same evolution as the weighted average changes.

([47]) There may also be other reasons, for example lower demand than expected and overcapacity as a result of the crisis.

Graph II.1.3: **Retail and wholesale electricity average price changes by Member State 2004-2011**



Note:The Consumption bands used were DC for Households (2500 kWh < Consumption < 5000 kWh) and IC for Industry (500 MWh < Consumption < 2000 MWh)
Source: Eurostat.

performance of these countries in the various components of the end-user electricity price between 2008 and 2011. Latvia had the largest percentage hike in taxes and levies, and relatively large increases in energy and supply and network costs, in the households' segment ([48]). Similarly, Malta had the third highest percentage hike in energy and supply costs in the industrial segment. At the other end, Netherlands had one of the largest percentage decreases in taxes and levies and energy and supply costs in the industrial sector, and relatively low changes in the household price components. The average annual rate of change in industrial end user prices over 2004-2011 has ranged from 17% in Malta to -0.15% in the Netherlands. The equivalent figures for household consumers were 15% and -0.03%, again in Malta and the Netherlands respectively ([49]).

Given these diverging paces and trajectories, there has been significant heterogeneity in end-user price levels across Member States over the sample period ([50]). Certain countries, such as Italy and Germany, have had relatively high average retail prices in both their household and industrial segments over the years 2004 and 2011. Similarly, others such as Estonia and Bulgaria have had the lowest retail prices across the EU 27 in both markets.

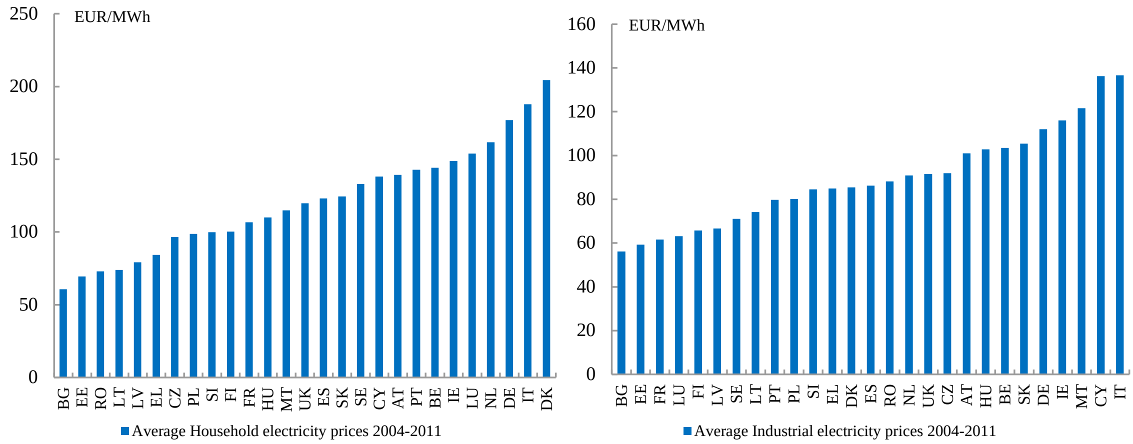
Moreover, household end-user prices have been much more varied than industrial prices. For example, in households the average end-user price in the five countries with the highest retail prices over the sample period was almost 150% above the average end-user price in the bottom five countries, whereas the equivalent figure was around 100% in the industrial segment. An important observation here is that taxes and levies constitute a much larger share in household end-user prices than in industries', whereas energy and supply costs are the dominant drivers of industrial end-user prices. More precisely, the respective EU average shares of energy and supply costs and taxes and levies in end-user prices over the period 2007-2011 were 44% and 22% in the households, whereas the equivalent figures in the industrial sector were 66% and 6%. The Commission's recent Communication on the internal energy market lends support to the claim that a large portion of variation in retail prices between Member States are driven by taxes and levies, as these elements, along with network costs, "*fall*

([48]) While data was unavailable to calculate the equivalent change in taxes and levies in the industrial sector in Latvia, this country also had the highest percentage increase in energy and supply costs and the second highest increase in network costs in this market.

([49]) Note that prices are illustrated in nominal terms. While only the Netherlands experienced an overall fall in electricity prices in its industrial and household segments in nominal terms, once we control for inflation, Bulgaria, Hungary, Italy, Luxembourg, Romania and the Netherlands reveal a net fall in real electricity prices over the sample period (Hungary and Luxembourg in the Industrial market, Italy in the Household market, and Bulgaria and the Netherlands in both markets).

([50]) This may be due to cross-country differences in taxation, since end-user prices including all taxes except VAT have been used. It may also reflect differing degrees of price regulation.

Graph II.1.4: **Retail electricity prices - Households and Industry**



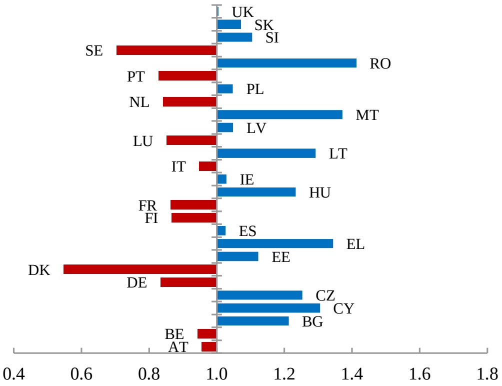
Note: The Consumption bands used were DC for Households (2500 kWh < Consumption < 5000 kWh) and IC for Industry (500 MWh < Consumption < 2000 MWh)
Source: Eurostat.

within the remit of the national legislations in each Member State" ([51]).

All countries had household retail prices that were higher on average than industrial prices, with the exceptions of Greece, Malta and Romania. However, the absolute size of the price difference was highly dispersed across Member States. While in countries like Romania the price for households was around 90% of the industrial price, the respective ratio was 240% in Denmark. Graph II.1.5 illustrates individual Member States' average industrial-household retail price ratios relative to the EU average. It gives a good indication of those countries where the relative industrial price was much higher than the EU average, and those countries where it was significantly lower. These outliers may be explained by active state intervention to pursue different objectives in industrial and social policy. For example, some Member States may allocate the cost of renewables support unevenly across different consumer groups. Denmark and Sweden stand out as countries where the industrial price relative to households' was much lower on average than for the EU-27 as a whole, at 54% and 70% of the EU average respectively. This suggests that industries in these countries might enjoy a relatively more favourable environment and lower costs than on average. Perhaps expectedly, Denmark and Sweden also had some of the highest shares of taxes and levies and the lowest shares of energy and supply costs in household end-user prices across Member States, while Sweden also had one of the lowest shares of taxes and levies in industrial end-user prices between the years 2007 and 2011. Romania, Malta and Greece, on the other hand, had a higher relative industrial price compared to the EU average, with the average at around 137 % of the EU 27.

([51]) European Commission (2012b)

Graph II.1.5: **Average ratio of Industrial to Household electricity prices, relative to the EU-27 average, 2004-2011**

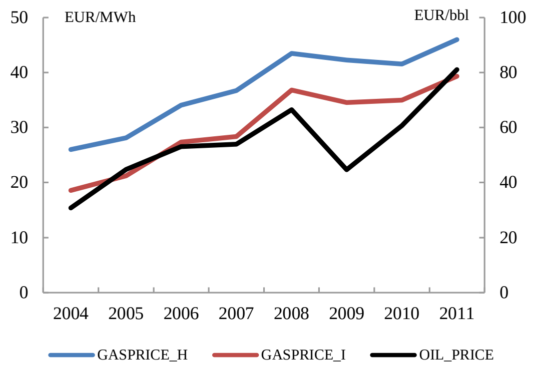


Note: The Consumption bands used were DC for Households (2500 kWh < Consumption < 5000 kWh) and IC for Industry (500 MWh < Consumption < 2000 MWh).
The measure is calculated as the sample period average ratio of industrial to household retail electricity prices, for a given Member State, divided by the EU-27 average ratio of industrial to household prices over the same period. Given that a "normal" level of relative industrial prices, in the absence of any cross subsidisation, is difficult to identify, it may be assumed that the EU average is an imperfect proxy of a "normal" price ratio and the best available benchmark to determine the likely direction and extent of cross subsidisation in individual Member States. When the ratio is above one, relative industrial prices are above the EU average, which may be taken as an indicator of cross-subsidisation from industries to households.
Source: Commission Services based on Eurostat database.

1.2.2. Natural Gas Market

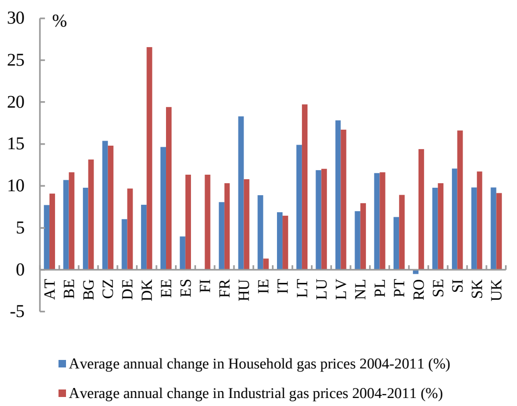
Both industrial and household natural gas prices have been rising over the sample period, aside from a decreasing trend between 2008 and 2009 (Graph II.1.6). In percentage terms, natural gas ([52]) prices have risen more than electricity prices over the sample period, and have been more volatile. Average household gas prices have increased by 77% between 2004 and 2011 (against 50% for electricity), whereas average industrial prices have more than doubled (against a 53% increase in industrial electricity prices). The diverging paces of retail price growth in the two consumer segments is reflected in the average industrial-household price ratio, which has risen by 14% over the period, highlighting the relatively faster growth in industrial prices. More precisely, industrial gas prices rose at an average annual rate of 11 %, compared to a 9 % average annual change in household prices.

Graph II.1.6: **EU-27 average domestic and industrial retail natural gas price and crude oil price evolution 2004-2011**



Note: The Consumption bands used were D2 for Households (20 GJ < Consumption < 200 GJ) and I3 for Industry (10 000 GJ < Consumption < 100 000 GJ
Source: Eurostat.

Graph II.1.7: **Retail natural gas price evolution by Member State 2004-2011**

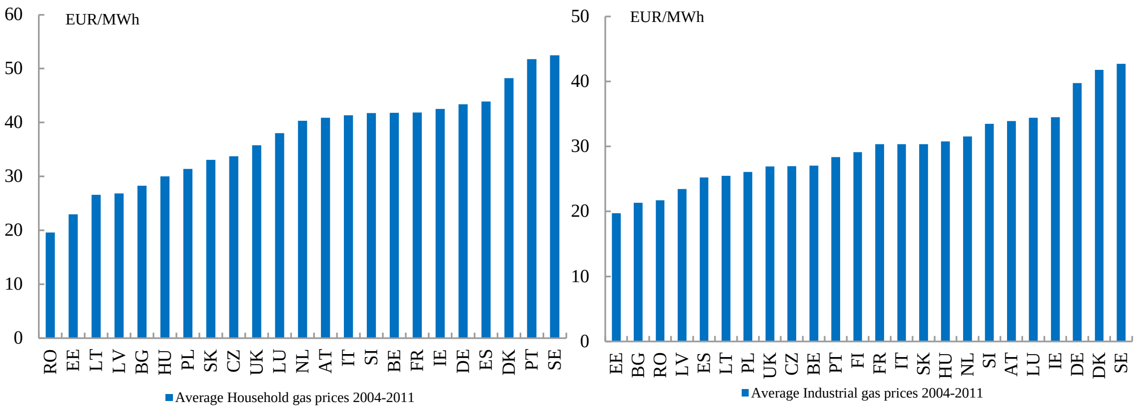


Note: The Consumption bands used were D2 for Households (20 GJ < Consumption < 200 GJ) and I3 for Industry (10 000 GJ < Consumption < 100 000 GJ)
Source: Eurostat.

Retail natural gas prices also loosely followed the trend of the Brent crude oil price between 2004 and 2011 (Graph II.1.6). This co-movement was much stronger than in the case of electricity prices, explained by the still large share of EU natural gas trade that is conducted via oil-indexed bilateral contracts.

([52]) As in footnote 4, the natural gas prices of the consumption bands D2 for Households (20 GJ < Consumption < 200 GJ) and I3 for Industry (10 000 GJ < Consumption < 100 000 GJ) were selected as they are considered as a representative household and industrial customer, respectively.

Graph II.1.8: **Retail natural gas prices - Households and Industry**



Note: The Consumption bands used were D2 for Households (20 GJ < Consumption < 200 GJ) and I3 for Industry (10 000 GJ < Consumption < 100 000 GJ)
Source: Eurostat.

As with electricity prices, however, cross country variations in the evolution of end-user natural gas prices are evident. In households Hungary experienced the highest overall percentage increase in natural gas prices over the sample period, with a hike of around 90%, whereas Romania was the only Member State to experience a fall in prices over the same period (by 17%). In the industrial sector, the changes were more profound. Although all countries experienced a rise in industrial prices over the sample period, the range of these increases in percentage terms stretched from 126% in Denmark to 32% in Austria.

Moreover, not all countries displayed similar price performances relative to other Member States across the two consumer markets. Hungary, Denmark and Romania were particularly distinct in this respect. While Denmark ranked at the top of the sample in terms of industrial gas price increases, it had a relatively small price increase in the household sector. The reverse was true for Hungary, which had the highest period price rise in the household sector, but ranked below the average in the industrial sector. Romania, which showed the only decrease in household prices over the period, experienced a simultaneous above average increase in industrial gas prices ([53]). Graph II.1.8 illustrates the annual average change in household and industrial natural gas prices by Member State. Denmark and Hungary, as expected, also had the largest annual price increases in the two sectors.

There has also been notable heterogeneity in the levels of end-users prices across Member States over the sample period, with a slightly higher range of prices for the household sector compared to industries ([54]). In the industrial segment, the average end-user price in the five countries with the highest prices for 2004 was more than double the average among the five countries with the lowest prices for the same year.

This gap shrunk marginally by 2011, where the former figure was around 86% higher than the latter. For households, the highest-priced five countries had end user prices that were on average 130% higher than the lowest-priced group in 2004, with the equivalent figure falling to around an 84% premium in 2011.

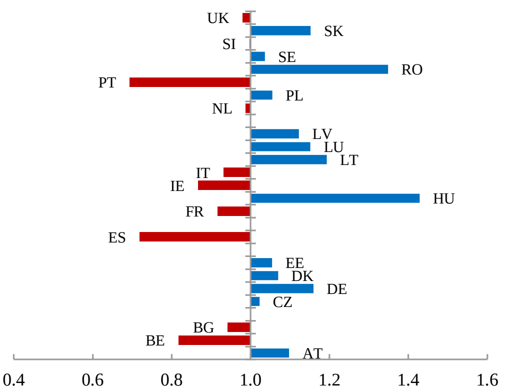
The relative prices of households and industries reveal significant outliers in certain Member States, implying the presence of some level of state intervention to satisfy different distributional preferences in industrial and social policy. Graph

([53]) As with electricity, natural gas prices are taken in nominal terms. Unlike the case with electricity, however, there is no substantial change in natural gas price evolution in Member States over the sample period when prices are taken in real terms.

([54]) European Commission (2012b)

II.1.9 illustrates individual Member States' sample period-average industrial-household retail price ratios, benchmarked against the EU average ratio. This highlights those countries where the relative industrial price was much higher than the EU average, and those countries where it was significantly lower. Portugal and Spain stand out as countries where the industrial price relative to households' was much lower on average than for the EU-27 as a whole, at 69% and 72% of the EU average respectively. Conversely, Romania and Hungary, had a higher relative industrial price compared to the EU average, exceeding the average EU 27 level by almost 39 %.

Graph II.1.9: **Average ratio of Industrial to Household natural gas prices, relative to the EU-27 average, 2004-2011**



The Consumption bands used were D2 for Households (20 GJ < Consumption < 200 GJ) and I3 for Industry (10 000 GJ < Consumption < 100 000 GJ)
The measure is calculated as the sample period average ratio of industrial to household retail natural gas prices, for a given Member State, divided by the EU 27 average ratio of industrial to household prices over the same period. Given that a "normal" level of relative industrial prices, in the absence of any cross subsidisation, is difficult to identify, it may be assumed that the EU average is an imperfect proxy of a 'normal' price ratio and the best available benchmark to determine the likely direction and extent of cross subsidisation in individual Member States. When the ratio is above one, relative industrial prices are above the EU average, which may be taken as an indicator of cross-subsidisation from industries to households.
Source: Commission Services based on Eurostat database.

In summary, end-user electricity and natural gas prices have risen substantially in the majority of Member States over the period 2004-2011. While electricity prices have evolved similarly for both households and industries, natural gas prices have increased much more for industries. Despite these common trends, a number of notable heterogeneities exist between individual Member States, which may be explained by the national energy mix, fragmented national policies including taxation, and other forms of state intervention which is illustrated by the variation in relative levels and relative evolutions of household and industrial prices across Member States.

1.3. THE POLICY DETERMINANTS OF ENERGY PRICES AT EU LEVEL

The period 2004-2011 has revealed some interesting trends in the evolution of end-user energy prices in the EU, which took place in a changing EU climate and energy policy landscape.

Since the 1990s, significant energy market reforms and policy initiatives have been introduced in the EU. On the one hand, the EU has launched a process of domestic and cross-border market opening of electricity and gas markets. On the other hand, the Energy and Climate change package adopted in 2009 significantly reoriented the energy production and consumption towards low carbon energy sources. This section aims to assess their potential impacts on recent end user price developments in the EU on the basis of economic rationale ([55]).

1.3.1. Market Opening in Electricity and Gas

The Commission's Third Energy Package of 2009 introduced a set of Directives and Regulations to further consolidate and open up the Internal Energy Market. While broadly adopted, these reforms have been implemented to varying degrees across Member States. The Commission's Communication on the Internal Energy Market in 2011 expressed concern about delayed implementation and the tendency toward "inward-looking or nationally inspired policies" in some Member States ([56]). These factors are hindering the achievement of full market-opening and effective competition. In 2011, more than 80% of power generation in eight Member States was still controlled by the historic incumbent, while in the natural gas market, the market share of the largest retailer was more than 50% in thirteen Member States and over 80% in eight of these cases. The

([55]) See Box II.1.2 for a brief summary of the literature review.
([56]) European Commission (2012b)

Commission is currently undertaking a number of actions to tackle the non-transposition of the Package's reforms, including infringement procedures against Member States for incomplete or improper implementation ([57]), in view of its target of completing the internal energy market by 2014.

Market functioning is one of the key determinants of prices in the energy markets, and the main objective of market opening is to ensure cost reflective energy prices and, where possible, to minimise the cost of energy supply. The natural gas and electricity markets, as with network industries in general, entail a unique combination of competitive activity, namely in generation and supply, and natural monopoly features in transmission and distribution. This has resulted in varying drivers of price formation along the supply chain - the competitive market vs. regulation – which are all combined in the final end-user price.

To identify the precise segment of price formation where market opening and competition are expected to have their largest impact, it is useful to start by distinguishing between the different components of end-user energy prices: energy and supply costs, network costs, and taxes and levies. The energy and supply component is determined by production, importation or generation costs, as well as market power and supply and demand dynamics in the wholesale and retail markets. Network costs entail the tariffs paid by suppliers to network operators for the use of transmission and distribution infrastructure. In a properly regulated system, these costs can be expected to take account of long term infrastructure maintenance and supply costs to give operators an incentive to make necessary long term investments. Finally, taxes and levies entail any state intervention to pursue a certain distribution of energy and supply costs, or to incentivise certain kinds of market (investment) behaviour.

This process of market opening in the wholesale and retail markets should gradually lessen the influence of market power in driving the energy and supply component of energy prices. That segment of end-user price formation has become increasingly driven by competitive pricing, generation cost fundamentals, market liquidity and supply and demand dynamics. Moreover, the independent regulation of TSOs and DSOs that form a key part of the competitive model broadly adopted should help ensure that network costs provide sufficient incentives for long term infrastructure investment, whilst ensuring non-discriminatory access to the networks.

The main direct benefits to be expected from reforms promoting competition include:

- Lower wholesale prices from higher competition among domestic generators, resulting from reforms such as the unbundling of TSOs and third party access to transmission networks: competition puts downward pressure on the profit margins of these players and provides an incentive to reduce costs.

- Lower end user prices from greater competition among retailers, through retail market opening legislation and the unbundling of DSOs from supply activities: competition puts downward pressure on retail price mark-ups above the wholesale price, as retailers compete for consumers that are eligible and enabled to choose their own suppliers.

- Price convergence from increased electricity trade: reform facilitating cross-border trade in electricity and gas increase price competition from external generators and suppliers, providing a further incentive for inefficient incumbent domestic players to cut costs and lower prices.

- More cost-effective achievement of the other two objectives of EU energy policy, security of supply and sustainability: security of supply will be supported by more diversified energy sources, and any generation cost savings from RES-E deployment will only be passed onto consumers in a competitive wholesale and retail environment.

([57]) European Commission (2012b)

Box II.1.1: Third Energy Package

The third package includes: (i) Directive 2009/72/EC, aimed at introducing common rules for the generation, transmission, distribution and supply of electricity; (ii) Directive 2009/73/EC, aimed at introducing common rules for the transmission, distribution, supply and storage of natural gas; (iii) Regulation 714/2009 laying down rules for cross-border exchanges in electricity; and (iv) Regulation 715/2009, laying down rules for natural gas transmission networks, gas storage and LNG facilities. The latter also concerns access to infrastructures, particularly by determining the establishment of tariffs (solely for access to networks), services to be offered, allocation of capacity, transparency and balancing of the network.

The basic elements of the third package include:

- A high standard of public service obligations and customer protection (e.g. provisions enabling customers to switch suppliers within three weeks; obligations on suppliers to provide information to consumers; obligation on suppliers to foresee efficient complaint handling procedures; and specific protection of vulnerable customers ([1]).

- Structural separation between transmission activities and production/supply activities of vertically integrated companies ("unbundling"). Non-discriminatory access to networks is an essential condition to allow fair competition between suppliers and to stimulate investment in infrastructure, also when new interconnectors may negatively impact on the market share of the vertically related supplier. The Directives grant Member States a choice between 3 possible models: Ownership unbundling (OU), Independent System Operator (ISO) and Independent Transmission System Operator (ITO).

- Stronger powers and independence of national energy regulators. National energy regulators must be legally distinct and functionally independent from any private or public entity (i.e. not part of a ministry). They must have a separate annual budget and adequate human and financial resources. National energy regulators must have the power e.g. to fix or approve the transmission and distribution tariffs or their methodology as well as to enforce the consumer protection provisions, to issue binding decisions on electricity undertakings and to impose effective, proportionate and dissuasive penalties.

- To close the current regulatory gap for cross-border transaction in gas and electricity, a European agency for the co-operation of Energy Regulators (ACER) has been created. It shall issue opinions on all questions related to the field of energy regulators. The agency will have decision-making power to review decisions made by national regulators and ensure there is enough co-operation between network operators.

- Co-operation between national TSOs for gas and electricity, which took place only on a voluntary basis, has been formalised through the establishment of the European Network of Transmission System Operator organisations (ENTSOs), which will have to develop harmonised standards for how companies access the pipelines and grids, ensure co-ordination, especially in the case of electricity, to allow synchronous network operation and avoid possible blackouts, and co-ordinate and plan network investments notably through the adoption of ten-year network development plans (TYNDP).

In its Communication on the internal energy market adopted on 15 November 2012, the Commission urges Member States to step up efforts to implement EU legislation.

([1]) Vulnerable customers are an important consumer category for investigation, especially in view of the increasing numbers of households facing difficulties to pay their energy bills. However, due to lack of data, this consumer category was excluded from the analysis, which was focused on the average type of household.

Effective competition in production and supply, along with strong cross-border interconnections between neighbouring Member States and efficient regulation of the monopoly network companies, should mean that end-user prices can only vary significantly to the extent that there are genuine differences in the cost of transmission, distribution and supply. Otherwise, arbitrage by consumers and wholesale traders would eventually force suppliers to equalise their prices in order to remain competitive. It is important to note, however, that these effects of market opening on energy prices can only be expected to hold in the absence of market failures and distortive price regulation ([58]). A traditional reason for government regulation of energy prices has been to prevent monopoly producers and suppliers from pricing substantially above long run marginal cost (LRMC) ([59]). Effective competition, however, removes the need for such intervention. The continuation of price regulation following market opening, to subsidise certain segments of customers for political reasons, can therefore be distortive ([60]). There is, however, a case for subsidising electricity consumption for vulnerable consumers on welfare and social grounds.

A price subsidy is present when the price is held below the marginal cost of supply, which indicates the economically-efficient level of pricing. When prices are held above marginal costs, there is over-pricing, and the surplus may go toward monopoly profits or to cross-subsidise other segments of the market. In fully liberalised markets, with long run marginal cost pricing, retail prices for industrial customers would be lower than for households. Supply costs to industry are much lower, as electricity is supplied at higher voltages which permit economies of scale. Moreover, capacity costs are also lower, as industrial customers tend to have flatter load profiles than households ([61]). According to the Energy Charter Secretariat (2003), electricity prices are very close to long run marginal costs in most Western European countries, where industrial prices are on average 50% of household prices. This is much lower than the EU-wide average ratio of 75% observed in the stylised facts, but it may give a rough indication of the efficient ratio of industrial to household prices.

([58]) The predicted price effect of market opening is also based on the assumption that market opening has a direct and positive impact on market concentration. However, it may be that the absence of sufficient competition and sustained dominant incumbent positions, despite legal market opening, may hold back the expected downward price effects.

([59]) Energy Charter Secretariat (2003): LRMC includes the investment and capital costs for any new generating, transmission and distribution capacity necessary, as well as short run operating costs and variable network costs.

([60]) There is, however, a case for subsidising electricity consumption for vulnerable consumers on welfare grounds.

([61]) Energy Charter Secretariat (2003)

Retail prices are still regulated in some countries and they are often held below production cost. In particular, when markets are liberalised and price regulation is lifted in parallel, a 'catching-up' effect may be observed: prices may initially rise following market liberalisation if they were previously held below costs under price regulation. Price adjustment towards the level of long run marginal cost could have the added benefit of providing the right investment signals to producers, to invest in new capital and infrastructure where capacity is constrained, especially in the lower marginal cost generation technologies. In the longer term however, once this initial adjustment is achieved, the expected negative price effect from market liberalisation are likely to be observed.

1.3.2. Achieving a low carbon economy

The Climate and Energy Package of 2009, combined with the Energy Efficiency Directive, has provided a common framework and a set of targets both at the EU and Member State level to accelerate the shift to a low carbon economy. The three headline targets of the 2009 Package are:

- A 20% reduction in total EU greenhouse gas emissions from 1990 levels by 2020. This entails an EU-level 21% reduction from 2005 levels in emissions from ETS sectors, and country-specific reduction targets for non-ETS sectors under the Effort Sharing Decision amounting to 10% reductions compared to 2005.

- A 20% share of renewable energy sources in gross final consumption of energy by 2020.

- A 20% improvement in the EU's energy efficiency.

The EU ETS has been established as the main market-based instrument to facilitate the achievements of these targets in the energy supply and industry sectors, but it has also been supplemented by national policies facilitating the achievement of the emission target in the other sectors not covered by the ETS, supporting the development and deployment of renewable energy sources and measures to improve energy efficiency. Recent assessments show that the EU is on track to meet the climate and renewables targets by 2020, while the indicative efficiency target might not be fully achieved even with the recently adopted Energy Efficiency Directive. However, the potential impact of these policies on energy costs in the EU has become an issue of concern.

1.3.2.1. EU Climate change policy: the Emission Trading Scheme (ETS)

Since 2005, the EU ETS has been used as a market-based instrument which aims to internalise the external costs of GHG emissions through a cap and trade system. The amount of emissions originating in the energy-intensive and power industries has seen a rapid decrease since 2008. This coincided with a steep fall in the carbon price over 2008-2009; since then, the carbon price has decreased further.

The ETS gives flexibility to operators on how to meet their compliance obligations, and will therefore incentivise them to reach the cap at the least cost across the EU. Independently of other measures, an emissions trading scheme (ETS) such as the EU ETS can be expected to raise GHG emission costs for conventional fossil fuel generators. As long as these plants set the wholesale electricity price, this would raise the wholesale and ultimately the retail electricity prices. This increases the incentive to invest in renewable energy and energy efficiency measures, in particular those that are most cost-effective. As it also increases wholesale electricity prices, the ETS also incentivises sufficient investment in conventional generation if the cost is passed on (in particular those which are less carbon-intensive), which will continue to be necessary for a secure supply of energy.

1.3.2.2. Renewables policy

The binding targets set by the Renewables Directive 2009/28/EC for 2020 have supported the growth of renewable energy sources (RES-E) in electricity generation. The combined share of wind, solar and photovoltaic energy in electricity generation has been rising continuously over the sample period, with an increase in the average growth rate since 2010. This is true both on average and in a large majority of Member States ([62]).

([62]) See part III on renewables

The intermittent nature of availability along with the high capital investment cost of renewable energy technologies make them under the prevailing market conditions in the EU less competitive than the conventional power units. As a result, the majority of RES-E generation beyond pumped storage hydro units is supported by public support schemes, most of which are financed via a special levy imposed on consumers, which are subsequently claimed to raise the retail electricity price ([63]). Moreover, the intermittency of renewables production, and the consequent fixed and maintenance costs for back-up capacity, as well as the need for higher investments in networks infrastructure, entail an additional cost to the end-consumer for ancillary services and networks use.

However, there is one possible way in which RES-E could have the opposite effect on the retail electricity price, independently of support schemes. As renewable energy is characterised by negligible marginal costs relative to conventional fossil fuel technologies, high levels of RES-E penetration would drive the conventional thermal plants with higher marginal costs out of the market. Given sufficient competition at the wholesale level, this should lower the wholesale electricity price, which is a significant component of retail tariffs ([64]). In addition, when the development of renewables is combined with an emission trading scheme (ETS), higher RES substitution of conventional fossil fuel generation technologies would lower the demand for ETS allowances in the generation sector, which would lower the price of these allowances. This would reduce costs for conventional electricity generators and, hence the wholesale electricity price (Saenz de Miera et al. 2008) ([65]).

What is fundamental in these arguments is which impact renewables will have on retail prices. Generally, it seems that the wholesale price effects on retail prices have been limited so far and the RES-E production increase the overall cost of electricity supply to end users. Hence, under the

([63]) Moreno and Lopez (2011)
([64]) Jensen and Skytte 2003; Saenz de Miera et al. 2008; Senfuss et al. 2008
([65]) Note that greater RES-E promotion may also *raise* costs for conventional thermal plants with high capital costs, since these fixed costs will have to spread over fewer load hours, leading to calls for capacity payments.

current pricing regimes for RES-E production and the low levels of RES-E penetration, the wholesale market dynamics may not compensate for the investment cost associated with the RES-E promotion that most categories of electricity consumers tend to pay.

1.3.3. Security of supply

Security of supply has been one of the main objectives of EU energy policies. It has several dimensions; import dependence and diversification constitute two important elements ([66]). Threats to energy security of supply, among others, "*include the reliance on imported and insufficiently diversified energy sources, the political instability of several energy-producing and transit countries, (and) global competition over energy sources*" ([67]).

A country's import dependence is measured as the share of its net imports in total final inland consumption. In the case of natural gas, this measure has been highly volatile across the EU 27 on average over the sample period, but this result is clearly driven by volatility in a handful of countries. The import dependence of the majority of countries has remained relatively stable across the sample period, as compared to the mean trend.

The higher the energy import dependence, the greater the exposure to external supply disruptions, and sudden price hikes. While this channel may be important for price changes in the short term, the often higher cost of imported energy sources, such as natural gas, may be a driver of long term prices. It is important to note, however, that the impact of import dependency on end-user energy prices is likely to be highly mediated by the degree of import diversification. The more diversified a country's import sources, the more room it will have to negotiate favourable contracts and secure the cheapest sources. The price impact of import dependency is also likely to be affected by the degree of competition amongst the energy importers and suppliers, as this will determine the price mark-ups that local consumers face, as well as the degree of diversification in the energy mix.

Security of supply is an issue of particular in the natural gas market, given the high level of gas import dependency in the EU ([68]). The EU natural gas market always has had, and will continue to have, a large international dimension. It is estimated that even with complete integration in the internal natural gas market, the introduction of meaningful competition among domestic players, and the exploitation of potential domestic gas reserves, the EU will continue to import a large share of its natural gas consumption from third countries ([69]). Hence the scope for lowering import dependency is limited. The natural gas market, given its significant external dimension, thus differs from electricity in the sense that national and EU policies on market liberalisation and the completion of the internal market can only have a limited impact on prices.

In electricity, the notion of security of supply is very different. Given the non-storability of electricity, transportation depends significantly on the distance and takes place only in cases where this is economic viable in relation to energy losses. This factor significantly reduces the international dimension to supply risks. What is more important for secure electricity supplies is rather the proper management of the grid and sufficient investment in generation and network infrastructure. Security of supply in electricity is nevertheless ameliorated to some extent by the on-going deployment of renewables. When governments decided to promote renewables, this was not only with a focus on sustainability but also in view of reducing import dependence, diversifying their energy sources, and, to a lesser extent, promoting security of supply in electricity.

([66]) Other sources of security of supply concerns can come from the intermittency of renewables and the phase-out of nuclear production in some Member States.
([67]) European Commission (2013b)
([68]) Security of supply is also a huge concern in the oil market, which is beyond the scope of this paper.
([69]) Parmigiani (2013)

Box II.1.2: **Literature Review**

A number of studies have tried to establish the relationship between market opening and energy prices empirically, by looking at the impact of market opening reforms on electricity and gas end-user prices. In general, most studies have confirmed the expected downward energy price effects of market opening. Steiner (2000), conducted one of the first empirical studies of the effects of electricity sector reforms and found that the vertical unbundling of generation activities, third party access and the introduction of wholesale electricity markets were all linked to lower retail electricity prices for large industrial consumers, whereas private ownership did not necessarily improve competition. Similar results were found by Martin and Vansteenkiste (2001) and Dee (2010), while ECB (2010) contributed to the existing literature by establishing that the indicators of entry barriers and vertical integration have a positive impact on electricity prices, whilst entry barriers, public ownership and market concentration all have the expected positive effect on gas prices.

Not all studies are in agreement, however. Hattori and Tsutsui (2004) and Nagayama (2007) concluded that unbundling of generation and the introduction of spot wholesale markets do not necessarily lower prices and may possibly increase prices. Hence, there is some debate in the literature on the impact on certain market opening reforms on energy prices.

Erdogdu (2011) built on these studies by considering the collective impact of the different policy variables, in order to estimate the effect of market opening on the price-input cost margins. Rather than trying to capture the effect of any one reform measure, he uses an electricity market reform score variable aimed at measuring the overall progress towards complete market opening. He finds that greater progress toward market opening triggers convergence in these margins, and goes some way in highlighting the collective impact and potential interactions between reforms at different stages of the supply chain on retail price developments.

An interesting new avenue of research is the impact of electricity generation from renewable energy sources (RES-E) on energy prices, and its potential interactions with market liberalisation. The majority of renewable energy technologies are not profitable at current prices, and their development is mainly driven by different public support schemes which tend to be financed by the retail electricity market. This implies an additional cost for the consumer, and an increase in the retail electricity price. Nevertheless, the empirical literature is divided on the direction of the net effect of RES_E deployment on the retail electricity price. Moreno, Lopez and Garcia-Alvarez (2012) confirm that the cost of the support schemes pushes up the end-user price.

However, Saenz de Miera et al. (2008), Sensfuss et al. (2008) and Jensen and Skytte (2003) point to counter-dynamics in the wholesale electricity market to justify their findings that RES_E deployment contributes to an overall reduction in the retail electricity price, especially in the presence of an ETS (Saenz de Miera et al. 2008). These conflicting results suggest that further work needs to be done on quantifying the various components of the overall price effect, on differentiating the net impact by type of consumer and by type of renewable energy promoted, and on identifying any interactive effects with other factors such as the degree of competition in the market.

1.4. ASSESSING THE IMPACT OF ENERGY AND CLIMATE POLICIES ON ELECTRICITY AND NATURAL GAS PRICES

In this section, an empirical estimation of the impact of energy and climate policies on final consumer prices - industry and households - is presented. For this reason, the analysis focuses on retail electricity and natural gas prices, which are part of the last stage of the energy value chain and include four main components:

- Network costs, which are the costs of transporting electricity from the generators to customers via the transmission and distribution networks.

Box II.1.3: Methodology and Data

In order to estimate the effect of recent energy regulatory reforms, such as market opening, and other energy policy decisions on end-user prices, two sets of equations are used for households and industrial consumers. Both are estimated using a log-linear regression, based on panel data analysis. The dependent variables for the two sets of regressions are the end user electricity and natural gas prices, for industrial and household use, respectively. In particular, the empirical analysis is based on the general specification of the following log-linear equation:

$$Log Y_{it} = \alpha_i + \beta_{it} \log X_{it} + \mu_{it} + u_{it} \qquad (1)$$

where: i stands for countries (1-27) and t stands for years (2004-2011).

Y is the annual average electricity or natural gas end-user price, including all taxes and excluding VAT for households or industrial customers, X is a set of variables on regulation, market concentration, energy policy variables impacting on price, proxies for price cross-subsidisation, and other relevant control variables. Finally, μ is the unobservable time-invariant country specific effect ([1]).

Based on the LM and Hausman tests, both the electricity and natural gas price models for industrial and household consumers are estimated with the fixed effects estimator, which assumes that a country-specific, time-invariant effect is present that is moreover correlated with some of the explanatory variables. The natural gas price model also includes a time fixed effect to capture the aggregate effects of unmeasured factors that are time-variant but constant across countries. In the electricity price model, however, such an effect is excluded, and the crude oil and carbon prices are explicitly controlled for in the model specification to identify their individual effects.

([1]) See Appendix 1 and 2 for further information on the model specification and variables.

- Energy costs, which are mainly the costs of purchasing energy from generators and suppliers on the wholesale level in the electricity and natural gas market respectively.

- Support scheme costs and taxes, which represent the costs of complying with specific targets of the EU energy legislation and national taxation.

- Retail costs and margin, which includes the costs of running the retail business.

1.4.1. Drivers of electricity prices

One of the main factors driving the cost of electricity is the fuel used in generation activity. The results (Table II.1.3) indicate that the price of electricity depends significantly on the structure of each market's fuel mix for both consumer groups ([70]). In particular, a shift in the generation fuel mix from natural gas ([71]) to coal generation units would at least reduce retail prices, as this would entail a substitution of peaking or inter-medium load generation units with lower marginal cost base load units, though these units require higher capital investment cost and produce higher GHG emissions.

On the contrary, the coefficient of RES penetration in the electricity sector implies that a shift in the generation fuel mix from natural gas to wind, solar-thermal and photovoltaic power will increase the industrial and household end-user prices. This variable might be considered as a proxy for the size of supporting schemes for RES production or

([70]) Wooldridge (2006): As the fixed effects estimator controls for time-constant, country-specific heterogeneities that are correlated with explanatory variables, the effect of certain explanatory variables such as the generation fuel mix that are relatively stable over time may get swept away by the fixed effects transformation. This will result in less significant coefficients than in the absence of the fixed effects control.

([71]) Natural gas was used as a reference case for the generation fuel variables as a result of the technical characteristics of the regression analysis, in order to avoid perfect multicollinearity. The results are robust regardless of the reference case fuel choice.

Table II.1.1: **Results of Electricity price model**

	Households		Industry	
Variable	Coefficient	Coefficient	Coefficient	Coefficient
	(1)	(2)	(3)	(4)
Constant	2.274**	4.806***	4.251***	4.223***
Unbundling of DSO	-0.028***	-0.030***	-0.052***	-0.048***
RES	0.138***	0.108***	0.133***	0.127***
Nuclear	-0.017	-0.015	-0.007	-0.013
Pumped Storage Hydro	0.049	0.007	0.047	0.005
Coal	-0.123***	-0.072*	-0.106**	-0.148**
Concentration Ratio Retail	-0.057***	-0.048***	-0.039**	-0.027**
Concentration Ratio Generation	-0.030	-0.100	0.039	0.013
GDP	0.279**			
Relative Price Deviation	-0.136**		0.274***	
Relative Price Deviation < 1 * RES		0.044***		-0.013
Crude Oil Price	0.072*	0.183***	0.097	0.171***
Carbon Price	-0.001		0.005	
R^2	0.95	0.95	80%	0.77
#Obs	144	164	144	164

Note: *, **, *** Indicates significance at 10%, 5% and 1% confidence level.
In (1) and (3), the models for households and industry are estimated including the explanatory variable 'Relative Price Deviation' which measures a country's industrial-households electricity price ratio relative to the EU average ratio in year t-1. This is taken to indicate the presence and extent of cross-subsidisation in retail tariffs, and therefore acts as a proxy for end user price regulation. In (2) and (4), this variable is excluded, and instead the models are estimated including an interaction term between a) a dummy variable that takes a value of one in cases where the 'Relative Price Ratio' is below one, and zero otherwise, and b) the share of renewables in electricity generation ('RES'). In cases where the 'Relative Price Deviation' is below one, we can assume that there is greater cross-subsidisation of industrial tariffs by households, relative to the EU average benchmark. In such cases, it may be reasonable to expect that households bear a greater share of the costs from renewables support schemes, and therefore that the expected overall positive effect of RES on end-user prices will be higher for households and lower for industries relative to the counterfactual with no cross-subsidy.
Source: Commission Services.

the RES levy used for the reimbursement of RES production, which are usually paid by the consumers. However, this effect might not be applicable to specific consumer categories that might be protected from the RES levies increase ([72]).

As expected, the measure of cross-subsidization between industrial and household tariffs is statistically significant and has the expected sign for both consumer groups. An increase in the benchmarked industrial-household end user price ratio in the previous year will raise industrial prices and lower household prices in the current period. Whether such an increase in the benchmarked ratio constitutes a removal of cross-subsidies depends on the initial level of the ratio. When this ratio is below one, an increase towards one would imply a reduction in the cross-subsidisation of industrial tariffs by households, whereas when it is above one, an increase would entail a strengthening of the cross-subsidisation of households by industrial consumers.

When testing the interaction of cross-subsidization from households to industries with renewables penetration, the results are significant for the household segment and carry some interesting implications. As predicted, where industrial tariffs are likely to be cross-subsidised by household consumers (i.e. where the benchmarked ratio is below 1), the deployment of renewables has a greater overall effect in raising household prices relative to the case of no cross-subsidisation, implying that households bear a larger share of the cost of renewable support schemes in these cases.

The prices of electricity are also broadly aligned with the price of crude oil, the coefficient of which is positive and statistically significant for both consumer groups – households and industry. This linkage is stronger for industrial consumers than for households. Given that crude oil is one of the most important global commodities, the fluctuation in its price has a direct impact on the global economy. The crude oil price variation directly influences sentiments and hence the volatility of markets worldwide, especially those such as the electricity markets that depend on energy commodities.

([72]) Note that when using the electricity prices of heavy energy intensive industries (band ID) as a dependent variable, this coefficient was negative and insignificant, perhaps as a result of the exemption of these industries from the RES levy in some countries.

Conversely, as expected the carbon price does not influence retail prices, due to relatively low levels observed over the recent years.

Consistent with most of the existing literature ([73]), the results support the hypothesis that the higher the competition among suppliers, the lower the expected end user prices. The retail market competition variables are statistically significant and have the expected sign in both regressions. A plausible explanation is that greater competition amongst suppliers in formerly highly concentrated markets puts downward pressure on profit margins, and provides an incentive to reduce costs and achieve higher levels of efficiency. Particularly, the retail competition effect is higher for households relative to industrial consumers. Along the same lines, results indicate that unbundling of distribution networks leads to lower electricity prices, perhaps due to the removal of entry barriers and greater competition among retailers in formerly vertically integrated activities. This effect is slightly larger for industries and highly significant for both consumer types.

1.4.2. Drivers of natural gas prices

Measures related to security of supply such as import dependency and diversification of imports are found to be highly significant drivers of household natural gas prices. Given the relatively low levels of domestic natural gas reserves in Europe and the limited diversification in supply sources in the present scenario, this suggests considerable scope for policy action in this area. A greater dependence on natural gas imports leads to higher retail prices in both the industrial and household markets, although the coefficient of the industrial customers found not to be significant. In addition to this, more concentrated import sources of supply also lead to higher prices for household consumers. It seems that industries are relatively less exposed to price dynamics from the external dimension of security of supply. This might be either a result of cross-subsidization between the two consumer categories or a result of the industrial customer's access to natural gas hubs where market to market competition takes place.

In particular, the measure of the cross-subsidization between the two consumer groups, as in the electricity price model, is represented as the price ratio of industrial to residential tariffs relative to the respective average price ratio of the EU-27. It displays the expected sign and is significant for both industrial and residential consumers. For households this effect is significantly greater than for industrial customers. In other words, an increase in the relative price ratio during the previous year will lead to an increase in industrial natural gas prices and a decrease in household natural gas prices. As discussed in the previous section, whether this is an adjustment in the right direction (i.e. a removal of cross-subsidies) depends on the level of the benchmarked ratio. For instance, this adjustment would entail a reduction in the cross-subsidisation of industrial tariffs by households only in cases where this ratio is initially below one.

The unbundling of TSO networks from gas production and importation activity appears to have a highly significant but small effect in lowering industrial prices, and although the direction of the effect is the same and as expected for households, the price effect in this consumer segment is insignificant. The unbundling of DSO network ownership from natural gas retail activity, however, leads with high significance to lower prices for both consumer groups. While the unbundling of DSO networks is currently not a requirement under EU legislation, these results suggest that there may have been significant competitive energy price benefits to such a policy in the Member States that have pursued it.

The measure of retail market competition does not appear to be a significant determinant of prices for either consumer type, whereas legal market opening, that is the capacity for all consumers to choose their own natural gas supplier, has a significant effect in lowering mainly industrial end-user prices. The effect of retail market opening is insignificant for household consumers. A plausible interpretation of this result may be the presence of informational constraints and switching costs that might be larger for households with low consumption, and which may pose a greater obstacle to switching suppliers and achieving any potential price reductions despite the legal ability to do so.

([73]) Steiner (2001); Martin & Vansteenkiste (2001); ECB (2010); Dee (2011)

Table II.1.2: **Results of Natural gas price model**

	Households	Industry
Variable	Coefficient	Coefficient
	(1)	(2)
Constant	28.345***	25.266***
Import Dependency	0.629**	0.344
Concentration Ratio Importers	0.034**	0.012
Market Opening	-0.011	-0.037***
Unbundling of Generation	-0.008	-0.008***
Unbundling of Retail	-0.034***	-0.022***
Population Density	-5.873***	-4.951***
Concentration Ratio Retail	-0.013	0.002
Gas to Gas Competition	-0.066	-0.092**
Relative Price Deviation	-0.268**	0.071*
R2	91%	89%
#Obs	90	89

Note: *, **, *** Indicates significance at 10%, 5% and 1% confidence level
Source: Commission Services.

Although wholesale gas trading hubs are still limited both in number and accessibility in the EU, it seems that access to a spot trading hub does lead to lower natural gas prices for industries and households. This is intuitive, as spot prices tend to be lower on average than oil-indexed prices set in long-term contracts which have been the most prevalent form of gas trade in the EU. Population density also has a large and significant effect in lowering end-user prices for both consumer types, despite a slightly larger effect on households. Again, this is to be expected, as more dense populations are associated with lower unit network costs.

1.5. CONCLUSIONS

Fossil fuels remain key drivers of electricity and natural gas prices. Gas prices followed the evolution of crude oil prices, as large part of EU gas trade is still based on oil-indexed contracts, while electricity prices were strongly affected by the generation fuel mix. Moreover, market opening and competition in the energy sectors can have significant downward price effects for both household and industrial consumers. In both markets, empirical estimates confirm that EU energy policies, such as unbundling of networks and market opening decrease retail prices.

In the electricity market, whereas greater market competition may have been successful in lowering end-user prices, and thereby improving industrial competitiveness and consumer's welfare, the empirical estimates indicate that the early penetration of not yet mature renewable technologies may have the opposite effect. At levels of deployment observed for these technologies between 2004 and 2011, the cost for retail consumers as a whole from RES support schemes seems still to outweigh the merit order effect whereby the wholesale price is lowered with RES deployment. As indicated, some literature highlights that this may be different with higher deployment levels of more mature technologies, e.g. wind. Moreover, in cases where households were likely to be subsiding industrial tariffs, they were also likely to bear a greater share of the cost of these support schemes, meaning the overall positive price effect of RES deployment for households was higher in such cases.

In the natural gas market, lowering import dependency and improving security of supply can have greater downward price effects, relative to market competition in the retail segment. Given the high degree of import dependency within the EU, along with the high degree of concentration ratio of importers, this result is not surprising and shows the need to ensure diversification into alternative energy source and improve energy efficiency.

Finally, in cases where there is cross-subsidisation of one consumer category by another, this plays a crucial role in the following year's price formation through the asymmetric application of taxes and levies. Although such state intervention may be motivated by different distributional preferences, it nevertheless increases distortions and negates the effectiveness of market opening in delivering competitive price signals. This result is of high importance when considering the Commission's insistence on phase-out timetables for regulated prices as part of Member States' structural reforms.

2. ASSESSING THE DRIVERS OF CARBON PRICES: AN EMPIRICAL ESTIMATE

2.1. INTRODUCTION

In 2007, the EU made a unilateral commitment to reduce overall Greenhouse Gas Emissions (GHG) from its 27 Member States by 20% compared to 1990 levels by 2020. This commitment is enshrined in the Energy and Climate package agreed in late 2008. In addition, it is also one of the headline targets of the Europe 2020 strategy, along with two other energy targets –achieve 20% of share of renewables in final energy consumption and increase energy efficiency by 20%.

In order to achieve the transition to a low carbon economy, the EU has always promoted the use of market based instruments. In that spirit, the ETS (Emission Trading Scheme) is a market based instrument that provides incentives to reduce GHG emissions at least cost. A cap on the allowed carbon emissions set by EU legislation, alongside various other market fundamentals, delivers a carbon price which is expected to provide the signal to invest in clean technologies and to reduce carbon emissions. Moreover, the carbon price is expected to translate into higher electricity final prices. However, as seen previously, the carbon price did not have any impact on electricity retail price, probably due to its low level observed since the onset of the financial and economic crisis in late 2008.

The low level of the carbon price has triggered discussions among academia, think tanks, business and NGOs about the design and the effectiveness of this instrument and its combination with other energy target. In late 2012, the Commission published a first carbon market report ([74]) assessing the supply-demand balance in the European carbon market, with particular consideration on issues arising due to some regulatory decisions in the transition from phase II to phase III of the ETS (on top of the economic crisis). The report found a large growing surplus of allowances that is likely to weigh heavily on the carbon price and related incentives for many years to come.

The objective of this chapter is to assess the carbon price drivers and especially the interaction with other energy policies that contribute to the greenhouse gas emissions reduction, such as the deployment of renewables. Section 2 describes the carbon price developments over the three phases of the Emissions Trading System (ETS) and analyse the factors underlying the evolution of carbon emissions. Section 3 describes the policy framework in which the carbon price has developed. Section 4 proposes an empirical model to assess the carbon price drivers. Conclusions are presented in section 5.

2.2. STYLISED FACTS: EVOLUTION OF CARBON PRICE

2.2.1. Carbon price evolution 2005-2013

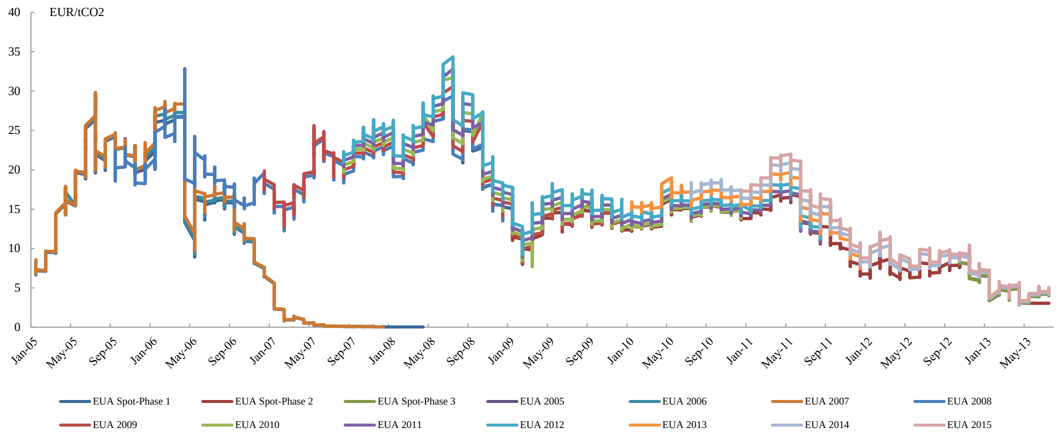
The evolution of the European carbon price (European Union Allowances-EUA) has been influenced by the regulatory design of the different phases ([75]). During the first phase of the implementation of the ETS (2005-2007), the carbon price was below 10€/tCO2 until mid-2005 before rising to a peak at just above 30€/tCO2 in April 2006. Then it fell sharply, followed by a small rebound during the second part of 2006. The publication of the first verified emissions data at the start of the second quarter of 2006 has revealed the existence of a large surplus of allowances in the first phase which was mostly due to the regulatory feature chosen by most Member States, i.e. not to allow for banking allowances([76]). Such a surplus has led to an abrupt decrease in the carbon price at the end of the first phase. The Commission's strict assessment of national allocation plans defining *inter alia* the caps per Member State for the second period has contributed to strengthening the price at the beginning of the second phase. However, during this phase (2008-2012), the economic crisis has contributed to lowering the number of CO2 emissions as well as output, leading to a decrease in the carbon price. In early 2009 the carbon price

([74]) The ETS Directive provides for the Commission to produce an annual carbon market report as of the third phase of the EU ETS, which started in 2013.

([75]) The third phase started in 2013 and will end in 2020. The first phase took place in 2005-2007 and the second phase between 2008 and 2012.

([76]) Carry-over of unused allowances into the second phase.

Graph II.2.1: **Evolution of EUA Futures prices**



Source: Bluenext, Bloomberg.

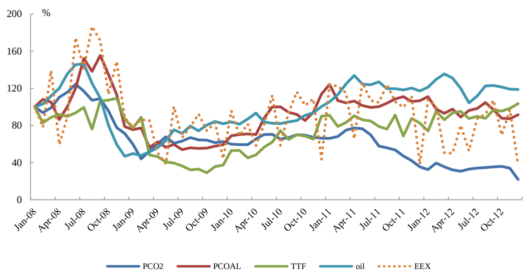
plunged to a level below 10€/tCO2. After some recovery in 2009-2010, the price returned to single digits in 2011 mainly as a result of the slow recovery and the correspondingly weak demand for allowances (along with the effect of possible other factors such as energy policies and international offsets).

The start of the third phase in 2013 was characterised by one of the lowest levels of carbon prices since the beginning of 2007. This low price level is to a large extent due to the regulatory change in late 2012 with the initiation of large-scale auctioning of free allowances. In 2013 on average some 12 to 15 million allowances are auctioned per week ([77]). In addition, this decreasing trend of prices can also be attributed to some extent to the slow progress in discussions on back-loading. The Commission announced its intention to propose back-loading in April 2012 and make formal proposals in July 2012. The market has seemingly priced in a back-loading premium and the slow progress in decision-making has reduced or eliminated this premium. Finally, other factors such as international offsets and the transferred EUA from phase II to phase III are also likely to have played a role in carbon price evolution.

2.2.2. The evolution of other fuel prices

The carbon price evolution follows the pattern of other commodities prices except the short term variations of electricity prices (EEX spot price). Electricity prices tend to fluctuate in the short-term due to day-to-day and seasonal variations in supply and demand, but in general, they revert toward a long-term equilibrium. Since mid-2011, the carbon price has been decoupled from the other fuel prices, in particular from natural gas and coal prices, as the difference of prices between those two fuels shrank significantly. It is likely that the emergence of the allowance surplus has made the carbon price more sensitive to market expectations around regulatory action proposed to restore scarcity and market confidence.

Graph II.2.2: **Evolution of carbon price, fuels and electricity prices over 2008-2012**



Source: Ecowin.

([77]) Auctioning allowances implies that allowances have to make it "through the market" and cannot be silently absorbed on registry accounts (as free allocation is) but translates on a one-to-one basis into market supply.

Table II.2.1: **Descriptive statistics of EUA, fuels and electricity price changes (%), 2008-2012**

	EUA	COAL	TTF	NBP	OIL	EEX	POWERNEXT	Nord Pool
Mean	-1.99	0.47	1.28	0.99	0.72	10.27	17.48	13.82
Max	21.23	26.77	41.58	35.75	18.24	183.06	318.43	540.51
Min	-35.70	-30.50	-45.63	-30.17	-26.89	-65.52	-72.69	-86.26
Std. Dev.	10.19	11.09	15.71	11.57	9.00	56.08	79.58	81.96

Source: ECOWIN, Bloomberg.

Carbon prices have been less volatile than electricity prices, but almost as volatile as most other primary energy sources (Table II.2.1). This can be explained by the differences in the underlying characteristics of supply, and in the behaviour of demand in those different energy commodities.

2.3. CLIMATE AND ENERGY POLICY DEVELOPMENTS

2.3.1. The ETS design

The ETS is a market-based instrument which aims to internalise CO2 external cost through a cap and trade system. The overall level of emissions allowed is capped and within that limit, participants in the system can buy and sell allowances as they require. The cap on the total number of allowances creates scarcity in the market, allowing the market to set the equilibrium price. The market price of allowances would correspond to the equalisation of marginal abatement costs of buyers and sellers.

The ETS is linked to other parts of the world through project based mechanisms leading to a reduction of emissions. Industrial installations can meet part of their emission reductions with Kyoto offsets – Certified Emissions Reductions (CER) and Emission Reduction Units (ERU). This mechanism gives some flexibility to operators while allowing a transfer of low carbon technologies to foreign countries. At the same time the use of international credits allows companies to collectively emit above the cap.

A lot of experience has been gained which contributed to the improvement of the regulatory practice and design over the different phases. In particular, the first phase 2005-2007 was a learning process. Member States were responsible for drawing up National Allocation Plans (NAPs), by specifying how many allowances they intend to allocate, and how the total will be distributed between the covered installations, while respecting the criteria of Annex III of the Directive on ETS (2003/87/EC). To this end, Member States submitted National Allocation Plans to the Commission, while the Commission was mandated to assess these plans and could reject them if the Annex III criteria were considered to be violated. In the second phase (2008-2012), Member States were obliged to show that their planned allocation, together with other policies and measures, would enable them to meet the Kyoto commitments. Furthermore, during these two phases, the directive obliged Member States to allocate most of the allowances for free – they may auction at most 5% for the 2005-2007 period, and at most 10% for 2008-2012.

The third phase started in 2013 and will end in 2020. Compared to the previous periods, substantial design changes have been brought in. The most important change concerns the cap. The system of National Allocation Plans was discontinued and the Directive determined the cap for 2013 onwards. By means of a linear factor (a percentage defining by how many allowances the cap is reduced each year) an expectation was also created how the cap would evolve beyond the end of phase 3. The linear factor of 1.74 % implies that by 2050 the annual amount of allowances put in circulation would be more than 70 % lower than the second phase cap. A significant amount of carbon allowances are auctioned. The level of auctioning for non-exposed industries will increase in a linear manner with a view to reaching 100% by 2027. Industries exposed to carbon leakage are allocated allowances for free. Subject to state aid approval, Member States may also be entitled to compensate certain installations for CO2 costs passed on in electricity prices. Certain Member States are allowed an optional and temporary derogation to continue free allocation for power plants up to 2019 ([78]).

According to Chevallier (2011), regulatory decisions on the ETS, as much as evolving market fundamentals, are likely to influence the carbon price. For example, during the second year of the first phase, in 2006, companies reported to Member States and the Commission on the actual emissions. In their report, it became obvious that the market had been over-supplied, which led to a fall of the carbon price by 50% in a few days (Chevallier, 2011). Another example is the decision taken by most Member States not to allow for the transfer of any banked allowances from phase I to phase II, leading to a discrepancy between spot phase I and future prices for phase II (Chevallier 2011).

2.3.2. Policy developments and the interactions with energy policies

In addition to a reduction in greenhouse gas emissions from 1990 levels, the "20-20-20" targets set two more key objectives for 2020 in order to fight against the climate change.

The first one is to raise the share of renewables in gross final consumption of energy to 20%. The development of renewables has been costly compared to conventional energy sources ([79]) and has required support from authorities to ensure their take up. The most common support schemes of renewables have been feed-in tariffs, feed-in premiums and green certificates. The feed-in tariff provides the renewable producer with a guaranteed price for the power they infuse into the grid. Compared to the feed-in tariff, the feed-in premium offers a guarantee (premium) over the electricity price, which means that the renewable producer has to cope with the variation of the electricity price. Green certificates are based on quota obligations where consumers or suppliers must have a certain percentage of the electricity produced by renewable sources ([80]). The development of renewables has been promoted through the use of support systems mostly financed via the electricity market ([81]), but more recently, Member States have started to revise the level of their support schemes, as some technologies have become more mature.

The second objective refers to a 20% improvement in the EU's energy efficiency. The new Energy Efficiency Directive proposes different way to achieve energy efficiency – e.g. by an energy savings obligation on suppliers, etc.

Overall, the identification of these three targets had a common objective: accelerating the reduction of GHG emissions in a cost effective way. At the same time the renewables and energy efficiency targets are pursued by wider motivations like enhanced supply security and industrial policy and competitiveness considerations. The impact assessment ([82]) accompanying the Energy and Climate Package acknowledges the interactions between renewable and climate policy, in particular the extent to which they reinforce each other in order to achieve both targets. More specifically, modelling results show that each policy alone is less effective in reducing carbon emissions and the combination of both carbon and renewable policies contribute to reaching both targets by 2020. At the same time, the impact assessment stresses that renewable policies contribute to lowering the carbon price needed to achieve the 20% GHG emissions reduction (from 49€/tCO2 to 39€/tCO2).

Since the discussions on the three 2020 targets, there has been discussion in the literature on the overlap between renewable and climate instruments and their impact on carbon prices. Most of the papers reviewed focused on the price interactions and found that the combination of both policies reduces the allowance price. Furthermore, the interaction of policies leads to two fold effects (second order effects): a decrease in the carbon price and an increase in carbon emissions (see box II.2.1).

([78]) Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Poland and Romania submitted applications, which have all been approved by the Commission.
([79]) Although the marginal cost of renewables is lower.
([80]) See Canton and Johannesson Linden (2010).
([81]) If not, leading to the emergence of tariff deficit in the electricity system (Spain, Portugal for example).
([82]) SEC(2008)85, vol.II.

Box II.2.1: Literature on the interaction between energy and climate polocies

Böhringer and Rosendahl (2010) provide a theoretical model building on a combination of black quota such as an ETS and green (renewables) quota and show how renewable quotas contribute to increasing production from the most CO2 intensive power generation technologies. This paradox is explained by two effects. First, the increase in the share of green power reduces the profitability of carbon intensive power producers, and reduces its output. However, as there is a cap for dirty power (total carbon emissions), the reduction of output by dirty power producers leads to a fall of the price of emissions, which at the end, benefits under the cost assumptions of the model to the dirtiest technologies.

Philibert (2011) reviews the consequences of the interaction of both policies on technology development, but favour the focus on the renewable development. Renewable policy can unlock the potential for renewable deployment, but is not likely to lock-in fossil fuels technologies. The author stresses the importance of energy efficiency policy in order to avoid locking –in societies' too high energy consumption pattern. Finally, another influence of the development of renewables is to change the merit order curve and lower the power spot prices. The author concludes by recommending to better take account of the interactions of both policies. More specifically, given the strategic importance of developing renewables (for energy security reasons), the carbon policy should be adjusted.

In a more provocative paper, Moselle (2011) proposes to scrap the renewable target. The author recalls the need to have a sufficient level of investment in clean technology in order to contribute to mitigation from a long term perspective. By focussing on short term targets, renewable policies focus on deployment. A policy aiming at maximising long term cost reductions would focus on promoting innovation and would be much more balanced between R&D and deployment. The author suggests that EU policy should shift towards treating all low carbon energy sources on a more equal footing via a technology neutral support scheme (suc as a carbon price floor) that would provide a reliable long term price signal that supports investments.

Zachmann and al (2012), based on Böhringer and Rosendahl (2009), shows how the combination of renewable support and a cap and trade scheme contribute to reducing the carbon price by further reducing the demand for emission permits. More specifically, they show how the subsidising of low carbon electricity sources (i.e. renewables) shifts demand of permits as they reduce the financial cost of the renewable abatement option. The reduced demand with a fixed supply (cap) leads to an excessive supply of allowances, contributing to reducing prices. The excess allowances are bought by carbon-emitting activities as it becomes more profitable to produce with traditional fossil fuel energy sources.

Gavard (2012) analyses the combination of CO2 price and support to wind development in Denmark. Denmark has promoted wind development since 1976 through the development of support schemes (either with feed-in tariffs or fixed premium). It appears that electricity prices do not have any impact on the decisions to connect new turbines to the grid. By contrast, the author shows that the support level is the dominant parameter. The author estimates the level of support needed to observe connection of new turbines to the grid (with a probability of 0.5). no average the probability of observing new turbine connections to the grid is 50% for a support level of 22€/MWh. Then, she compares the equivalence between carbon price and renewable support. A 22€Mwh is then equivalent to a carbon price of 26€/ton if competing with electricity production from coal or 46€/ton if competing with electricity production from gas (under the assumption of revenue certainty equivalence). In that case, Gavard shows that the combination of both climate and renewable policies contributes to lowering the cost of carbon reduction. However, as the author points it out, the case of Denmark is specific as the country has a long tradition of wind development. Further evidence would need to be found for other countries.

By contrast, Weigt and al (2012) find a positive interaction between renewable and climate policy. The authors estimate the reduction in demand for CO2 allowances as a consequence of renewable deployment in Germany over the period 2006-2010. The authors find that the renewable deployment led to a reduction of carbon emission by 10% to 16% during this period. They also find that the abatement attributable to renewable injections greater in the presence of an allowance price.

2.4. ASSESSING THE DRIVERS OF CARBON PRICES

In this section, an empirical estimation of drivers of carbon prices is presented.

2.4.1. Main drivers of green-house gas emissions and prices

Greenhouse gas emissions generated by industrial and non-industrial activities depend mostly on economic and energy factors (Kaya, 1990). As regards the ETS sectors, the demand and supply of allowances derived from greenhouse gas emissions will drive the carbon price. Market equilibrium depends mainly on the following:

a**) The fixed supply of allowances,** as defined by the ETS cap**.**

b)Macro-economic factors that drive carbon emission. The recent economic crisis has contributed to a significant drop in carbon emissions. Therefore, it expected that the carbon price will be positively correlated with economic growth.

c) **Energy prices** (oil, gas and coal) that influence the fuel switching behaviour of power producers which account for the majority of ETS emissions.

d) **Weather conditions (including precipitation patterns)** that drive the short-term demand for heating and cooling and hence the demand for allowances, as well as the operation of hydroelectric units.

e) **Institutional factors** that influence the behaviour and expectations of market agents, such as decisions about back loading, directives etc.

f) **International environment** and number of **CERs** and **ERUs** surrendered in the ETS. Surrendered CERs and ERUs add to the domestic supply of allowances and can be expected to modify allowance prices.

g) **Energy policies** that influence overall carbon emissions, hence the carbon price.

h) **Innovation and technological developments** with influence the marginal abatement costs and demand for allowances.

Box II.2.2: Methodology and Data

In order to estimate the effect of the aforementioned drives on carbon prices an Autoregressive-distributed lag (ARDL) ([1]) bounds tests approach for co-integration (Pesaran et al.,2001) is employed due to its certain econometric advantages compare to the co-integration techniques proposed by Engle and Granger (1987) and Johansen and Juselius (1990). This approach is considered superior to multivariate co-integration for two reasons: first, it can be applied regardless of the stationary ([2]) properties of the variables in the system and second, it is more robust with the small sample properties of co-integration bounds testing (Narayan, 2004).

In particular, the long-run relationship between carbon prices, economic activity, renewables penetration, coal prices and hydro production for EU is tested using the following linear logarithmic functional form ([3]):

$$PCO2_t = a_0 + a_0 + a_1\ IP_t + a_2\ RES_t + a_4\ PCOAL_t +\ a_5\,HYDRO_t\ + a_7\ D_t + u_t \qquad (1)$$

where u_t is the error term, t, stands for the months of the period 2008-2012, PCO2 is the price of EUA in €/tCO2, IP is the industrial production index (2010) for Mining and quarrying; manufacturing; electricity, gas, steam and air conditioning supply, PCOAL is the coal ([4]) (ARA) prices in €/tonne, RES is the electricity produced by renewables, Hydro is the electricity produced by hydroelectric units, and D is a set of dummies ([5]) employed in order to capture the institutional factors and policy effect. The monthly futures carbon and coal prices were retrieved by ECOWIN, the industrial production by EUROSTAT and the energy variables by International Energy Agency (IEA) ([6]).

Consequently, the short-run ([7]) impact of the aforementioned factors is examined by the following general representation of equation (1) ([8]):

$$\Delta PCO2_t = \beta_0 + \beta_1\ PCO2_{t-1} + \beta_2\ IP_{t-1} + \beta_3\ PCOAL_t + \beta_4\ RES_{t-1} +\ \beta_5\ HYDRO_{t-1} + \beta_6\ \textstyle\sum_{i=0}^{n} \Delta IP_{t-i} + \beta_7\ \sum_{i=0}^{n} \Delta RES_{t-i} +\ \beta_8\ \sum_{i=0}^{n} \Delta HYDRO_{t-i} + \beta_9 \sum_{i=1}^{n} \Sigma\Delta PCO2_{t-i}\ + e_t \qquad (2)$$

Table 1 reports the F-statistic associated with the null hypothesis of no co-integration, along with the asymptotic critical values of the bounds testing procedure for the three specifications. As regards the first specification, the F-statistic was calculated when each of the rest of the variables is used as a dependent

([1]) The ARDL model is a general dynamic specification, which includes the lags of the dependent variable and the lagged and contemporaneous values of the independent variables. By this way the short-run can be directly estimated, while the long-run equilibrium relationship can be indirectly estimated.

([2]) The ADF and PP tests showed that the variables included in the analysis are not integrated of same order I(n). For example, carbon and coal prices, as well as industrial production were I(1), while the renewables and hydro production were I(0). Due to space limitations the results are not presented here and are available upon request.

([3]) In comparison to the existing literature, the price of natural gas was not included in the analysis, as it was highly correlated with the price of coal in order to avoid the case of perfect multicollinearity.

([4]) The fuel switching price was used as an explanatory variable, but was found to be insignificant probably as a result of the change in the pattern of natural gas and coal prices over the last two years of the sample. For this reason, only the price of coal was included as an exogenous variable.

([5]) Two dummies were introduced in the regression in order to capture structural breaks observed in June 2011 and March 2012. These periods coincide with the adoption of the proposal for an Energy Efficiency Directive in June 2011 and public debates of their future interaction with the ETS, and with rising evidence for and the start of the policy discussions on the growing supply-demand imbalance in the carbon market and backloading as a measure to tackle it in March 2012.

([6]) Although Certified Emissions Reductions (CERs) found to have a negative impact on prices, they were excluded from the analysis as this effect was not systematic on phase II. This is likely to be explained by the limitations of data availability (available data are monthly issued CERs, United Nations). Similarly, due to lack of data the oversupply of the EUAs could not be taken into account in the analysis.

([7]) The difference between short-run and long-run impact is that in the first case factors may deviate from the long run equilibrium.

([8]) The F-test is used in order to identify whether a co-integrating relationship exists among the variables in equation (2), by testing of the joint hypothesis significance of the independent variables levels in each specification i.e. Ho: Bi=0 based on the critical values provided by Pesaran and Shin (1998), Pesaran et al. (2001) and Narayan (2005).

(Continued on the next page)

Box (continued)

variable in the testing procedure. The results shows that a co-integrating relationship at 1% significance level exists only for the carbon prices and for the coal prices, as the F-statistic exceeds the upper critical value at that level. This among others implies that carbon prices are affected by the RES production and the economic activity and not vice versa.

Table 1: Results of bound tests

Specification	Dependent Variable		(1)		(2)	
Computed F-statistic	PCO2		6.49***		5.09**	
Computed F-statistic	IP		1.27			
Computed F-statistic	RES		3.83			
Computed F-statistic	PCOAL		7.44***			
k (variables)			3		4	
Critical Values (Pesara et al., 2001)		1%	5%	10%	1%	5%
Lower bound value - I(0)		5.17	4.01	3.47	4.4	3.47
upper bound value - I(1)		6.36	5.07	4.45	5.72	4.37

*, **, *** Indicates significance at 10%, 5% and 1% confidence level.
Source: Commission Services

Note: In specification (2) all variables were included in the analysis, while in (1) the hydro production was excluded, as it was statistically insignificant.

2.4.2. Main drivers impact on carbon prices

In this section, the impact of economic activity and energy factors on carbon prices is tested ([83]). Table II.2.2 reports the short and long-run coefficient estimates obtained from the Error Correction Model (ECM) version of the ARDL model. All the estimated coefficients have emerged with the theoretically expected signs and many are statistically significant.

In the long run model, economic activity and renewable policy as well as the coal price have had an impact on the carbon price in the period 2008-12. The long-run model reveals that the coefficient of the variable that represents the economic activity is positive and statistically significant, indicating that business cycles have a strong influence on the carbon price by affecting the demand for allowances. For the same reason, the renewable penetration impacts negatively the carbon price as it substitutes part of the conventional units operation and thus lowers the demand for allowances. Similarly, the negative coefficient of coal prices suggests the possibility of fuel switching by electricity producers, when coal prices increase, towards a less carbon intensive energy source, such as natural gas. Conversely, the hydro production found to be statistically insignificant, which implies that the weather conditions (dry or wet year) would in this five year period not have had any systematic impact on the fuel electricity production mix, hence on the carbon price formation. The coefficient of the error-correction term (ut-1) reveals that any deviation from the long-run carbon prices path, due to changes in the explanatory variables, is corrected by approximately 50% over the following month. Moreover, the negative sign of this term implies that the carbon prices series is non-explosive, implying that price revert to its long-run equilibrium after an unexpected insistent. In terms of time, the speed of convergence of carbon price to its long-run equilibrium after a shock is at least two months, resulting in the high volatility of the market ([84]).

([83]) Due to data availability, variables corresponding to international offsets (CERs, ERUs), to weather and to energy efficiency could not be included.

([84]) The formula for calculating the number of months needed for prices to convert on its long-run equilibrium is $\ln(0.5)/\ln(1+\beta 1)$.

Table II.2.2: **Results of the carbon model**

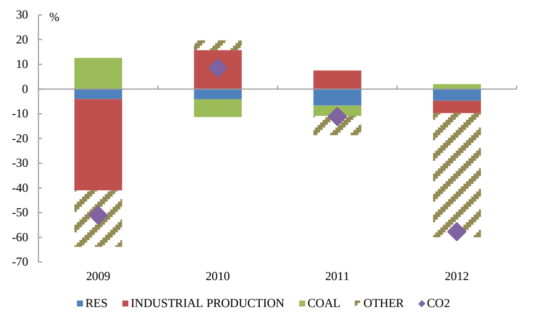
Dependent Variable: $\Delta PCO2_t$	Coefficient	Coefficient
Variable	(1)	(2)
Short-run relationship		
Error Correction Term (u_{t-1})	-0.490***	-0.525***
Carbon price change over the previous period ($\Delta PCO2_{t-1}$)	0.375**	0.371**
Current inustrial production index change (ΔIP_t)	1.649	1.861
Current RES-E production change (ΔRES_t)	-0.233**	-0.260**
Current price change of coal ($\Delta PCoal_t$)	-0.311**	-0.270*
Current change of hydro production ($\Delta HYDRO_t$)		-0.047
Long-run relationship		
Constant	5.670***	6.167***
Trend	0.004	0.004
Industrial production index (IP_t)	5.002***	4.841***
RES-E production (RES_t)	-0.553**	-0.560**
Price of Coal ($Pcoal_t$)	-0.406*	-0.362
Hydro production ($HYDRO_t$)		-0.191
Dummy variable (D_{2011})	-0.355***	-0.357***
Dummy variable (D_{2012})	-0.371***	-0.348***
R^2	52%	53%
#Obs	58	58
The Δ sign represents differences (changes)		

Note: *, **, *** Indicates significance at 10%, 5% and 1% confidence level.
Source: Commission Services.

On the short-run the effect of most of the explanatory variables on the carbon price is still statistically significant, but lower than in the long run relationship. Allowance price changes have a long memory, as they depend strongly on the previous period price changes. Once again the renewable penetration and the evolution of coal prices are one of the most important factors influencing price formation in the short-run. Consistent with the long-run results, both affect prices negatively by lowering the demand for allowances. By contrast, the results indicate that economic activity, as well as the hydro production, despite that their coefficients have the expected sign, do not affect the carbon price in the short run.

Moreover, the coefficients of the dummies included in the regression in order to test the impact of institutional factors on prices, indicate that institutional as well as policy factors play an important role in the carbon price formation. The proposal on energy efficiency made by the Commission in June 2011, as well as the discussions on the ETS market imbalance led to the lowest levels since the recession-led sell off in March 2009. Apparently, the news was integrated immediately by market agents, who adjusted accordingly their demand for allowances.

Graph II.2.3: **Decomposition of Carbon Price Changes over 2008-2012**



Source: Commission Services

Finally, in order to identify the degree of influence of the independent variables on the change of carbon prices during the ETS phase 2, a decomposition analysis based on the estimated coefficients of the model (Table II.2.2) was carried out. The contributions of these determinants were analysed on a yearly basis. Results (Graph II.2.3) indicate that there has been significant changes in carbon prices over the sample period and that the economic activity, as well as the power producers fuel preferences (fuel switching), along with the renewables penetration were the main determinants of these changes until 2011. At the beginning of phase 2 the economic crisis was the most important factor contributing to a significant decrease of carbon prices by cutting down GHG emissions and consequently the demand for EUAs. This variable exhibited a high volatility compared to the other variables such as fuel switching behaviour and renewables penetration. Renewables displayed a constant downward effect on carbon prices, while the influence of the power producers operating preferences was positive in 2008 and negative after, due to the evolution of coal prices in relation to the natural gas prices. By contrast, in 2012, it seems that other factors than those variables played a crucial role in the carbon price formation. Such factors could be the international carbon offsets, policy initiatives, or institutional decisions etc.

2.5. CONCLUSIONS

The ETS was introduced as the main instrument to achieve greenhouse gas emissions reduction in the most cost-effective way. However, the main feature of this market-based instrument - the fixed supply of allowances (ETS cap) and the elastic demand - has made the carbon price more sensitive and responsive to demand factors. Among these demand factors, the economic activity which is a key driver of GHG emissions resulted into the lowest levels of carbon prices. Based on the empirical results, the economic recession impact becomes more apparent in the long-run, as market agents appear to adjust their expectations and demand for allowances in the long-run, rather than in the short run.

Other factors also contribute to carbon price evolution, even though to a lesser extent, i.e. the conventional power producers operating preferences and the RES deployment. As already indicated in the 2008 Commission impact assessment for the Climate and Energy Package, renewables do not emit CO2, and the renewables penetration in electricity decreases the demand for allowances and hence contributes to lowering the carbon price-- as would do the spreading of any other significant abatement activities falling within the scope of the scheme. It was observed that renewables affect carbon prices and not vice versa. The latter could be explained by the low level of carbon prices and the fact that the renewables deployment in many Member States has not been driven by the carbon prices, but by guaranteed supporting schemes very often disconnected from market evolution. Finally, the impact of the accelerated use of international credits in the ETS could not be tested in the present analysis due to data limitations. However, the role of other drivers in recent years points to the importance of this factor as well as institutional factors.

Along the same lines, the on-going discussions on the ETS made the market participants and the market more sensitive to regulatory and institutional factors such as the discussions about the appropriate policy response to the growing supply-demand imbalance in the carbon market. It seems that market participants, such as power producers which account for the majority of ETS reductions, respond to any type of pricing relevant information and especially on the evolution of the relative fuel prices. This underlines that abstracting from the over-supply problem in principle the carbon market performs well as a tool to allow for cost-effective emission abatement.

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APPENDIX 1

Electricity and Natural Gas Price Model and Variables Description

Electricity Price

Variable	Description	Source	Sample
Retail Electricity Price – Households	2008-2011: Average of bi-annual household retail prices (EURO), excl. VAT; Consumption band **DC** (Annual consumption: 2500kWh < C < 5000kWh). 2004-2007: Average of bi-annual household retail prices (EURO), excl. VAT; Consumption band **Dc** (Annual consumption: 3500 kWh)	Eurostat	EU 27 2004 - 2011
Retail Electricity Price – Industry	2008-2011: Average of bi-annual end-user prices (EURO); Consumption band **IC** (Annual consumption: 500MWh < C < 2000MWh) 2004-2007: Average of bi-annual industrial end-user prices (EURO); Consumption bands Id (Annual consumption: 1250MWh), Ie (Annual consumption: 2000MWh)	Eurostat	EU 27 2004 - 2011
Unbundling of DSO	Proportion of the country's DSOs that are ownership-unbundled %	CEER database	EU27 excl. EE 2004 - 2011
Concentration Ratio Retail	Number of companies with more than 5% share of the retail market by volume	CEER database	EU 27 excl. UK 2004 – 2011
Concentration Ratio Generation	Cumulative capacity share of the 3 largest generation companies by net generating capacity %	CEER database	EU 27 2004 - 2011
Relative Price Deviation	Each country's relative price ratio between industrial and household tariffs with the respective ratio of the EU27.	Eurostat	EU 27 2004 - 2011
Carbon Price	EUA Spot prices	Bloomberg	2005 - 2011
RES-E	Share of gross electricity generated from Solar Thermal, Solar Photovoltaic, and Wind in Total Gross Electricity Production %	Eurostat	EU 27 2004 - 2011
Relative Price Deviation < 1 * RES	An interaction term between a binary variable taking value 1 when the Relative Price Deviation is below 1 (0 otherwise), and the RES variable	Own calculations based on Eurostat data	
GDP		Eurostat	EU 27 2004 - 2011
Coal	Share of electricity generated from Coal in total gross electricity generation %	Eurostat	EU 27 2004 - 2010
Pumped Storage Hydro	Share of electricity generated from Pumped Storage Hydro in total gross electricity generation %	Eurostat	EU 27 2004 - 2010
Crude Oil Price	Annualised Crude Oil Brent prices (EURO)	ECOWIN	EU 27 2004 – 2011
Nuclear	Share of electricity generated from Nuclear in total gross electricity generation %	Eurostat DG ENER Country Factsheets	EU 27 2004 - 2011

Natural Gas Price

Variable	Description	Source	Sample
Natural gas retail price - Households	2008-2011: Average of bi-annual domestic retail prices (EURO), excl. VAT; Consumption band **D2** (Annual consumption: 20GJ < C < 200 GJ). 2004-2007: Average of bi-annual domestic retail prices (EURO), excl. VAT; Consumption bands **D3**, **D3-b** and **D2-b**	Eurostat	EU 27 excl. CY, EL, MT 2004 - 2011
Natural gas retail price – Industry	2008-2011: Average of bi-annual end-user prices (EURO), excl. VAT; Consumption band **I3** (Annual consumption: 10 000 GJ < C < 100 000 GJ) 2004-2007: Average of bi-annual end-user prices (EURO), excl. VAT; Consumption bands **I3-1** and **I3-2**	Eurostat	EU 27 excl. CY, EL, MT 2004 - 2011
Market Opening	Proportion of retail customers eligible to choose their supplier %	CEER database	EU 27 excl. MT 2004 - 2011
Concentration Ratio Retail	Cumulative market share of the 3 largest companies in the retail market by volume %	CEER database	EU 27 excl. CY, DK, MT UK 2004 - 2011
Import Dependency	Share of net imports of natural gas in total final inland consumption of natural gas %	Eurostat	EU 27 excl. CY, MT 2004 - 2011
Population Density	Inhabitants per km2	Eurostat	EU 27 2004 - 2011
Unbundling of DSO	Proportion of the country's DSOs that are ownership-unbundled %	CEER database	EU 27 excl. EE 2004 - 2011
Unbundling of TSO	Proportion of the country's TSOs that are ownership-unbundled %	CEER database	EU 27 excl. EE 2004 - 2011
Concentration Ratio Importers	HHI index on natural gas import sources	CEER database	EU 27 excl. MT 2004 - 2011
Gas to Gas Competition	Binary variable taking value 1 when a Member State had access to a wholesale gas trading hub, and 0 otherwise	Based on data from DG ENER, OECD, and NRA's annual reports	EU 27 2004 - 2011
Relative Price Deviation	Each country's industrial-household retail price ratio from period t-1, divided by the equivalent average ratio of the EU 27	Eurostat	EU 27 2004 - 2011

APPENDIX 2

Carbon Price model and variables description

Variable	Description	Unit	Source	Sample
Carbon Price	Futures Carbon Prices	€/tCO2	Ecowin	January 2008- December 2012
Industrial Production	Monthly Industrial production index (2010) for mining and quarrying; manufacturing; electricity, gas, steam and air conditioning supply	Index (2010)	Eurostat	January 2008- December 2012
RES-E	gross electricity generated from Solar Thermal, Solar Photovoltaic, and Wind in IEA Countries (EU 20)	GWh	IEA	January 2008- December 2012
Price of Coal	Coal (ARA) prices in €/tonne	€/tonne	Ecowin	January 2008- December 2012
Hydro	gross electricity generated from hydro units in IEA Countries (EU 20)	GWh	Eurostat	January 2008- December 2012
D2011	Binary variable that takes the value of 0 before June 2011 and 1 after that date	(0-1)	Own estimation	January 2008- December 2012
D2012	Binary variable that takes the value of 0 before March 2012 and 1 after that date	(0-1)	Own-estimation	January 2008- December 2012